1 Danube Delta Biosphere Reserve
2 Lower Prut Nature Reserve
3 Lower Prut Floodplain Natural Park
4 Small Wetlands of Braila
5 Kalimok-Brushlen Protected Site
6 Rusenski Lom Nature Park
7 Persina Nature Park
8 Iron Gates Natural Park
9 Đerdap National Park
10 Lonjsko Polje Nature Park
11 Kopački rit Nature Park
12 Gornje Podunavlje Special Nature Reserve
13 Duna-Dráva National Park
14 Duna-Ipoly National Park
15 Fertö-Hánsag National Park
16 Dunajské Luhy Protected Landscape Area
17 Záhorie Protected Landscape Area
18 Donau-Auen National Park
19 Narrow Valley of the Danube in Passau district
20 Donauauwald Neuburg-Ingolstadt

Evaluation of Carrying Capacity in the **DANUBEPARKS**

Network of Protected Areas

Final Report

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DANUBEPARKS network of protected areas STEP 2.0

ETC-SEE Project

DANUBEPARKS 2.0
network of protected areas STEP

Evaluation of Carrying Capacity in the DANUBEPARKS

Network of Protected Areas

Final Report

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1 Abstract

In the context of DANUBEPARK Step 2.0, the implementation of a Carrying Capacity assessment tool is intended. This tool will be based on information about disturbances of species, specific for the protected areas along the Danube. In order to guarantee a data set specific for the Danube, all

DANUBEPARK-Partners were asked to define typical and endangered flora and fauna of their park and specific impacts on these species. Moreover, the parks informed about the number of visitors, their distribution all over the year and the typical way of locomotion. Additional facts and threats to the species, like breeding-season, typical habitat or size were generated by reviewing literature. Finally, this information will be inducted in a databank with open access to all DANUBEPARK-Members and will lead to a first approach to estimate how many visitors one park is able to compensate without endangering its species and its visitor attraction. Additionally, zones of disturbance can be defined and the database will provide solution approaches on how to support and how to protect the different species.

2 Carrying Capacity in protected areas

*"Carrying Capacity in tourism is conceived as a maximum number of visitors that can be tolerated without irreversible or unacceptable deterioration of the physical environment and without considerably diminishing user satisfaction (*SEIDL & TISDELL, 1999, p.104)*."*

The first formal ideas for Carrying Capacity were developed by WAGAR (1964). He described three important characteristics that are still applicable today:

1. Carrying Capacity is not an absolute value.
2. Carrying Capacity depends on the needs and values of people and can only be defined in relation to some management tasks.
3. Limitations can be reduced through management actions, like zoning, engineering, etc.

SEIDL & TISDELL (1999) state that if there is any kind of human activity in nature or anything depending on it, Carrying Capacity is a complex normative concept, influenced by ecological practices, human interests, institutional settings and management practices. Therefore, Carrying Capacity strongly depends on the management and stakeholders and not only on the environment or the visitors themselves.

These short descriptions show that with a higher amount of interests in one area and a greater number of decision makers, stakeholders or other interest groups, it can be very difficult to determine a common goal, or an ought-to-be standard. In case this can be achieved, it will be possible to generate a Carrying Capacity output close to absolute values, based on the specific needs and conditions of the evaluated park.

Summarizing, the attitude towards the aspects of Carrying Capacity has changed. Thus, during the 1990s, quantitative determinations were made according to MALTHUS (1998). Today, biological and social aspects of protected areas and their changes due to touristic activities do have priority. In result for the DANUBEPARK project, research had to be done on species and habitat composition. Possible impacts of tourism on these species and their habitats in specific areas had to be considered as well. In particular, literature review on the impacts of human activities took place. Some studies were focusing on the relationship between visitors and condition of nature. This is detected by means of soil compaction or destruction of vegetation. In addition, the implication of social aspects, such as the experiences of visitors, is very important.

Carrying Capacity should therefore be a multi-variable draft, combining different social and ecological issues. This includes also quantitative analysis, such as attendance, but this should not be the only attribute.

3 Methods

3.1 Definition of hypotheses

On the basis of a literature review the following hypotheses were deduced.

1. A certain defined radius to wildlife's points of interest is needed to guarantee its protection.
2. Visitors cause impacts on wildlife. Nevertheless, not the attendance but the behaviour is the crucial factor.
3. Educational programs encourage the comprehension of sensitivity of wildlife and regulations. In consequence this leads to adapted behaviour (e.g. sticking to paths, noise, etc.).
4. Visitors allowed to camp anywhere and overnight in park areas are more likely to disturb animals. Consequently, more settlements in the park area have the same effect.
5. A clear visitor guidance concept helps wildlife to adapt to regularly frequented areas. Anyway, retreat areas for wildlife are necessary.
6. Wildlife is sometimes more sensitive to disturbances. Specific regulations (e.g. attendance, closure of some parts of the park, etc.) during this period reduce impacts.

3.2 Creation of survey

3.2.1 Topics and questions of the survey

As basis for further analyses a survey was developed that consists of three parts (see appendix).

3.2.2 Survey 1st part: General questions

The first part contains five general questions about the park. There are three fast and easy-to-answer questions. The name and the area are requested to identify special problems within one park and whether they are somehow related to the area. *"Are the visitors sticking to the marked routes and trails?"* is another question easy to answer. We hoped to get information about the general feeling about the visitors' behaviour. The other two questions covered the amount of infrastructure (e.g. hiking, waterways or roads) and the number of educational programmes. Why is the education necessary? It is an idea that arose during the design of the survey: Is it possible that in parks with a higher amount of educational programmes, the relative number of disturbances is smaller than in other parks?

3.2.3 Survey 2nd part: Utilization of the park

The second part of the survey contains 11 questions about the utilization of the park. As Carrying Capacity tries to find a maximum number of visitors that can be tolerated within the given objectives, there are seven questions about the visitors' behaviour and rights.

The first three questions are about the visitors. "*How many are coming? How are they distributed over the year? How long do they stay?"* The answers to these questions should help to identify overlapping periods of higher sensibility, such as breeding and visiting. Further we asked about the visitors movements in the park area, in order to estimate the amount of possible disturbance by different kinds of shifting. To estimate how protected a park really is, the participant had to answer a question about the usage of the park (e.g. not used at all, used by: tourism, forestry etc.). These questions shall help to identify hot spots of disturbances within the park's border. Especially during dawn, several species react highly sensible and might get disturbed. In combination with GIS data we hope to identify disturbance patterns for the specific park region. The last questions of the second part are related to the amount of settlements and their location in or around the park. In combination with GIS and monitoring data of disturbances, it could be possible to identify areas where there are more disturbances than in others.

3.2.4 Survey 3rd part: Gathering information about animals and plants

The following part of the survey is divided into flora, mammals, reptiles & amphibians, fishes, birds and others. In general, there are the same questions on every species. They only differ in their specific terms. Therefore, a detailed description of every species is left out in the following passage and the questions asked and their intensions are kept general.

First of all, it is important to know how many species are known in the park and how many of them are flagship species.[1] They are specifically important, because of their role in public relations. Sometimes the term gets confused with umbrella, indicator or keystone species, but nonetheless sometimes additional species do profit from the protection of one flagship species (WALPOLE & LEADER-WILLIAMS 2002). Due to monitoring data, the participant could answer the next question about which species are particularly sensitive or worth protection. Further we asked when, where and what the cause was, if there had been a disturbance. This data should be combined with the GIS data for further analyses according to the disturbance area and should lead to the generation of possible buffer zones for each park. To close the survey

[1] For the concept of flagship species in the DANUBEPARKS Project visit www.DANUBEPARKS.org

we asked if hunting is permitted in the park, because there are many examples where hunting can protect some kinds of flora. (KÖNIG 1997, AMMER et. al. 2000)

3.3 Analysing monitoring data by using GIS

On the basis of monitoring data of the single parks and literature, possible zones of impacts on several species due to infrastructure and tourism can be deduced. Figure 1 illustrates the approach of the GIS analysis.

Using monitoring data, such as nesting sites or other preferred locations of the various species, as well as tourist hot spots and the road network, it is possible to define overlapping areas for each park by the overlay analysis. As the result, a map of the corresponding park was planned which should represent and highlight these areas. In this way, specific measures can be taken to regulate the situation in these areas and to eliminate disorders of the species.

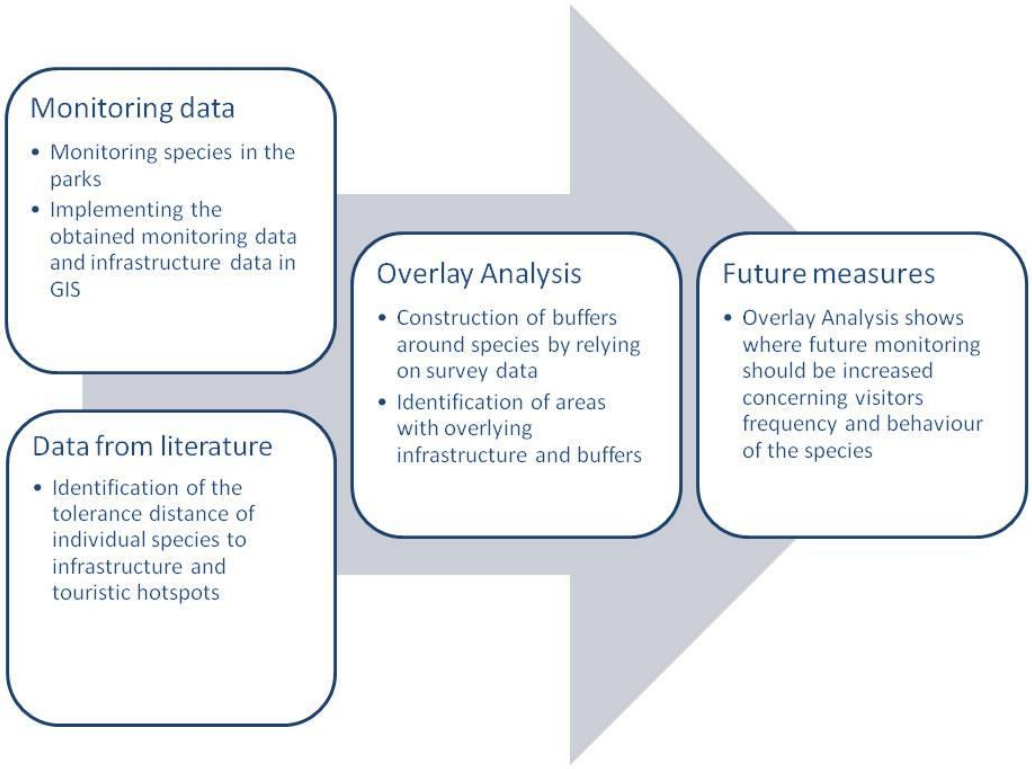

Figure 1) Approach of the GIS analysis

As a first measure, the transfer of a map or an aerial image of the corresponding park in a geographic information system (GIS) has to be done. Subsequently, the data about the types and the infrastructure is added. This could have been realized either by an import of existing data or by digitizing from maps.

For each species an individual tolerance distance can be set. It describes the minimum distance of the species' point of interest to human activities. According to literature, human activ-

ity beyond this radius won't lead to disturbances of the species. The determination of this radius is supplemented by the empirical values of the park and is backed by literature.

Furthermore, this tolerance distance radius is transferred in GIS by constructing buffers around the species (see Figure 2). Applying an overlay analysis to the anthropogenic infrastructure and to the occurrence of the buffered species leads to zones of disturbance. Finally, a colour coding of the overlapping areas is used to highlight these zones on a map. That is the reason why it is possible to monitor systematically those zones of disturbance to look for changes in behaviour of the species.

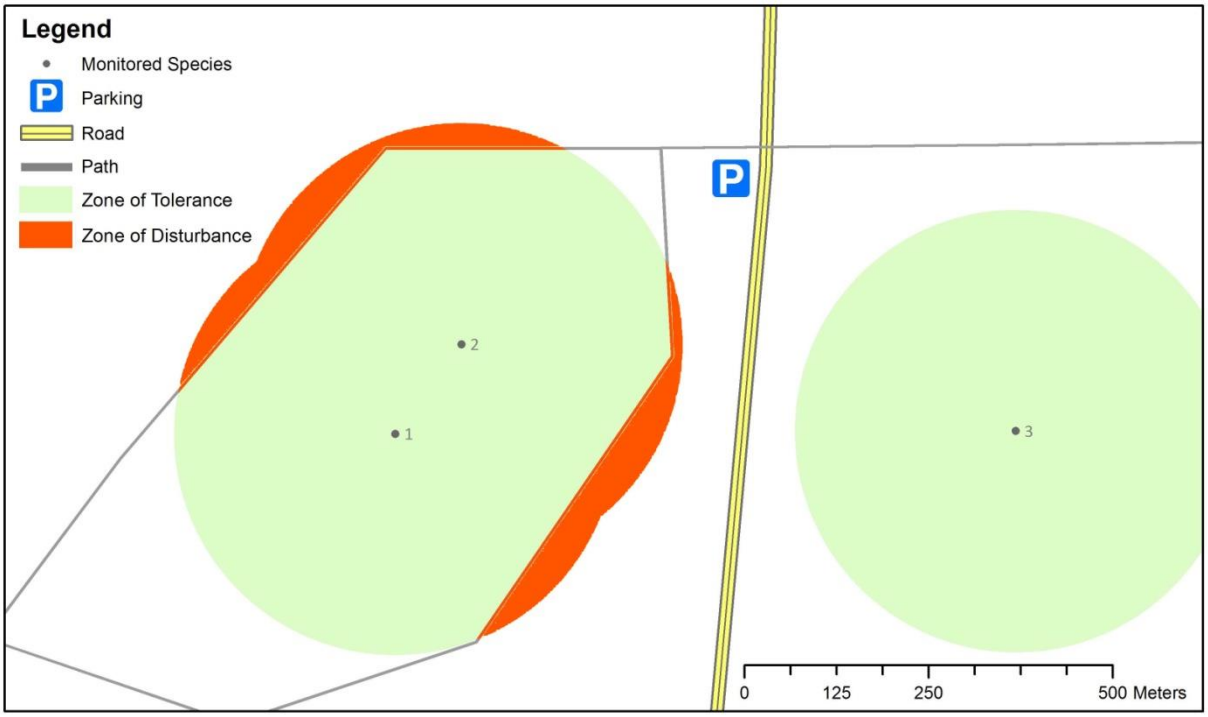

Figure 2) Overlay-Analysis
Specified buffer around one exemplary species in correlation with infrastructure using GIS. The monitored species 1 and 2 are threatened by two paths, whereas species 3 isn't being disturbed.
Source: Own illustration

Besides the overlay analysis, the distance between infrastructure and monitored species leads to park-specific data. The comparison of the smallest distance in the park to literature data is possible and indicates if the value is lower or higher than the average.

3.4 Correlation analysis

To verify if given usage characteristics are connected to some of the disturbances and to find connections between the different topics of the survey and the given disturbances which are not promptly seen, it is necessary to submit the given data to a correlation analysis. In this case the disturbances will be correlated with every other recorded value. The correlation itself will be done after the concept of BRAVAIS-PEARSON (ARTUSI et. al. 2002).

4 Results

4.1 Literature review and deducing hypotheses

Many impacts are mentioned in literature, but in most cases a clear, territorial and typal differentiation of protection areas is not possible. Thereby it has to be mentioned that detailed numbers are quite rare in literature. Thus, only general statements and suggestions are possible. Specific differentiation has to be carried out in consideration of local conditions. Besides it was determined, that the definition of sensitivity to disturbance of certain species is a very a complex undertaking because the populations in the parks are unknown and have to be estimated. In addition, there is a lack of information on the sensitivity of most species in literature, so it is only possible to create general statements and suggestions. The legal basis for the protection of species - if existing at all- can only be used restrictedly, given that in most cases it does not protect sufficiently enough.

For these reasons, only speculations on the sensitivity of disturbance of many species can be made. Protection zones concerning the character of the parks as a protection area should therefore rather be large than too small. Education programs and information on wildlife do establish understanding and willingness keep to requirements and rules.

4.2 General analysis of the survey

4.2.1 General questions

In addition to the specific questions on flora and fauna, the survey included a general introductory part which is mainly related to the use of the respective parks. Unfortunately, not all questions were answered adequately, making an extensive evaluation partly impossible. The data is given in % and serves only as a general overview. It should not be regarded as absolute values. Nevertheless, the analysis provides interesting insights in the Danube Nature- and National Parks.

From the 17 parks included in the survey, only 12 sent back information classified as adequate for this evaluation. In the first section of questions we asked about the established infrastructure. The findings of these questions are distributed as follows:

Waterways occur mostly at 41 % in the DANUBEPARKS. They are followed by maintenance roads (country-, forest-, non-public roads) at 38 %, as second largest position. Ways for cyclists and hikers clearly lay behind at 14% of all infrastructures. Surprisingly, public roads occur even less at only 7 % (see Figure 3). The interviewee was also given a chance to refine

his answer in a few sentences and to describe other infrastructure details. Unfortunately, no one made use of it. The next question asked was quick to answer, either “yes” or “no”: Are the visitors keeping to the marked routes and trails? Eleven out of the twelve participants answered with yes, only one with no. In a comment they mentioned that this is a great problem for the park. It seems that the visitors are at their best practise in most of the parks.

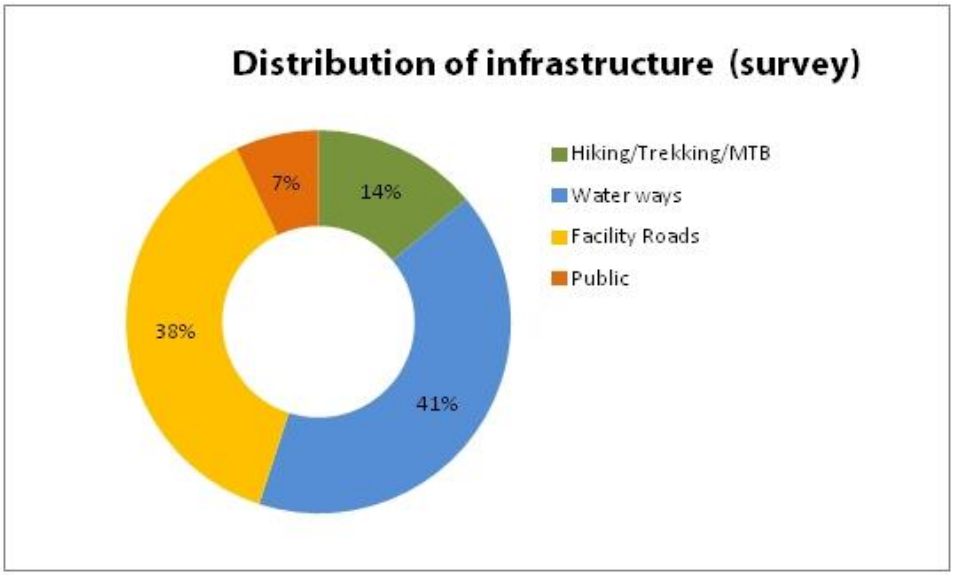

Figure 3) Distribution of infrastructure
Source: survey, own illustration

The number of visitors ranges from 500 to over one million and it is therefore difficult to compare the parks on this basis. On average, the number of visitors is 157.000 per year. This number is more like a numbers game, instead of real impotence for further analysis. Nevertheless, this value gives a pretty good abstract about the possible visitor streams. In particular and in reference to a passage mentioned before, only problems with visitors leaving the trails occurred in a park with merely 3000 visitors/year. This could lead to the assumption that problems with visitors behaving inappropriate are not directly connected to their total number. Depending on the low number of examples, a statistical resilient statement cannot be given.
Regarding the areas, there are some similarities to the number of visitors. There is a wide range from 34km² to 5800km² and there are no significant correlations between the amount of visitors and the size of the area. All parks together cover an area of roughly 8687 km².
We further asked about the usage of the park in order to be able to determine possible retreat areas. Surprisingly, only 10% of the area is not used at all or strictly protected. 40% are used for forest activities. Tourists have free access to 28% of the whole area (see Figure 4).

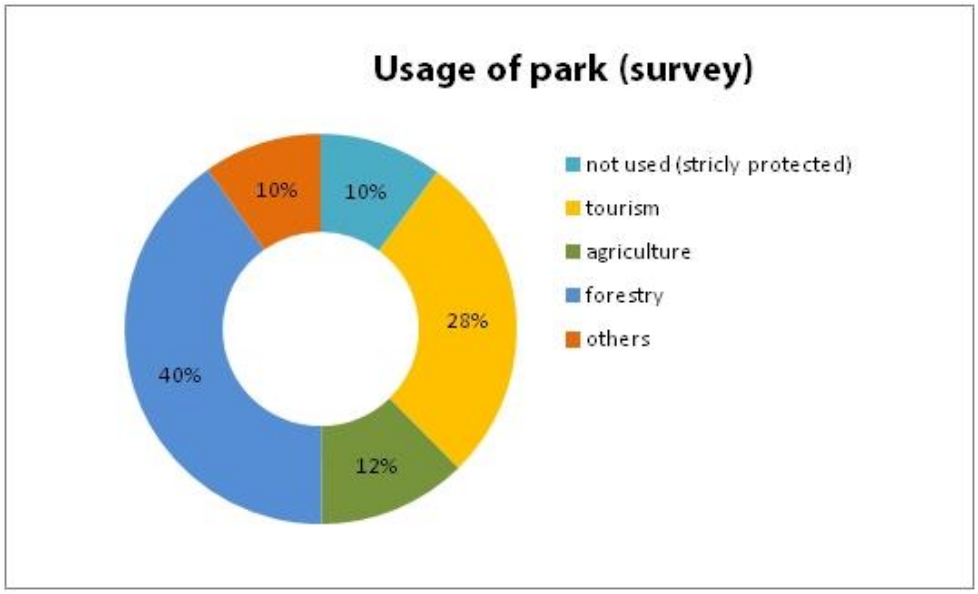

Figure 4) Usage of park
Source: survey, own illustration

Besides the ways of usage, we wanted to know if there are settlements in or around the park areas and where exactly they are located. The given answers in the survey showed that there are indeed settlements in the middle of the park area (25%). Most settlements (38%) are located at the border of the park. 25% are located along the Danube river and 12% are located in other places. The distribution of the settlements in the park region is illustrated in Figure 5). Altogether there are 119 settlements with a total number of 410.910 citizens along, within, or next to the protected DANUBEPARKS area.

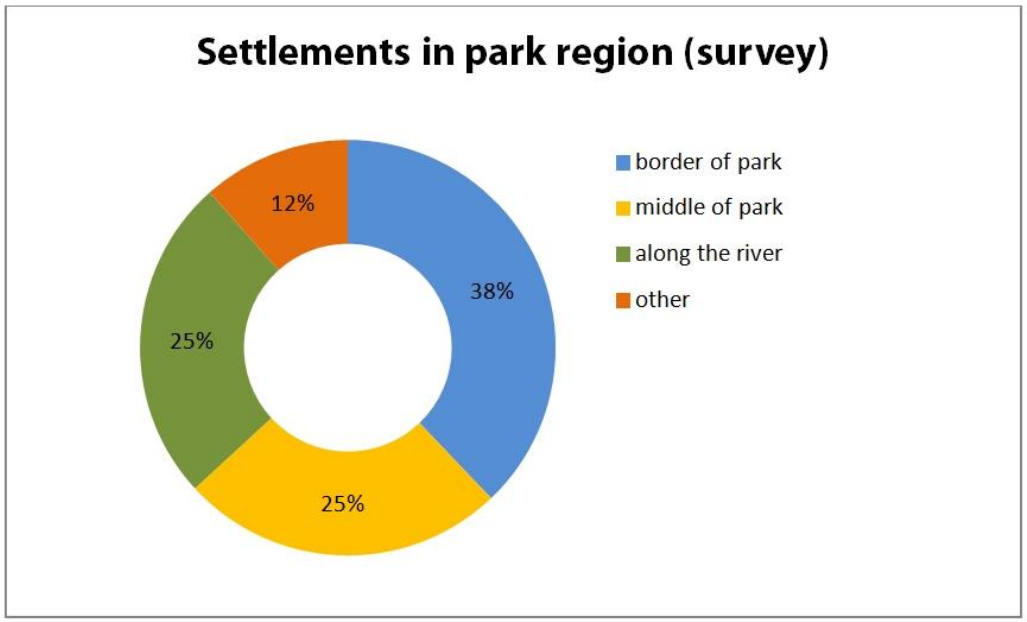

Figure 5) Settlements in park area
Source: survey, own illustration

One very important factor concerning the concept of Carrying Capacity is the way of locomotion in park areas. Depending on that, animals have more or less retreat areas to rest and reproduce. The answers in the survey were given as follows: 30% of the visitors are using the (marked) hiking trails, closely followed by the use of their own car (28%). Much less visitors are using a coach to get there and around (15%). Not far behind is the use of a bicycle (13%). About 10% of the visitors are using a boat within the park areas to get around and another 4% are paddling their own canoe within the park boundaries (see Figure 6).

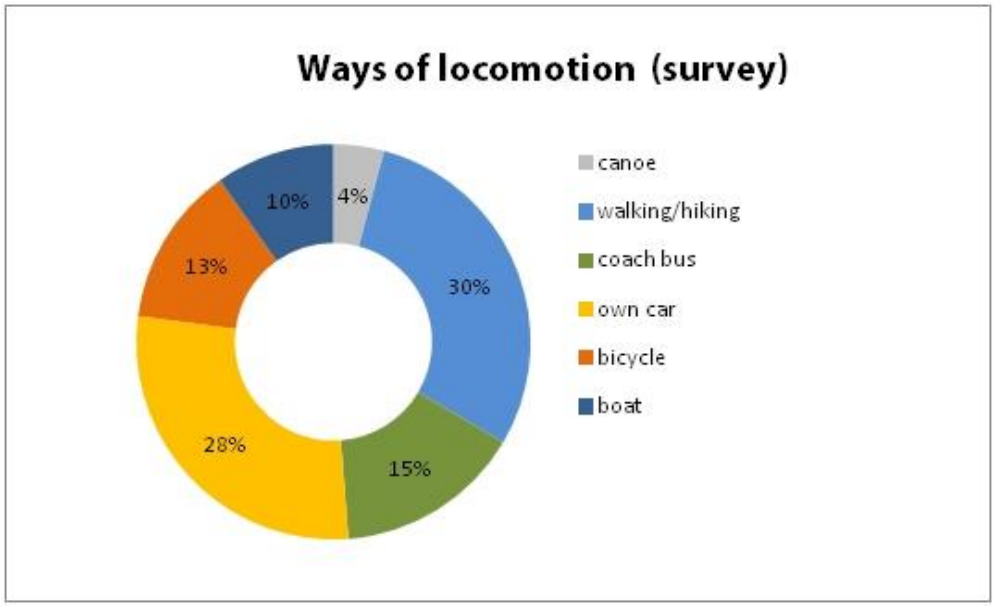

Figure 6) Ways of locomotion
Source: survey, own illustration

The average overnight stay is down to 1.4 days. Nine of twelve parks offer accommodations for their visitors, ranging from campgrounds, over hostels to hotels.

Another very important factor for assessing the Carrying Capacity of an area is the knowledge of typical and most frequently occurring disturbances. If it is possible to solve problems caused by particular disturbances, them flora and fauna can be protected. Maybe even at the same or higher number of visitors. To give the attendee best flexibility and to gather all possible disturbances, the question was presented as an open question. Despite this, the given disturbances were very similar in many cases. This allowed us to classify the answers into main typical groups of disturbances in the DANUBEPARKS.

The survey shows that disturbances caused by noise are holding the biggest share of 22%. At 19% slightly behind and second common is the disturbance “attention” (people getting into the flight initiation distance of animals).

Subsequently, there is a big drop to the next issue and the amount of listed disturbances is getting very similar. Hunting and poaching are listed third at 9%. All traffic disturbances combined are summing up to 8%. Although waterways are the longest transportation routes within the park areas, of all disturbances there are only 7% each listed for hydraulic engineering and canoeing. Illegal fishing and forest activities are listed at 6% each. The collection of samples is common with 5% of all occurring disturbances. At 4% each, trampling and campfires are also a threat. Boats that drive on tourist routes through the parks are the last listed disturbance at 3 %, the typical disturbances mentioned in the survey are shown in Figure 7.

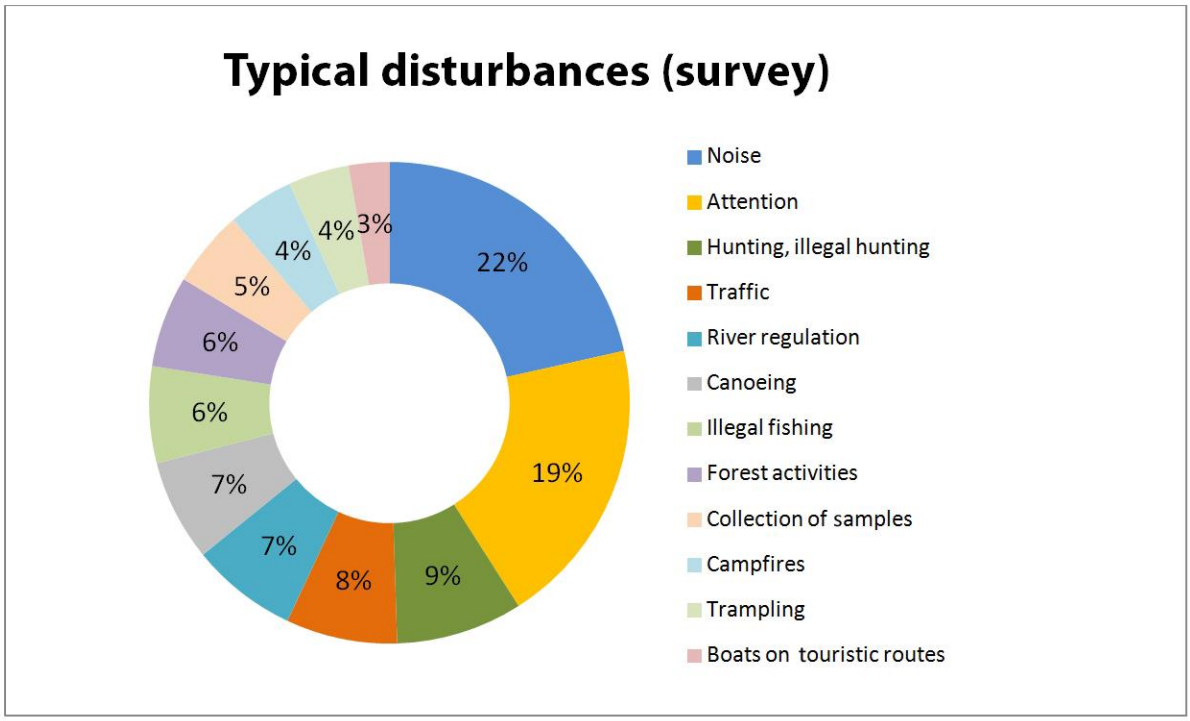

Figure 7) Typical disturbances
Source: survey, own illustration

4.2.2 Breeding Seasons and visitor distribution

Taken from the species-specific part of the survey, we combined the breeding/flowering seasons of each species group with the visitor distribution over the year (see Figure 8). The shown data is based on every single species named in the survey (52 birds, 36 fishes, 27 mammals, 26 reptiles, 41 plants). It can be seen very clearly that the highest peak of activity for birds, fishes, reptiles, and amphibians and plants starts at the beginning of May and continues until the end of May. There is an offset of roughly two weeks to the visitors' main activities. From mid of May to end of May, there is an overlap of the visitor and nature activities.

Interestingly, there is a small drop of visitor activity in July, almost exactly at the mammals' main activity period. During this period every country listed in the DANUBEPARKS project has summer vacation and no country has a break in between. The answers to the question if there are periods where the entrance to the park is restricted or forbidden was most of the time just answered with yes or no. Therefore it could be possible that some parks limit or restrict the access for visitors during this period, in order to protect the mammals' lactation activity. This assumption cannot be proven by the collected data. It could also be possible, that the drop is caused due to inaccurate answers; hence it is not a very big drop.

At this point it is suggested to restrict the visitors' access to nature parks during May and July, for optimal preservation of flora and fauna. With the knowledge of breeding/mating sites there is no need to deny access completely, it is much more important to guide the visitors away from these places.

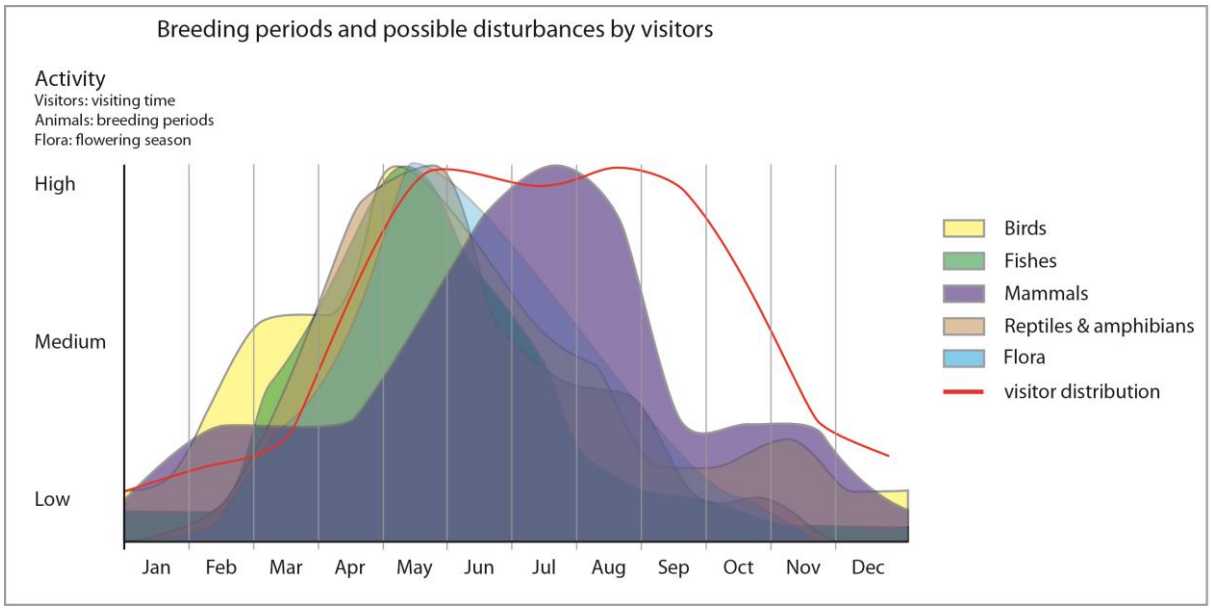

Figure 8) Breeding periods and possible disturbances by visitors
Source: survey, own illustration

4.2.3 Correlation analysis

The recorded disturbances were grouped across the species and correlated with the number of visitors, the amount of hiking/trekking, mountain biking (MTB) trails, size of the road and path network as well as with water ways, facility roads and the area. Furthermore, we correlated the different usage, like tourism, forestry, agriculture, the allowance of staying overnight and the average duration of stay, with the disturbances. As shown in Figure 9, there are no highly significant correlations between the items. There is a slightly positive correlation towards the number of visitors. Scientists state that the amount of visitors is a disturbance key

feature for nature (e.g. BROWN 2009). For the DANUBEPARKS and within our recorded data we couldn´t find this dependence.

Sum of all disturbances

Name	Correlation Value	Ranking
Number of visitors	0,55	slight
Hiking/trekking/MTB	0,46	low
Road and Path Network	0,18	very low
Waterways	0,16	very low
Area [km²]	0,08	very low
Tourism	0,06	very low
Overnight stay permitted	0,05	very low
Forestry	-0,02	very low
Agriculture	-0,03	very low
Facility roads	-0,10	very low
Average duration of stay	-0,30	low

Legend: < -0,2 very low; 0,2 - 0,5 low; 0,5 - 0,7 slight; 0,7 - 0,9 high; <0,9 very high; value range [-1;1]

Figure 9) Correlation analysis of disturbances and usage of the park
Source: survey, own illustration

4.2.4 Data acquisition for matrix of species and corresponding impacts

A list of species was created on the basis of the completed surveys. It contains 205 different species which were divided into different types of creatures. To unify this list cross linguistic, the Latin names of the species were used and then supplemented with their English names. The list was subsequently updated with different information from the literature. For example, descriptive characteristics of each species were added (size, weight). In addition, information such as the habitat, the dietary, the demands on reproductive sites, or the occurrence of species in the various parks were included in the matrix, to facilitate the assignment of the individual species in corresponding habitats in the park areas. As the focus should be on particu-

larly sensitive and endangered species, also the current threat after the IUCN Red List was added.

In addition to the species, disorders and disturbance periods mentioned by the parks were taken from the surveys, as these represent the problems to be solved. This information was supplemented in separate columns with data from literature. The main task was to find appropriate solutions from the literature for these disorders and disturbances. Such solutions could be taken, for example, from other parks and projects. By doing this, a base of information will be created. It will serve the DANUBEPARKS as platform concerning suggestions and proposals. The decision whether the individual measures for each region are suitable or not, is at the discretion of the park management.

The following table (Table 1) shows all comprised data that has been included in the matrix, using the example of the Eurasian Eagle Owl (*Bubo bubo*):

Table 1) Example of collected information on species, threats and possible solution
source: survey, own illustration

name (lt.)	*Bubo bubo*
name (eng.)	Eurasian Eagle Owl
type	bird
habitat	varied structure of hedges, coppices, open waters
	and open land areas
size [cm]	61 - 67
weight [kg]	1,8 - 3,2
sociology	
nutrition	ground-dwelling mammals, birds, invertebrates soil dwellers
reproduction time	february - august
reproduction places	in cliffs and steep slopes and in old nests of birds
	of prey, rare on buildings or on the ground
maturity [years]	
peculiarities	
Red List / IUCN	
disorder (survey)	disturbance and noise
disturbance period (survey)	breeding season
disorder (literature)	killed by traffic, disorder in breeding places by rock climbers
solutions	receiving diverse structured landscapes (prohibition of
	reforestation and conservation of grassland in the area of
	breeding sites), protection of natural rocks and quarries
	with breeding populations, prohibition of climbing rock
	faces with hatcheries
parks	Rusenski Lom Bulgria

After the final count of all the species that were mentioned in the survey, we looked up the typical disturbances for each species und compared it with the given answers from the survey. Hence a matrix from all collected data was created that gives an outline of typical disturbances and solutions (see Table 2).

Table 2) Matrix example containing all collected data
Source: survey, own table

	typical disturbances (literature)	typical disturbances (survey)	solutions
Mammals	habitat destruction and -fragmentation; roadkill; pollution, light and noise disturbance (especially bats); (illegal) persecution, hunting, poaching, trapping; invasive species	forest activities; noise disturbance (e.g. traffic noise); hunting; visitors pick the feeding plants; physically disturbance; hiking, jogging, mountainbiking; attention	protection of natural habitats (e.g. ancient woodland (high density and connection); preservation of dead-wood "Forest roads and trails should avoid roosting areas; tourist paths should pass around potential roost and den sites whenever possible; education programmes"
Reptiles & Amphibains	collection as pet; trade; killing; habitat loss; fragmentation or destruction; intensive tourism; disturbed by other animals; road traffic; overgrazing; burning of grassland; agricultural use; erosion; pollution; predatores	collecting as pet, trade, killing; habitat loss; intensive tourism/attention; disturbed by other animals; noise; introduction of alien specimes	protection of habitats; education of local population and visitors; adapted grasscutting; controled population of wild game
Fishes	overfishing (meat, caviar); illegal fishing (poaching); Dam construction; other river engeneering; parasites; water pollution; drainage of wetlands	illegal fishing; water pollution	strictly controlled fishing quotes; increasing controls; political arrangements; biolocical resarch
Birds	###Beispiel Text	###Beispiel Text	###Beispiel Text
Flora	rural replotting; grazing; trampling; collecting of flowers/fruits and cutting of woods; non natural water regime; higher nutrient and pesticides contamination; climate change forest fire/ burning of dry grass etc.; drainage; livestock; too early swath; destroying of plants	habitat loss/ rural replotting; grazing trampling/ water tourism; collecting of flowers/ cutting of woods; non natural water regime; parasites	clear visitor guidance to prevent trampling; renaturation of habitats; sensitization of visitors and local population to flora

4.3 Impacts and solution approaches to threatened species

4.3.1 Flora

Impacts on Flora

The impacts on flora in all of the protected areas along the Danube River are quite similar (Figure 10). The following impacts were extracted from results of the survey and from reviewing the literature. Also the plants, noted in the survey, were attributed to the impacts.

Whereas flowering flora are mostly threatened by people collecting them (e.g. *Eranthis hyemalis*, *Himantoglossum hircinum* (L.) W.D.Koch, *Hottonia palustris*, *Nuphar lutea*, *Orchis simia* Lam.), meadow plants are endangered by overgrazing (e.g. *Cytisus kovacevii* Velen., *Polygala sibirica* L., *Verbascum dieckianum*) and trampling (e.g. *Apium repens* (Jacq.)) or by too early swath (e.g. *Orchis simia* Lam.). Other widespread impacts are aggressive water tourism (e.g. *Nymphaea alba*) and pollution.

More rarely, fruit collection leads to impacts and the decline of the species (e.g. *Juglans regia*, *Trapa natans*, *Vitis vinifera*). Furthermore, land-use change such as the construction of dikes, draining of wetlands (e.g. *Hottonia palustris, Marsilea quadrifolia*), as-well as excessive use of fertilizers in agriculture (e.g. *Fritillaria meleagris*, *Gladiolus palustris*) lead to loss of biodiversity (ALLAN 2004, SARBU, 2003).

Besides these impacts directly induced by humans, some literature explains the loss of biodiversity by climate change and increasing dryness (IUCN 2013, TILMAN & LEHMAN 2001). This assumption is reinforced by comments of some parkemployees, who noticed changes in the water regime. Especially riparian woods, such as the black poplar (*populus nigra*), suffer from this development (WARD 1998).

Nevertheless, trampling and collecting seem to be the most important issues in the protected areas along the Danube. Research especially on the impact of trampling, exists. In general, scientists agree that the plants' tolerance, resistance and resilience are the major factors in determining the impacts of trampling. Resistance is understood as the ability to withstand the initial trampling impact. Tolerance is the capability to withstand repeated trampling. Resilience is the plant’s potential to recover from damage caused by trampling. (UFZ 2013, TOMZCYK 2011, WHINAM & CHILCOTT 2003)

Another issue is the on-water tourism of small boats, for example kayaks. First, it is difficult to control and to guide. Second, even boaters, informed by signs, ignore local interdictions such as swimming (STERL et al. 2002). On the other hand, big ships and motorboats cause waves, which lead to undercutting of the riverbanks and loss of land. In order to understand

the dimension of this issue, research was done all over the world. Exemplary rivers are the California Delta (BAUER et al. 2002), Murray River in Australia (BALDWIN et al. 2009), Marlborough Sounds in New Zealand (PARNELL et al. 2007), the Kenai River in Alaska (DORAVA & MOORE 1997) and the Illinois and Mississippi River systems (BHOWMIK 1981). The ability of vegetation to reinforce river banks partly depends on scale of the vegetation compared to the stream. This stabilization seems to be most effective at the banks of small water courses (THORNE 1982, GATTO 1984, NANSON & HICKIN 1986, DAVIES-COLLEY 1997), whereas on larger streams, fluvial processes tend to dominate because of the deep erosion, mostly under the root system of the riparian woods. (GATTO 1984, NANSON & HICKIN 1986). It has to be considered that large trees may locally tend to increased mass failure of banks, due to the surcharge weight which cannot be compensated by the dense root system (THORNE 1982, GATTO 1984).

The land-use change e.g. in Eastern Croatia from natural marshy and flooded areas to agricultural used fields strongly influenced the water quality. The use of fertilizers leads to unnatural high nutrient enrichment. Especially phosphor and nitrogen is reaching high levels. This leads to the disappearance of more sensitive species such as *Lemna trisulca*, *Riccia fluitans* and *Ricciocarpus natans* (ALLAN 2004, KOČIĆ et al. 2008, KREMSER & SCHNUG 2002).

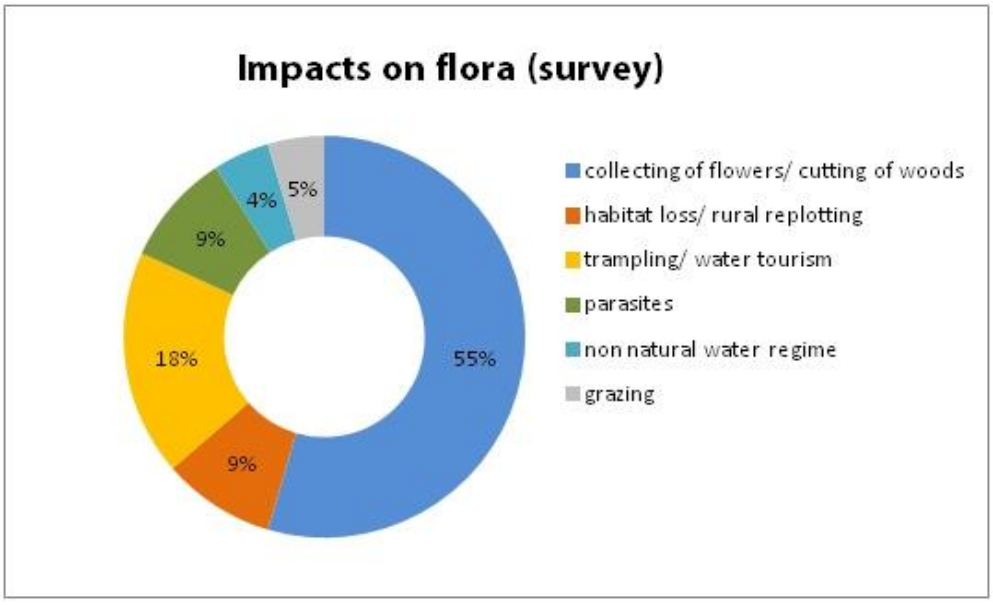

Figure 10) Impacts on flora
Source: survey, own illustration

Solution approaches in literature

There haven't been any solution approaches in the survey, which is probably due to the difficultness of confronting the impacts. Land-use change took place over many years and it is

difficult to restore the initial landscape - at least in this extend. Nevertheless, projects to restore "natural" riparian vegetation do exist, e.g. Auenzentrum Neuburg-Ingolstadt. The preserving of natural habitats should be first priority.

In the following, the main focus is on trampling. Proper tourist traffic channelling and preventing informal trails is the key issue to protect flora. This issue includes implementing clear visitor guidance (e.g. maps, signs) and the construction of boardwalks to protect sensible vegetation from trampling (VISTAD 2003, WINTER 2008). COLE (1995) claimed clearly marked campgrounds to prevent illegal camping and channelling their consequences. (BARROS et al. 2013, SILKORSKI 2012)

The education and sensitization of visitors and local population alike is one of the most important tasks to ensure ecologically aware behaviour in the park area.

4.3.2 Amphibians and reptiles

Impacts on amphibians and reptiles

The threats to amphibians and reptiles along the Danube according to the surveys are the following: habitat loss (e.g. by draining), intensive tourism, attention, collecting of amphibians and reptiles for home pets or eating, killing, noise and disturbance by other animals (e.g. wild boar). These disturbances are illustrated in Figure 11.

In literature the following impacts are mentioned: fragmentation of the habitat (EDGAR & BIRD 2006, EL MOUDEN et al. 2006), intensive agricultural use (BARBIERI et al. 2004, EL MOUDEN et al. 2006, SANTOS et al. 2008, SANTOS et al. 2009), burning of grassland (SZÖVÉNYI & JELIĆ 2011), overgrazing (EDGAR & BIRD 2006), erosion (HERCZEG et al. 2007), road traffic (BORCZYK 2004, ROZYLOWICZ et al. 2003, ROZYLOWICZ & DOBRE 2010, SANTOS et al. 2008, SANTOS et al. 2009, VALKANOVA et al. 2009), pollution (BARBIERI et al. 2004), pets (as dogs and cats) (FILIPPI & LUISELLI 2000, HERCZEG et al. 2007, SZÖVÉNYI et al. 2011, VALKANOVA et al. 2009), predators (HERCZEG et al. 2004, SZÖVÉNYI et al. 2011), trade (ANADÓN et al. 2007, COGĂLNICEANU & MIAUD 2002, COGĂLNICEANU et al. 2013, ERISMIS 2010) and land-use change (KOVÁCS & ISTVÁN 2010, READING et al. 2010, STRUGARIU & GHERGHEL 2008).

Amphibians and reptiles suffer most from land-use change (e.g. drainage, agricultural use, urbanization, road construction) and the resulting loss, fragmentation or degradation of habitats. These human impacts are the reason why about one fifth of the European reptiles are threatened by now (COX &TEMPLE 2009). *Viper ursinii moldavica* is probably the most threatened European snake (EDGAR & BIRD 2006). The snakes' habitat is above water level and in herbal vegetation, used as basking sites and during gestation. If vegetation diminishes

due to grazing activity, the natural habitat area decreases constantly. Controlled fires in spring, used by farmers to facilitate the growing of fresh vegetation, are another threat. Forestation, such as the planting of poplar near Sfântu Gheorghe, Romania, leads to habitat loss and in this case to fragmentation. Roads and constructing activities also lead to a decline of the habitat area as-well as killing. Other threats to vipers are the actual cynegetic management. Wild boars, for example, are well-known predators of the viper and decrease the number of the species in addition. Leisure activities, such as off-road and quad driving, as well as shuttle busses to the seaside (e.g. Sfântu Gheorghe, Romania) and tourism lead to more traffic in the habitat of the *Viper usinii moldavica* and endanger the snake. Illegal collecting and killing of the Moldavian Viper cause additional decline (ZAMFIRESCU et al. 2011).

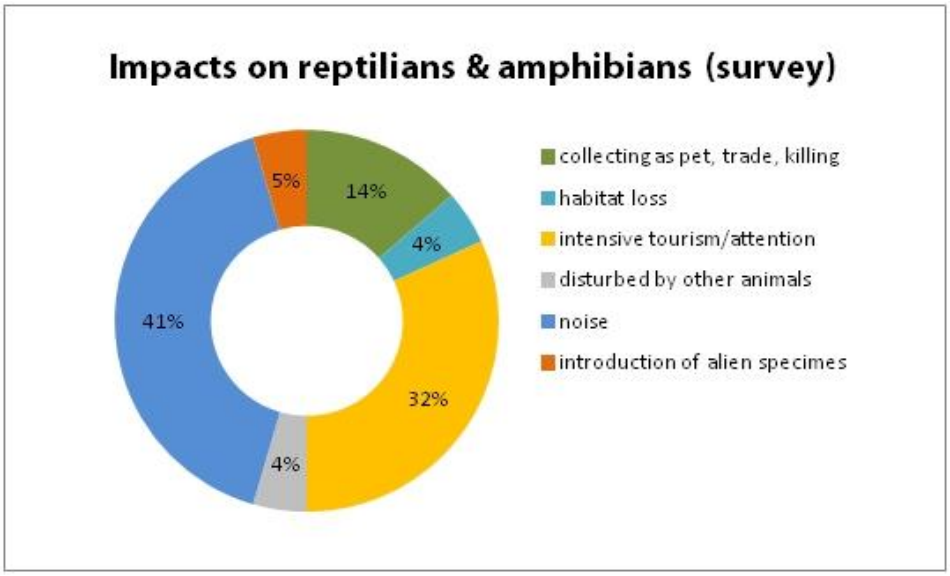

Figure 11) Impacts on reptilians & amphibians
Source: survey, own illustration

Solutions

Solutions to the above mentioned impacts are manifold but need to be applied to the respective species. The following proposals are extracted from literature reviews.

At first, strict regulation of forest and wildlife management is important. That means the population of wild boar and deer should be kept at relatively low density. Second, grass cutting should be done in the way that animals still have sufficient hiding places during their whole activity period. Furthermore, park edges should be annually cleared of invasive plants to preserve the natural habitats. (HERCZEG et al. 2004, SZÖVÉNYI & JELIĆ 2010)

Another important step to safeguard the population of amphibians and reptiles is to inform the tourists and the local population about the importance of the strict protection of habitats. To convince the visitors to stick to the paths, not to litter and not to touch or even steal the animals, are already the first steps to protect the habitats and the species. Depending on the spe-

cies, special measurements can be taken to reinforce the habitat. Regarding to *Ablepharus kitaibelii fitzingeri* for example, the park management could support south-facing, open, thermophilous oak forests which naturally grow on limestone, dolomite or loess basement. *E. Orbicularis* in contrast would profit of the reconstruction of pond banks or of new ponds as habitat (RIVERA & FERNÁNDEZ 2004, HERCZEG et al. 2004, SZÖVÉNYI & JELIĆ 2010).

4.3.3 Birds

Impact on birds

Among birds some threats occur in the questionnaire frequently. The most common disorders are noise, human disturbance and boats/canoeing. It can be attributed to the tourism in most cases. Other disorders mentioned in the questionnaire are the following in descending order: Attention, hunting, traffic and forest management. Figure 12 gives an overview of the threats mentioned in the survey.

Interestingly, the loss, degradation or modification of the habitat has been mentioned in the questionnaires not a single time although in literature they are the most common disorders (HEREDIA 1996, SHUFORD & GARDALI 2008, GARDALI 2008). In other cases, the exercise or the intensification of agriculture and forestry are mentioned as responsible for this. MEYBURG et al. (1997) list, for example, for the following forestry measures:

1. Opening up of new roads by forestry companies;
2. Clear-felling or reforestation with exotic tree species;
3. Selective cutting of old and large trees;
4. Srainage of the forest,;
5. Disturbance during the breeding period by logging.

Corresponding measures in agriculture are after MEYBURG et al. (1997) for example:

1. Loss of landscape mosaic leading to loss of feeding areas that has caused the decline of the most important prey;
2. Loss of grassland;
3. Natural regeneration;
4. Afforestation;
5. Loss of water meadows;
6. Intensification / monoculture;
7. Creation of reservoirs
8. Cultivation of unsuitable crops.

For other types (e.g. *Phalacrocorax pygmeus*) also the loss of habitat and breeding territories by drainage and serious degradation of wetlands and their associated woodland, as-well as

water pollution by pesticides and heavy metals is mentioned (CRIVELLI et al. 1996). Another factor is the destruction of nesting sites with special properties, such as individual nesting trees (MEYBURG et al. 1997). Other disorders listed in literature are, among other things, (illegal) hunting (CRANSWICK et al. 2010), disturbances by fishermen and tourists (TRIPLET et al. 2008), collisions with and electrocution by power lines (HEREDIA 1996), as well as the theft and the illegal trade of eggs or young birds for collectors or for falconry (MEYBURG et al. 1997).

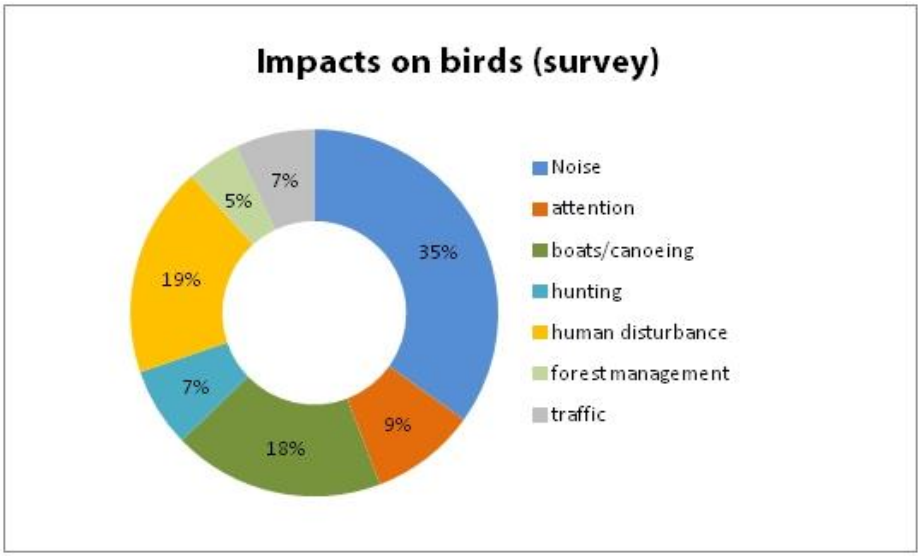

Figure 12) Impacts on birds
Source: survey, own illustration

Solutions

As the loss and the degradation of the habitat are described as the major problems in the literature it is obvious to find corresponding solution approaches. According to HEREDIA (1996) governments should review their forestry and agricultural policies, if not done already. It should be compatible with the conservation of the vulnerable species. Furthermore, precise guidelines for forestry and farming should be defined and matched to the existing range of species (HEREDIA 1996, MEYBURG et al 1997). The measures to be taken can vary widely. However, they must prevent that the relevant habitats continue to be destroyed, decimated, degraded or otherwise influenced in a negative way. This can include both the protection of existing natural and semi-natural habitats and appropriate revitalization measures to improve or restore these habitats.

Furthermore, it is important to avoid disturbance of the species, especially when breeding. Therefore protection zones could be established, either around individual nesting sites of certain species or with a large spatial extent. Such protection zones can be set permanent or sea-

sonal (MEYBURG et al 1997) and can act as a total exclusion zone or as areas with special conditions and limitations.

According to HEREDIA (1996) careful monitoring is necessary to highlight any potentially harmful activities and to locate breeding pairs to ensure that buffer zones are declared to prevent disturbance during the critical periods of incubation and rearing. In addition, guidelines for habitat management should be developed and provided to the landowners and users.

4.3.4 Fishes

Impact on fishes

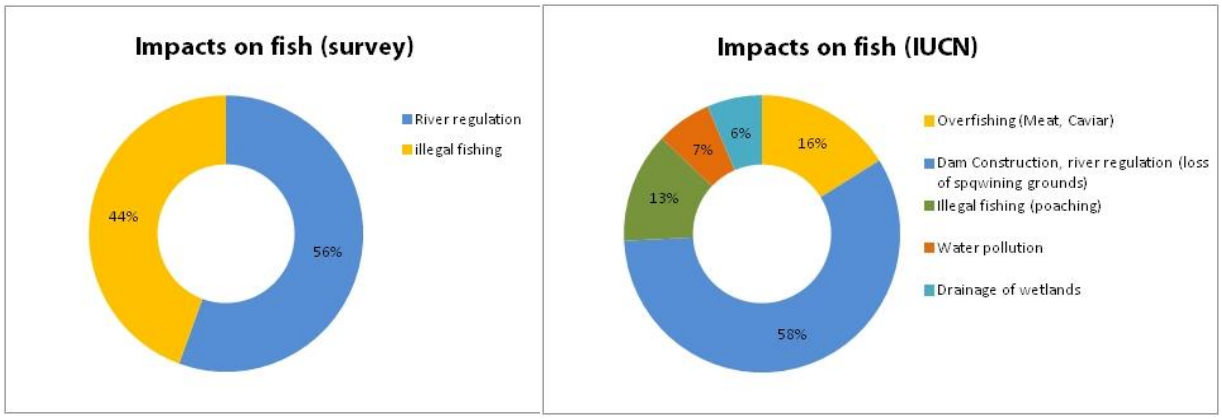

Figure 13) Impacts on fish from survey (a) and IUCN (b)
Source: survey, IUCN (2013), own illustration

In the following part "threats by literature" derive from the IUCN Red List of Threatened Species™ (following termed as IUCN). Other sources are separately marked.

European fishes face much more possible disturbances in literature, than given in the survey. At least the two biggest threats (River regulation and illegal fishing) were mentioned. Noise, a strong threat to all land based species (survey) is not even listed as a threat for fishes. The biggest problem is river regulation and dam construction. Very important spawning grounds are getting lost (BEDNAREK 2001). This makes it more difficult to obtain a stable, self-sustaining population of a species (ROCHARD et al. 1990, BUNN & ARTHINGTON 2002). In particular there are three very important river habitats getting lost or altered, due to dam construction.

First: there are some species like the *Zingel streber* or the *Acipenser stellatus*, which rely on strong currents, either for their daily live or for spawning.

Second: many fishes, like the *Acipenser ruthenus* or the *Salmo labrax*, travel upstream to reach their spawning grounds. Due to the dam construction this is getting harder or even impossible.

Third: Due to the intense river regulation, some species like the *Cyprinus carpio* losing their shallow water spawning grounds.

The second big problem for fishes is overfishing and illegal fishing (BLOESCH et. al 2006 and own data, survey). Both lead to a strong reduction of the affected species (e.g. *Anguilla anguilla*, *Acipenser gueldenstaedt*i). Not only has the amount of caught fish constituted a problem. The main issue is that most of the time the largest specimens are getting caught which consequently reduces the natural reproduction (IUCN).

The recorded species can also be affected by pollution and parasites, regarding to the IUCN – but in the survey no such case was recorded.

Solutions

According to the literature, possible solutions to the threats mentioned above could be the following. Regarding to the high amount of threatened fishes worldwide BRUTON (1994) suggested that it is important to bring international conservation programs into action. In case of the DANUBEPARKS, where actions are already planned and implemented, it is necessary to gain and obtain a high standard of collaboration and to find common protection goals. This has to take place on a political as well as a nongovernmental level. At this point we suggest taking a very close look at any further planned and ongoing river regulation project, not only because they are one of the two biggest impacts on fishes in the DANUBEPARKS (Survey), but also undamming of rivers is often a successful step to a sustainable water biotic diversity (BEDNAREK 2001). The 2005 by the Council of Europe accepted Sturgeon-Action-Plan, is a good example for, common higher goals (BLOESCH et al. 2006).

Regarding the second biggest impact on fishes in DANUBEPARKS, illegal fishing, there is an effective solution. CHARLES et al. (1999) examined the economics of illegal fishing on basis of a behavioural model. They concluded: "*..., whatever the set of regulations, there is absolutely no effect on fisher behaviour if those regulations are not enforced (assuming an absence of moral considerations*)" (CHARLES et al. 1999). With a higher level of enforcement and higher fines, getting caught is uneconomical and will be avoided by fisherman. Within our research we cannot predict the effectiveness of such measures (e.g. hire new rangers, enforce higher fines). This has to be measured in each park individually. Another way so reduce illegal fishing is to strictly control fishing quotas (CHAVEZ & SALGADO 2005). Again, this is only possible with a higher level of enforcement.

To cope with the problems caused by water pollution and parasites it is necessary to gain knowledge about any recorded problem. These records have to be monitored scientifically

within biological researches. If it is possible to identify the origin of pollution or parasites, it is possible to tackle the detected problem.

4.3.5 Mammals

Impacts

The most common impacts on mammals of the Danube region according to the literature are habitat loss, habitat destruction (e.g. deforestation) and -pollution, (illegal) killing ,persecution and roadkill through habitat fragmentation (e.g. BARBOSA et al. 2001, RUSSO et al. 2004, YAVRUYAN et al. 2008, MARCELLI & FUSILLO 2009, MEINIG & BOYE 2009, LOY et al. 2010). The DANUBEPARKS survey showed the following impacts on mammals: Noise disturbance, hunting, (illegal) killing and persecution (see Figure 14). Most of the mammals are directly affected by these threats but they can also have impacts on their prey species and feeding plants (MICKLEBURGH et al. 2002). To follow from the study, bats and mammals living in semi-aquatic or aquatic habitats are particularly sensitive to land changes and disturbance and are therefore most affected by these threats. Mainly bats are affected by reduction of habitat size and quality. Common effects are removal of deadwood and uncontrolled forest activities. The use of pesticides in agriculture often pollutes the habitats of bats (PAPADATOU et al. 2011). Most bats use forest or woodland habitat for roosting, feeding and reproduction, but these habitats are universally threatened habitats. Many bats also need rich and diversely structured agricultural landscapes with tree lines and hedges. Those features are often removed. By opening caves for tourism, natural roosts are often being exploited by tourism and are under threat from regular uncontrolled random visits. The use for tourism often results in modifying or destruction of their entrance and interior and therefore destroys the native bat habitat. In addition, bats are affected by light and noise disturbance (PAPADATOU et al. 2011). But not only bats are suffering from habitat changes. The steppe species *Spermophilus citellus* and *Vormela peregusna* are also affected by habitat destruction. Critical threats to *Spermophilus citellus* are mostly related to agriculture or connected to lack of grassland management or land abandonment. Pesticides used in agriculture pollute groundwater and soil and thus also the natural habitats of species like *Spermophilus citellus* (JANÁK et al. 2013). This species is also secondarily affected by poisoning of rodenticides (GORSUCH & LARIVIÈRE 2005). Habitat fragmentation and degradation is caused by traffic development which also leads to roadkill (JANÁK et al. 2013). Mammals that live along river systems,such as *Lutra lutra*, *Castor fiber*, *Mustela lutreola* are - in addition to the factors mentioned above- very sensitive to loss of riparian vegetation, habitat (water) pollution and human disturbance (according to the survey:

hiking activities and water sports, e.g. canoeing) (BARBOSA et al. 2001, MARCELLI & FUSILLO 2009, LOY et al. 2010). Illegal hunting and poaching also present a critical threat to some species (e.g. *Mustela lutreola* and *Spermophillus citellus)* (JANÁK et al. 2013, MARAN et al. 2009).

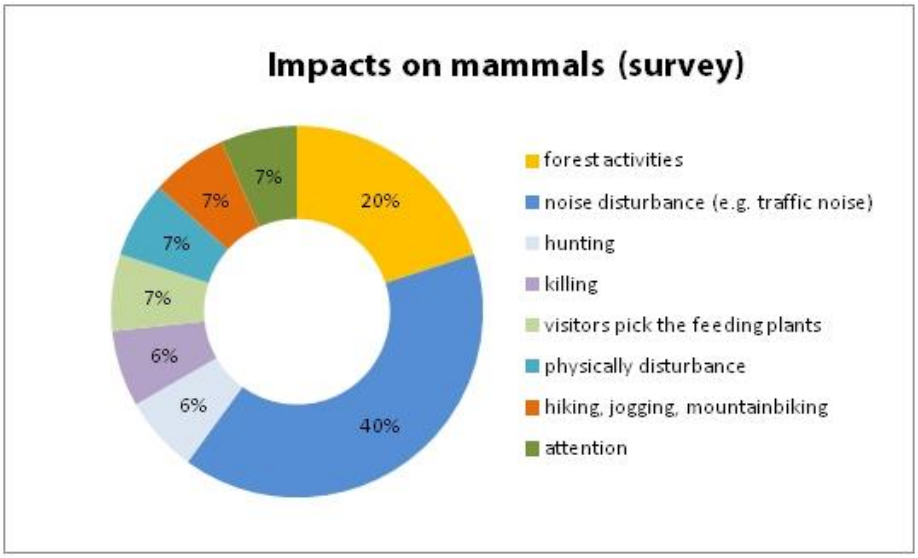

Figure 14) Impacts on mammals
Source: survey, own illustration

Solutions

Possible solutions to the threats mentioned above according to the literature could be the following: In order to avoid habitat degradation, e.g. for bats, protection of ancient woodland is essential. Therefore dead trees should be left in the forest. Where habitats cannot be upgraded, another possibility is the creation of new alternative bat roosts (PAPADATOU et al. 2011). Generation of artificial roost sites and small ponds in areas where water is absent should be encouraged (RUSSO et al. 2004). Protection of roost sites especially caves and karst areas should be an important issue in bat conservation. Caves that are important to bats should be registered first in order to keep and protect those (MICKLEBURG et al. 2002). To keep disturbance by (cave) tourism on a low level, regulation of tourist attendance could be a possible solution.

Another great impact is habitat fragmentation. The main consequence of the fragmentation is road kill. Roads and tourist paths should therefore avoid roosting areas and pass around those sites whenever possible (PAPADATOU et al. 2011, MICKLEBURG et al. 2002). By creating migration corridors or wildlife passages, habitat fragmentation and isolation can be reduced (WEINHOLD 2008).

Besides, education and school programs to gain interest in wildlife, contribute in protection of animals (MICKLEBURGH et al. 2002, PAPADATOU et al. 2011). Tourist paths could also provide

information on the importance of wildlife and habitat protection, in order to make visitors more sensitive to fragile habitats and their inhabitants.

4.3.6 Others

There were no disturbances mentioned for the group „Others“ in the questionnaires. The only exception was the sponge *Spongilla carteri*, which is getting touched and collected by canoeing people. Because this group contains various different animals, such as spiders and insects, the disturbances mentioned in the literature are very diverse. One of the disorders most often mentioned is the destruction and degradation of habitats, for example of *Argyroneta aquatic* and *Lycaena dispar* (see KOMNENOV et al. 2011; DUFFEY 1993). Another disturbance is the deterioration of the water quality due to eutrophication and toxic substances (see KETELAAR 2010). This disorder primarily affects creatures that are dependent on a habitat in or near the water, for example *Ophiogomphus Cecilia* or *Calopteryx splendens.* Again, the most important measure to maintain the species is the conservation and improvement of habitats.

4.4 Analysis of Monitoring- and GIS-Data

Due to scarce GIS-data supplied by the participating parks, unfortunately no GIS-analysis could be issued in satisfying amplitude. Apparently, this results from the lacking permission or willingness to provide these data or from the fact that those data don't exist yet. Understandably, it is especially the monitoring data that is treated with high circumspection. This is the reason why we would advise each park to conduct its own analysis. Furthermore, the literature review showed that it is difficult to define an exact disturbance radius around the species' points of interest. First, some species adapt to human induced phenomena, such as the sound of highly frequented streets (NABU 2001). This means that each individual has its own radius. At the most, it is probably only species from one area that can be aggregated concerning their zone of disturbance as they are living in a very similar habitat. This leads to the second argument. The highest success of these analyses is guaranteed by own monitoring data. As this study is already projected, the outcome data will serve to establish better figures for further calculation.

4.5 Conceptional creation of a database infrastructure

As a further step, the matrix of species and disturbances should be provided in form of an online database, accessible to all DANUBEPARK members. Until now, the data is available as an Excel file. The advantage of this solution is that all the parks always have access to the same latest version of the matrix. In this way, the data should be presented simply and clearly accessible, also for users with low computer skills.

In a search engine, the data can be filtered according to various criteria (see Figure 15), for example by the species' name, by a park, by a particular disorder or also by different types (e.g. bird, fish, mammal, etc.). The search result is either the data sheet of the searched species with the appropriate information, a photo and additional PDF files (see Figure 16) or, in queries with multiple searches results, a list of the matching species which then can be individually selected to open the corresponding data sheet. Such query results present the data in a compact, structured and clear format which facilitates the operation for the user. Furthermore, the additional information is available immediately and there is no need to search for them separately.

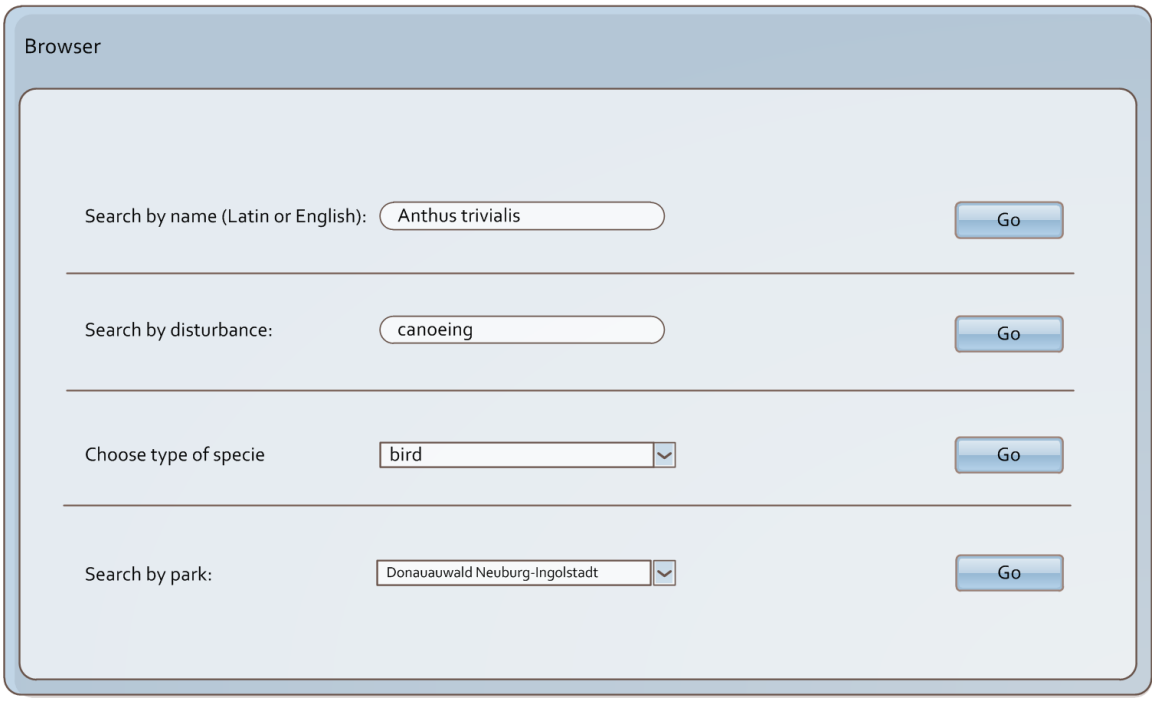

Figure 15) Prototype of Search-Mask
Source: survey, own illustration

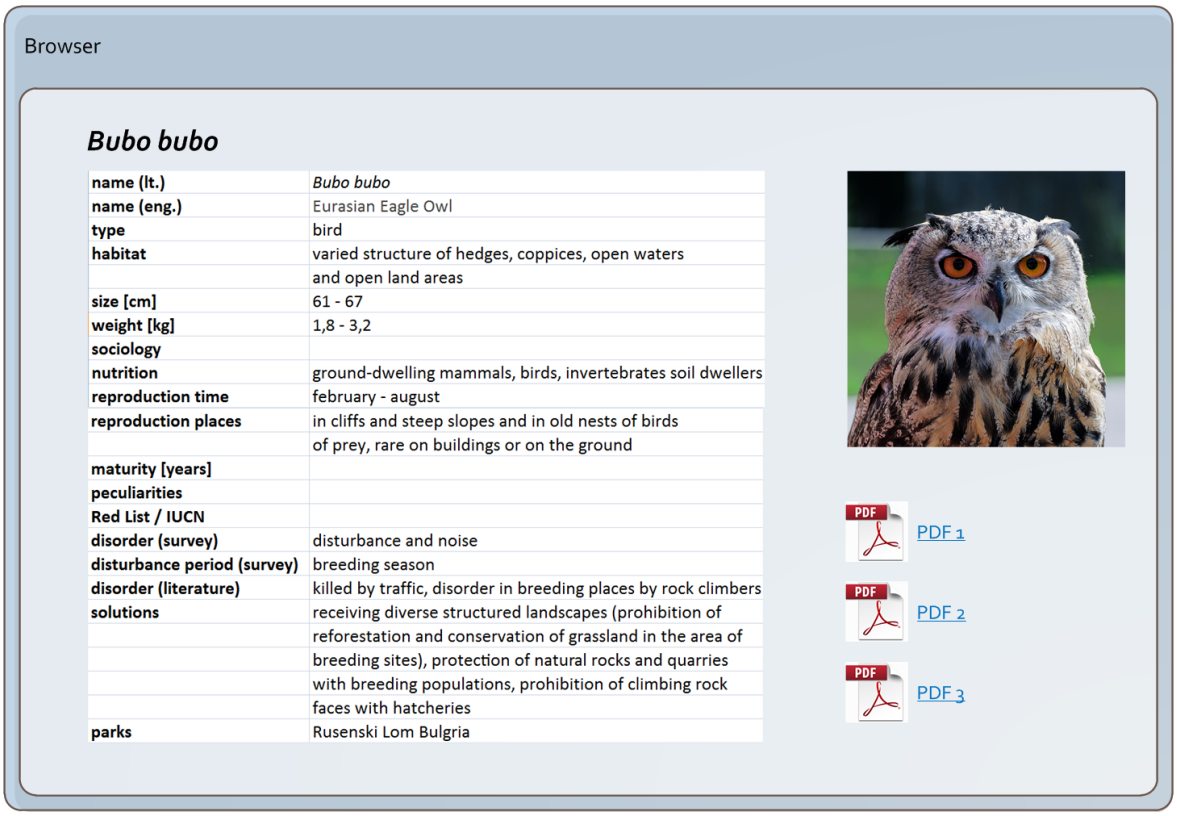

Figure 16) Prototype of result-page
Source: survey, own illustration

The evaluated species within this project display only a part (survey) from all existing species in the DANUBEPARKS area. In addition, possible disturbances and solutions are very diverse. For this reason, the present matrix of species and their disorders does not claim to be complete. Therefore, as a further function of the online database, the possibility to supplement data should be implemented. In order to ensure a certain standard regarding the form of presentation and the quality of data, some factors must be considered. The input of new data or the complement of existing records should be implemented by the use of a prefabricated matrix which will contain various labelled input features with explanations. Furthermore, there should also be an option available for uploading photos and additional files.

After generating the data in this way and submitting it, it should be checked by a reviewer before it is getting published to all parks. Thus, there will be a user hierarchy. The employees of the individual parks act as user and a few, nominated administrators can modify the database. In this context it is also important that the source of the data can be traced.

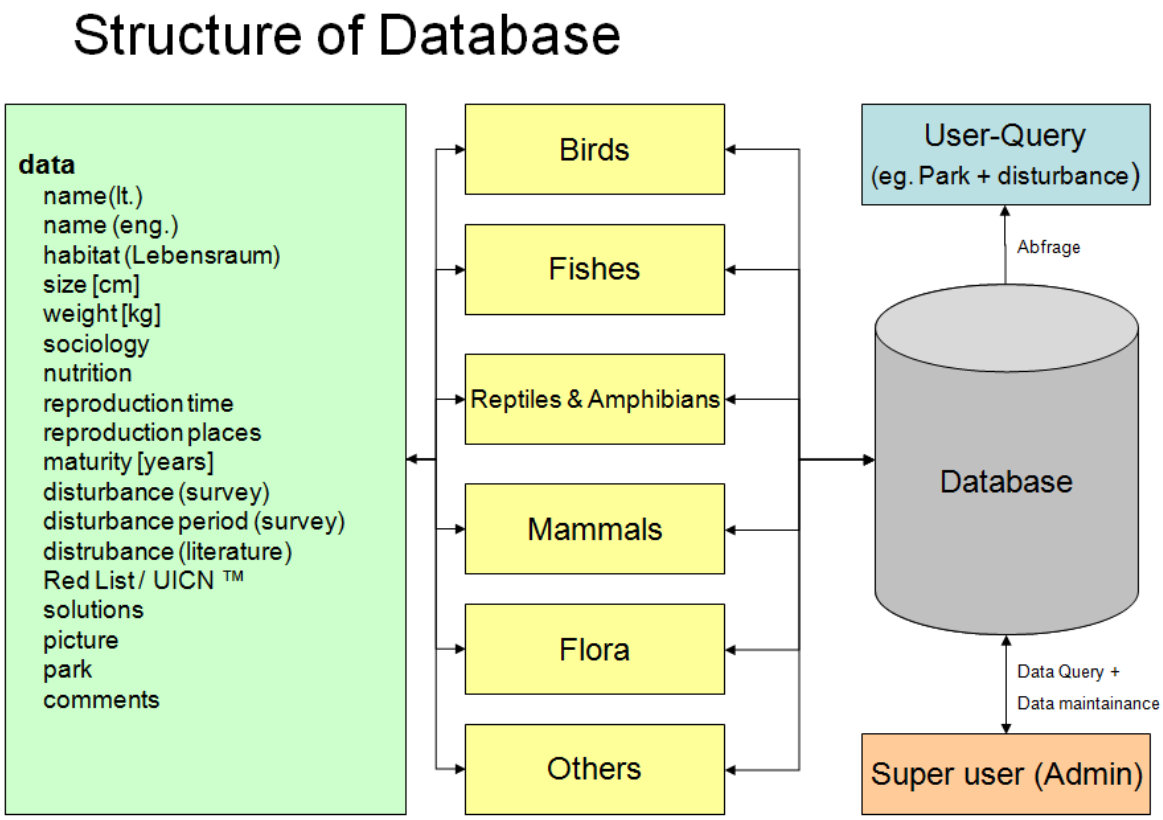

Figure 17) Structure of designed database
source: own illustration

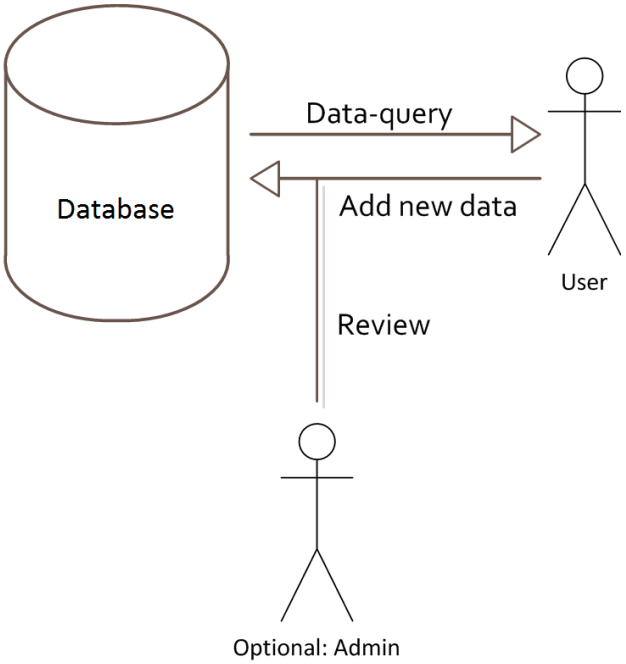

Figure 18) User hierarchy
Source: survey, own illustration

In order to illustrate the proposed on-line database, a prototype of the graphical user interface (GUI) has already been created (see figure 15 and figure 16) and was presented during the Steering Committee meeting in Tulcea, Romania. The prototype was accepted in major revisions. However, during the implementation of the online database the contact to the parks is of utmost importance to design the tool according to the requirements of the prospective users.

5 Verification of results and created hypotheses

The created hypotheses were attempted to be verified on the basis of the survey and analyzed literature. In our case, because of the low number of data, a statistical resilient statement cannot be given. Thus, only general statements and suggestions are possible.

Hypothesis 1: *A certain defined radius to wildlife's points of interest is needed to guarantee its protection.*

Many impacts are mentioned in literature, but in most cases a clear, territorial and typal differentiation of an impact zone (see chapter 3.3, p. 11) is not possible. Too many uncertain variables influence the distance to human activity needed by wildlife. Examples are behaviour of humans as well as sensibility of the individual and its adaption to human activity (e.g. roads). Specific differentiation has to be carried out in consideration of local conditions. Besides it was determined that the definition of sensitivity to disturbance of certain species is a very complex undertaking, because the populations in the parks are unknown and can only be estimated. In addition, there is a lack of information on the sensitivity of most species in literature, so it is only possible to create general statements and suggestions. This is the reason why no defined impact radius exists for all individuals of one species and for the entire year. The legal basis for the protection of species - if existing at all - can only be used restrictedly, given that in most cases it does not protect sufficiently. Protection zones reflecting the character of the parks as a protection area should therefore be rather large than too small.

Hypothesis 2: *Visitors cause impacts on wildlife. Nevertheless, not the attendance but the behaviour is the crucial factor.*

It is proven that visitors cause impacts on wildlife. Evident examples are trampling and the reduction of habitat quality (see chapter 4.3, page 22). Therefore, the behaviour of visitors plays an important role in causing disturbances and reducing these impacts (PÉPIN et al. 1996). Attendance though, plays a major role in social carrying capacity. Other visitors feel restricted in their personal experience of wildlife when many other tourists are around

Hypothesis 3: *Educational programs encourage the comprehension of sensitivity of wildlife and regulations. In consequence this leads to adapted behaviour (e.g. sticking to paths, reducing noise, etc.).*

MARION & REID (2007) state that educational programs encourage visitors to minimize impacts to protected areas. In the DANUBEPARKS most impacts seem to be due to noise, attention and (illegal) hunting. Other threats, such as illegal wood theft, arise from local people. Impacts reducing educational programs therefore constitute an important tool to protect wildlife.

Hypothesis 4: *Visitors allowed to camp overnight and anywhere in park areas are more likely to disturb animals. Consequently, more settlements in the park area do have the same effect.*

According to the survey, camping doesn't have big impact on wildlife. But the visit of the DDBR showed another pattern. In the delta region illegal camping is forbidden among others to reduce littering.

Initially, it was intended to correlate the question if visitors were allowed to stay overnight and the question in which areas they are allowed to stay. In combination with GIS data, disturbance patterns for the specific park region were expected. With a higher amount of people living in a park there should be a higher impact on nature – therefore more disturbances. But as explained above, not enough GIS Data could be collected during the time of the study. The same data processing was intended to deal with settlements in the park area.

Hypothesis 5: *A clear visitor guidance concept helps wildlife to adapt to regularly frequented areas. Anyway, retreat areas for wildlife are necessary.*

Wildlife is able to adapt to human presence (see e.g. NABU 2001). Some individuals even prefer to live near humans (see e.g. BARRON 2012). But it is a debatable point weather adaption of wildlife to human presence in protected areas should be intended to this extent.

Clear visitor guidance means that infrastructure and path network is constructed on the basis of monitoring data. The durability of visitor guidance over time helps wildlife to adapt to human presence in some regions.

Nevertheless, the aim is to balance human recreation and the preservation of wildlife in protected areas.

Hypothesis 6: *Wildlife is sometimes more sensitive to disturbances. Specific regulations (e.g. attendance, closure of some parts of the park, etc.) during this period reduce impacts.*

There are already periods where visitors have restricted access to parks because of special protection reasons, e.g. reproductive season or roosting. During this period, every listed country in the DANUBEPARKS project has summer vacation and no country has a break in between. The answers to the question if there are periods where the entrance to the park is restricted or forbidden was most of the time just answered with yes or no. Therefore it could be possible that some parks limit or restrict the access for visitors in this period, as shown in literature, in order to protect the species breeding activity. This assumption cannot be verified by the collected data. It could also be possible that the drop is caused due to inaccurate answers; hence it is not a very big drop.

During the development of the survey, the question arose if it possible that in parks with a higher amount of educational programs, the relative number of disturbances is smaller than in other parks. Hence not the constrain on a fixed attendance is important for Carrying Capacity, but the behaviour of the tourists as well as the guidance of visitors and the active shaping of the touristic options by the management of the parks. As shown in literature, education programs and information on wildlife establish understanding and willingness to observe requirements and rules. Same effects are achieved by well-developed trails because they avoid leaving. Thus, a higher amount of educational programs should help to prevent disturbances by visitors.

To encourage the communication between the members of DANUBEPARK and the Carrying Capacity Team, a trip to the Steering Committee Meeting was organised. The aim was to verify the theoretical analysis on Carrying Capacity by excursions in the Danube Delta Biosphere Reserve. Due to administrative difficulties of finding a partner in the Danube Delta, the Carrying Capacity Team stopped the theoretical part. This will serve as basis for further practical applications.

6 Conclusion

Due to increasing numbers of visitors in protected areas, park managers charged with balancing resource protection and recreation provision are more and more in a quandary. That is the reason why, on first sight, the concept or Carrying Capacity seems to be a perfect tool to regulate visitor numbers. But, as described in this study, the definition of clear numbers isn't possible without sufficient monitoring data.

Nevertheless, regarding the results of the correlation analysis, it is advantageous to restrict the visitor's access to nature parks during May and July, for optimal preservation of flora and fauna. By knowledge of breeding/mating sites there is no need to deny access completely. It is much more important to guide the visitors away from these places and to raise their awareness for sensible species by education programs or information panels.

Another issue is the on-water tourism of small boats, for example kayaks. First, it is difficult to control and to guide. Second, even boaters, informed by signs, ignore local interdictions such as swimming (STERL et al. 2002). On the other hand, big ships and motor boats cause waves, which lead to undercutting of the riverbanks and in consequence to loss of land. In order to understand the dimension of this issue, research was done all over the world (BHOWMIK et al. 1991, BAUER et al. 2002).

The preserving of natural habitats should be first priority. Education programs could also help a lot to achieve this. This is another important step to safeguard for example the population of amphibians and reptiles. Illegal hunting and poaching also mean a critical threat to many species, especially mammals (e.g. *Mustela lutreola, Spermophillus citellus*) but also affects some reptiles or amphibians (e.g. *Testudo graeca, Vipera ursinii moldavica*).

Informing the tourists and the local population about the importance of the strict protection of habitats and species probably will convince the visitors to stick to the paths, not to litter and to help protect the analysed species.

At this point, we suggest taking a very close look at any further planned and ongoing river regulation project, not only because they are one of the two biggest impacts on fishes in the DANUBEPARKS (Survey), but also because undamming of rivers quite often is a successful step to a sustainable water biotic diversity (BEDNAREK 2001). The 2005 Sturgeon-Action-Plan accepted by the Council of Europe is a good example for higher common goals (BLOESCH et al. 2006). By means of GIS data specific measures could be done. The creation of the arranged database can supply specific information as well. Therefore this report can only give

general statements and suggestions that have to be analysed in a specific monitoring program by each park on its own due to local conditions.

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8 Appendix

8.1 Survey

Danube Parks – Network of protected areas

Survey of the research project "Carrying Capacities

within the EU project "DanubeParks Step 2.0"

We are using your data in strict confidence just for scientifically purpose. Please try to answer the following questions as good as you can.

If there is any existing material about your park like

- Digitalized Spatial Data (Flore, Fauna, land use, paths, infrastructure, flooding areas etc.)
- Management Plan
- Visitor Management
- Monitoring Results (If they are important for this study.)

please send it with the answer of this survey.

I. General:

Name of your park: _____

1. How many kilometres of infrastructure do you have in your park?

   Hiking/Trekking/ MTB Trails: _____

   Water ways (open for boat usage): _____

   Facility Roads (not public): _____

   Roads (public): _____

   Others: _____ _____

   _____ _____

2. Are the visitors sticking to the marked routes and trails?

   ☐ Yes ☐ No

3. How many square kilometres is your park including?

   _____

4. Which educational establishments or programmes do you have?

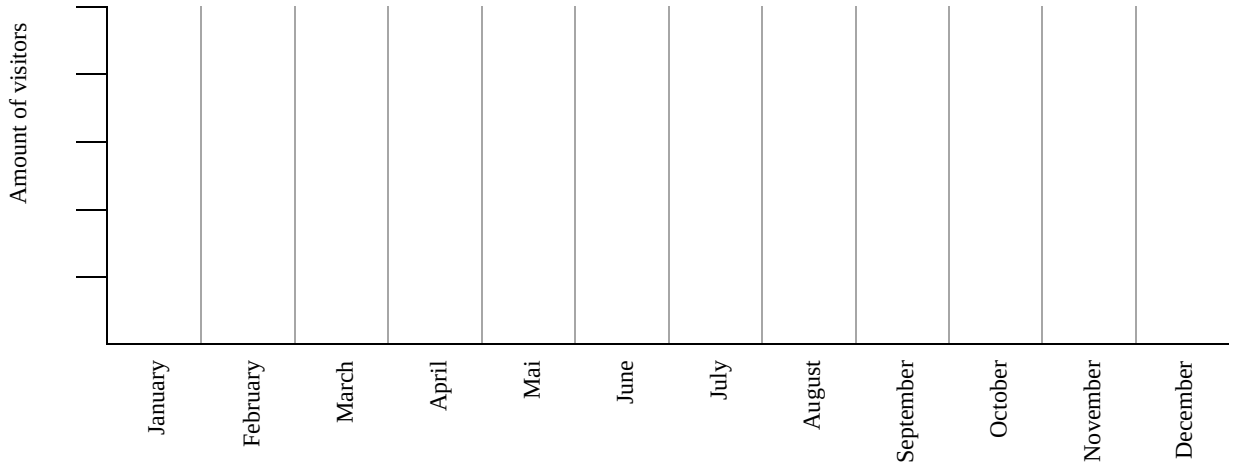
_____

_____

II. Utilization of the park:

1. How many visitors do you have approximately per year? _____

2. How are the visitors distributed throughout the year? Please draw a line corresponding to the temporal distribution of the visitors:



3. How are the visitors moving in the park area? Please estimate the proportion of the used transportation:

   ☐ Canoe _____ %

   ☐ Walking/hiking _____ %

   ☐ Coach bus _____ %

   ☐ Own car _____ %

   ☐ Bicycle _____ %

   ☐ _____ _____ %

4. How long are the visitors staying on average?

_____

5. How many percent of the park are

- ☐ Not used at all _____ %
- ☐ Used for tourism and recreation _____ %
- ☐ Used by agriculture _____ %
- ☐ Used by forestry _____ %
- ☐ Others: _____ _____ %

6. Are visitors allowed to spend the night in the park area?

☐ Yes ☐ No (If not, please continue with question II.8)

7. Are there special locations like campgrounds or hostels or are the tourists allowed to stay everywhere?

_____

_____

8. Are there any settlements or villages in the area of the park?

☐ Yes ☐ No (If not, please continue with III)

9. How many people are living there?

Settlement									
Citizens									

10. Where are those settlements?

- ☐ At the border of the park
- ☐ In the middle of the park
- ☐ Along the river site
- ☐ _____

11. Are there any areas which are not accessible to visitors (seasonally)?

_____

III. Flora:

1. How many different species of plants are known in your park? _____

2. Which flagship species of plants do you have in your park? Please note the Latin term if known.

   1) _____ 2) _____

   3) _____ 4) _____

   5) _____ 6) _____

3. Which of these species in your park are especially sensitive or worth of protection?

_____

_____

_____

_____

4. Are plants getting damaged by visitors (e.g. by trampling)? Please estimate the extend of it (m^2/year) and the cause of the damage.

Plant	Extend (m^2/year)	Where? (Near the road/ visitor center, small paths, etc.)	Cause

5. Are there special seasons during the year when plants react especially sensitive on disturbance?

_____

_____

IV. Mammals:

1. How many different species of mammals are known in your park? _____

2. Which flagship species of mammals do you have in your park? Please note the Latin term if known.

   1) _____ 2) _____

   3) _____ 4) _____

   5) _____ 6) _____

3. Which of these species in our park are especially sensitive or worth of protection?

_____

_____

_____

_____

4. Are mammals getting disturbed by visitors (e.g. noise) and when during the year?

Species	Period	Where? (Near the road/ visitor center, small paths, etc.)	Cause of disturbance

5. Is hunting mammals allowed in your park and how is it controlled and regulated?

_____

_____

_____

V. Reptiles and amphibians:

1. How many different species of reptiles are known in your park? _____

2. Which flagship species of reptiles do you have in your park? Please note the Latin term if known.

   1) _____ 2) _____

   3) _____ 4) _____

   5) _____ 6) _____

3. Which of these species in our park are especially sensitive or worth of protection?

_____

_____

_____

_____

4. Are reptiles getting disturbed by visitors (e.g. noise) and when during the year?

Species	Period	Where? (Near the road/ visitor center, small paths, etc.)	Cause of disturbance

VI. Fishes:

1. How many different species of fishes are known in your park? _____

2. Which flagship species of fish do you have in your park? Please note the Latin term if known.

   1) _____ 2) _____

   3) _____ 4) _____

   5) _____ 6) _____

3. Which of these species in our park are especially sensitive or worth of protection?

_____

_____

_____

_____

4. Are animals getting disturbed by visitors (e.g. noise) and when during the year?

Species	Period	Where? (Near the road/ visitor center, small paths, etc.)	Cause of disturbance

5. Is fishing allowed in your park and how is it controlled and regulated?

_____

_____

_____

VII. Birds:

1. How many different species of birds are known in your park? _____

2. Which flagship species of birds do you have in your park? Please note the Latin term if known.

   1) _____ 2) _____

   3) _____ 4) _____

   5) _____ 6) _____

3. Which of these species in our park are especially sensitive or worth of protection?

_____

_____

_____

_____

4. Are birds getting disturbed by visitors (e.g. noise) and when during the year?

Species	Period	Where? (Near the road/ visitor center, small paths, etc.)	Cause of disturbance

5. Is hunting birds allowed in your park and how is it controlled and regulated?

_____

_____

_____

VIII. Others:

1. Which other flagship species (e.g. insects) do you have in your park? Please note the Latin term if known.

   1) _____ 2) _____

   3) _____ 4) _____

   5) _____ 6) _____

2. Which of these species in our park are especially sensitive or worth of protection?

_____

_____

_____

_____

3. Are these species getting disturbed by visitors (e.g. noise) and when during the year?

Species	Period	Where? (Near the road/ visitor center, small paths, etc.)	Cause of disturbance

8.2 List of recorded species

Species	Danube Delta Biosphere Reserve	Djerdap National Park	Donau-Auen National Park	Donauwald Neuburg-Ingolstadt	Duna-Dráva National Park	Duna-Ipoly National Park	Fertö-Hanság National Park	Gornje Podunavlje Nature Reserve	Kopački rit National Park	Lonjsko Polje Nature Park	Persina Nature Park	Rusenski Lom Nature Park
Ablepharus kitaibelii						X						
Accipiter gentilis				X								
Acherontia atropos												X
Acipenser gueldenstaedti	X											
Acipenser nudiventris	X											
Acipenser ruthenus		X										
Acipenser stellatus	X											
Actitis hypoleucos			X									
Aedes cinereus											X	
Aeshna grandis							X					
Alburnoides bipunctatus			X									
Alcedo atthis			X						X			
Alosa immaculata	X											
Ameles heldreichi												X
Anas crecca		X										
Anemone ranunculoides							X					
Anemone sylvestris												X
Anguilla anguilla				X								
Anthus trivialis				X								
Apium Repens					X							
Aquila chrysaetos		X										
Aquila heliaca	X		X								X	
Aquila pomarina		X										
Arctia festiva							X					
Arctosa cinerea			X									
Ardea cinerea				X					X			
Ardea purpurea					X							
Ardeola ralloides	X											
Argyroneta aquatica							X					
Aspius aspius									X			
Aythya nyroca										X	X	
Barbastella barbastellus			X		X							
Barbus barbus			X	X								

Species	Danube Delta Biosphere Reserve	Djerdap National Park	Donau-Auen National Park	Donauwald Neuburg-Ingolstadt	Duna-Dráva National Park	Duna-Ipoly National Park	Fertö-Hanság National Park	Gornje Podunavlje Nature Reserve	Kopački rit National Park	Lonjsko Polje Nature Park	Persina Nature Park	Rusenski Lom Nature Park
Barbus carpathicus						X						
Bombina bombina			X				X				X	
Bombina variegata				X						X		
Branta ruficollis											X	
Bubo bubo												X
Bufo viridis	X			X								
Buteo rufinus												X
Butomus umbellatus									X			
Calliptamus italicus											X	
Calopteryx splendens	X											
Canis lupus		X										
Capreolus capreolus		X									X	
Carassius carassius										X		
Castor fiber			X	X	X	X			X	X		
Cerambyx cerdo			X							X		
Cervus elaphus		X	X					X	X			
Charadrius dubius	X		X	X								
Chlidonias hybridus											X	
Ciconia ciconia										X		
Ciconia nigra		X			X		X		X			X
Circus aeruginosus				X								
Circus pygargus							X					
Coracias garrulus												X
Coronella austriaca			X	X		X	X					
Corylus colurna		X										
Crataegus nigra					X							
Crex crex			X	X		X	X			X		
Cricetus cricetus												X
Cyprinus carpio				X				X		X		
Cypripedium calceolus				X								
Cytisus kovacevic Velen.												X
Dactylorhiza incarnata									X			
Darevskia praticola											X	
Dendrocopos leucotos		X				X						
Dryomys nitedula											X	

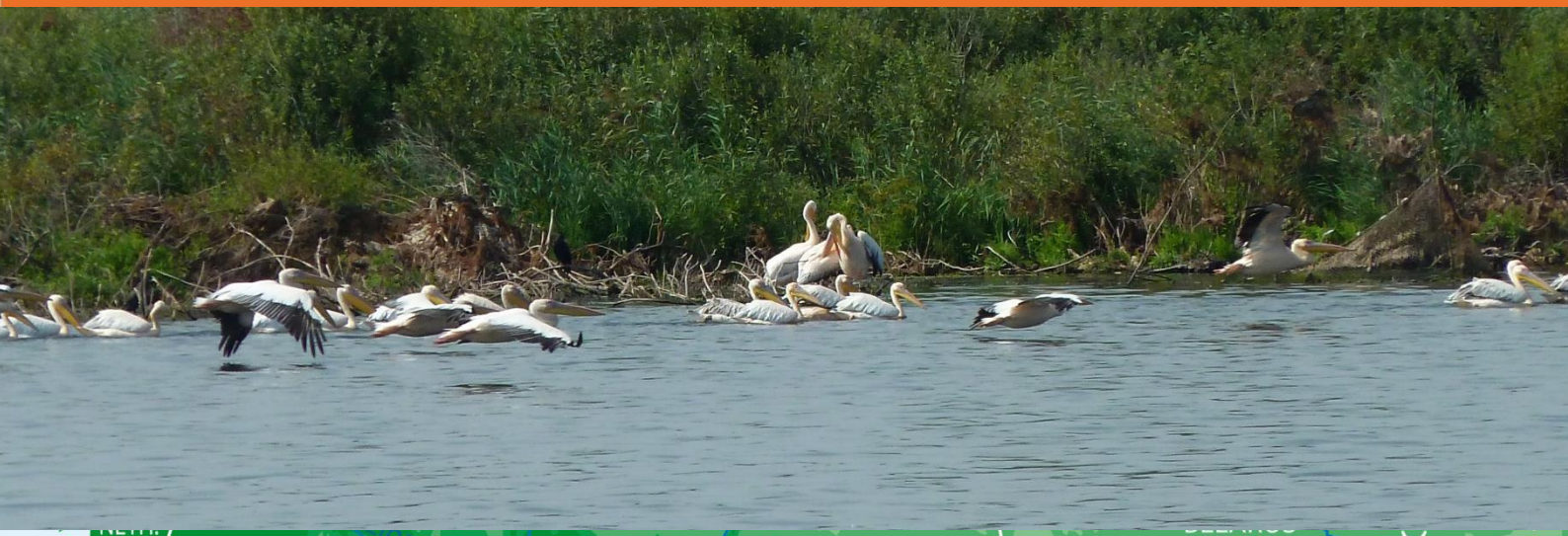
Species	Danube Delta Biosphere Reserve	Djerdap National Park	Donau-Auen National Park	Donauwald Neuburg-Ingolstadt	Duna-Dráva National Park	Duna-Ipoly National Park	Fertö-Hanság National Park	Gornje Podunavlje Nature Reserve	Kopački rit National Park	Lonjsko Polje Nature Park	Persina Nature Park	Rusenski Lom Nature Park
Dytiscus marginalis											X	
Elaphe quatuorlineata												X
Emberiza cia						X						
Emys orbicularis	X		X	X	X		X	X	X	X	X	
Eranthis hyemalis								X				
Esox lucius										X		
Eudontomyzon mariae					X	X				X		
Falco peregrinus		X										
Felis silvestris					X			X		X		
Ficedula albicollis		X		X								
Ficedula parva						X						
Fraxinus angustifolia					X					X		
Fritillaria meleagris										X		
Gentiana				X								
Gladiolus palustris				X								
Glis glis											X	
Gymnocephalus schraetzer						X			X			
Haliaeetus albicilla	X		X	X	X		X	X	X	X	X	
Himantoglossum hircinum												X
Hippuris vulgaris								X				
Hottonia palustris								X				
Huso huso	X										X	
Hyla arborea				X			X			X		
Iphiclides podalirius												X
Iris sibirica									X			
Ixobrychus minutus				X								
Juglans regia		X										
Jynx torquilla				X								
Lacerta agilis				X						X		
Lacerta viridis		X								X		
Lanius excubitor				X								
Leucaspius delineatus										X	X	
Leuciscus idus				X								
Leucojum aestivum											X	
Lilium bulbiferum							X					

Species	Danube Delta Biosphere Reserve	Djerdap National Park	Donau-Auen National Park	Donauwald Neuburg-Ingolstadt	Duna-Dráva National Park	Duna-Ipoly National Park	Fertö-Hanság National Park	Gornje Podunavlje Nature Reserve	Kopački rit National Park	Lonjsko Polje Nature Park	Persina Nature Park	Rusenski Lom Nature Park
Limosella aquatica			X									
Locustella fluviatilis				X								
Lota lota									X			
Lucanus cervus				X						X		X
Lutra lutra	X				X	X		X	X	X	X	X
Lycaena dispar	X									X		
Lynx lynx		X				X		X				
Marsilea quadrifolia										X	X	
Martes martes							X					
Mecostethus grossus											X	
Microtus oeconomus							X					
Milvus migrans				X	X							
Misgurnus fossilis			X							X	X	
Mustela erminea							X					
Mustela eversmanni											X	
Mustela lutreola	X											
Myotis alcathoe						X						
Myotis dasycneme					X							
Myotis daubentonii										X		
Myotis myotis						X						
Nannospalax leucodon						X						
Natrix natrix				X			X	X	X	X		
Natrix tessellata			X					X	X			X
Neophron percnopterus												X
Notonecta glauca											X	
Nuphar lutea	X										X	
Nycticorax nycticorax							X					
Nymphaea alba	X							X				
Nymphoides peltata					X						X	
Ophiogomphus cecilia				X								
Ophrys apifera							X					
Orchidaceae			X	X								
Orchis simia												X
Orphys insectifera							X					
Osmoderma eremita				X								

Species	Danube Delta Biosphere Reserve	Djerdap National Park	Donau-Auen National Park	Donauwald Neuburg-Ingolstadt	Duna-Dráva National Park	Duna-Ipoly National Park	Fertö-Hanság National Park	Gornje Podunavlje Nature Reserve	Kopački rit National Park	Lonjsko Polje Nature Park	Persina Nature Park	Rusenski Lom Nature Park
Palingenia longicauda	X											
Pelecanus crispus	X										X	
Pelecanus onocrotalus	X											
Pelecus cultratus											X	
Pelobates fuscus				X								
Pelobates syriacus	X										X	
Pelophylax lessonae				X								
Pelophylax ridibundus												X
Perdix perdix			X									
Pernis apivorus			X		X							
Phalacrocorax carbo							X					
Phalacrocorax pygmaeus											X	
Phengaris rebeli				X								
Phoenicurus phoenicurus				X								
Phragmites australis	X											
Picus canus				X								
Pipistrellus nathusii				X								
Platalea leucorodia	X									X		
Podiceps grisegena											X	
Polygala sibirica												X
Populus alba	X											
Populus nigra	X		X		X			X				
Pungitius platygaster											X	
Quercus robur					X			X		X		
Rallus aquaticus				X								
Rana arvalis							X					
Rana esculenta							X					
Rhinolophus euryale						X						
Rhinolophus ferrumequinum										X		X
Rhinolophus hipposideros										X		X
Rhodeus amarus				X								
Riparia riparia							X					
Rupicapra rupicapra		X										
Rutilus pigus				X	X							
Salamandra salamandra						X						

Species	Danube Delta Biosphere Reserve	Djerdap National Park	Donau-Auen National Park	Donauwald Neuburg-Ingolstadt	Duna-Dráva National Park	Duna-Ipoly National Park	Fertö-Hanság National Park	Gornje Podunavlje Nature Reserve	Kopački rit National Park	Lonjsko Polje Nature Park	Persina Nature Park	Rusenski Lom Nature Park
Salix babylonica			X									
Salmo labrax											X	
Salvinia natans										X		
Saxicola rubetra				X								
Schoenoplectus mucronatus									X			
Silurus Glanis										X		
Spermophilus citellus						X					X	X
Spongilla carteri							X					
Stizostedion lucioperca		X								X		
Stratiotes aloides			X							X		
Sympetrum depressiusculum							X					
Syringa vulgaris		X										
Tadorna ferruginea												X
Testudo graeca												X
Testudo hermanni											X	X
Tinca tinca		X					X	X				
Trapa natans	X										X	
Triops cancriformis			X									
Triturus cristatus				X								
Triturus dobrogicus	X		X			X					X	
Umbra krameri	X		X							X		
Upupa epops				X								
Verbascum dieckianum												X
Vipera ammodytes		X										
Vipera ursinii	X											
Vitis vinifera			X									
Vormela peregusna												X
Zamenis longissimus			X					X		X		
Zingel streber	X		X		X	X						
Zingel zingel									X			

1 Danube Delta Biosphere Reserve
2 Lower Prut Nature Reserve
3 Lower Prut Floodplain Natural Park
4 Small Wetlands of Braila
5 Kalimok-Brushlen Protected Site
6 Rusenski Lom Nature Park
7 Persina Nature Park
8 Iron Gates Natural Park
9 Đerdap National Park
10 Lonjsko Polje Nature Park
11 Kopački rit Nature Park
12 Gornje Podunavlje Special Nature Reserve
13 Duna-Dráva National Park
14 Duna-Ipoly National Park
15 Fertö-Hánsag National Park
16 Dunajské Luhy Protected Landscape Area
17 Záhorie Protected Landscape Area
18 Donau-Auen National Park
19 Narrow Valley of the Danube in Passau district
20 Donauauwald Neuburg-Ingolstadt



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