FUNCTIONAL ANALYSES OF THE LOWER DANUBE WETLANDS BY FAEWE/PROTOWET PROCEDURE

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Abstract: Functional analyses of the ecological systems refers to the methods for assessing the offer of goods and services provided by the natural capital. FAEWE/PROTOWET method was applied in 15 insular and riparian wetland landscapes of the Danube floodplain. Results show that some functions are positively related with the complexity of the landscape. The anthropic impact on the goods and services wetlands productivity is discussed. Implications for the restoration strategy of the Danube wetlands are drawn and limitations of the procedure are pointed out.

Key words: Lower Danube River System, functional analyses, restoration strategy

Introduction

The functional analyses of the ecological systems is the technique used for evaluating (qualitatively, quantitatively, or by modeling) the offer of resources and services provided by the natural capital (Cristofor et al., 1999). It can be part of the economic valuation methodology, as a first step, followed by the monetary valuation as a second step. It can also be involved in the environmental impact assessment, when the deterioration of the ecological systems have to be assessed in terms of the reduction of the offer of resources and services. Not least, it is needed in the design of the plans for the management of the natural capital, including those envisaging reconstruction activities. Box 1 presents the steps for designing a plan for the sustainable management of the relationships between natural capital and socio-economic systems. More information about the meaning of the terms “natural capital management” and “decision support system” are presented elsewhere (Iordache, et al., 2001, this Proceedings)

Box 1 Steps for designing a plan for the sustainable management of the relationships between natural capital and socio-economic systems.

1 Accessing the decision support system (DSS)

- 1.1 The specific information system
  - 1.1.1 **<u>The knowledge base.</u>** Identification of the natural capital (NC) and socio-economic systems (SESs). Set of rules, laws, models, on which depends the assessment of the natural resources and services, and the strategies, tactics, and operational activities for the natural capital management
  - 1.1.2 **<u>The data base.</u>** Values of the state parameters describing the natural capital and socio-economic systems on the which depends the same issues as mentions above in the case of the knowledge base
- 1.2 Applying the methods for the economic valuation of the natural capital
  - 1.2.1 **Functional analyses of the natural capital**
  - 1.2.2 Monetary analyses of the natural capital
- 1.3 Characterization of the state of the DSS components which cannot be restructured by management at local SES level (legislation, regulations, human resource formation, institutional infrastructure at regional and macroregional SESs level)

2 Designing the set of alternative solutions (packages of management objectives) concerning the restructuring of the natural capital, the restructuring of the SESs or their functional modules, and/or the restructuring of the management practices (concerning SES-NC relationships), with the final goal of using the NC below the support capacity and valorizing its full range of resources and services.

3 Assessment of the set of alternative solutions

- 3.1 Assessment of the restoration costs
- 3.2 Cost benefit analyses of the alternative solutions
- 3.3 Identification of all kind of resources needed for implementation, and design of the set of applications (projects)

4 Preparation of the set of recommendations for the decision makers.

The term “function” used in the functional analyses is not equivalent to the concept of function as part of the knowledge base of ecology. It rather corresponds to the term of service, including here also the ecological processes underpinning the production of renewable resources.

One have to assess the natural capital, it is recommendable to perform three steps:
- first, a qualitative (or semi-quantitative) assessment of the entire range of functions;
- second, a quantitative assessment of those functions found likely to be performed based on the results of the qualitative assessment;
- third, modeling of the dynamic of key functions; key function is that whom performance strongly control the performance of other functions, or is subjectively regarded as very important by the user of the assessment results.

The possibility to assess all functions performed by the different types of natural capital, at all precision levels, is depending directly on the available functional analyses procedures, and on the costs required for running the procedures, and depends indirectly on the knowledge base needed for developing the procedures.

The results presented in this paper were obtained for designing the management plan of the natural capital of the Lower Danube River System (LDRS), research project C89/1999 financed by the National Council for Scientific Research in the Higher Education (CNCSIS). From the three level of precision in assessing the resources and services, we present only the qualitative level. However, in the discussion chapter we will put the qualitative results in the context of quantitative assessment results already published (Cristofor et al., 2001), in order to provide enough arguments for advancing proposal for the strategy of wetlands restoration in LDRS.

Methods

We applied the FAEWE/PROTOWET procedure (Maltby, 1998) adapted to the Danube system conditions as recommended by previous studies (Vadineanu, 1997). 15 wetland landscapes of LDRS (current state) were investigated. The landscapes were selected in order to cover the complexity range, according to the scale presented in Vadineanu et al. (2001). The landscapes names can be found in the head of table 2. They are located between km 175 and km 790 of the Danube. The results of the assessment were expressed as follows:
- - (or score 0) = the function is not performed;
- xx (or score 2) = the function is performed to a small degree;
- xxx (or score 3) = the function is definitely being performed.

The primary results were obtained for each ecosystem (or group of ecosystems, depending of the function) from the landscape structure. Knowing the abundance (in surface terms) of the ecosystem in the landscape, and the landscape surface, one could compute the function score of the landscape as a weighted average of the scores in each ecosystem. The total score of the landscape could be compute for a landscape as the sum of the functions scores. An average score for a landscape was also computed.

Data were interpreted by looking for relationships between landscape complexity and each function or total scores. Also, knowing the dominant landscape types (in terms of the surface covered) in the current and reference state (Vadineanu et al., 2001), we compared the current and reference LDRS with respect to the functions performed by its wetlands.

Results

In order to show how average were computed, an example of results at local landscape level is presented in table I. Table II includes the average function scores for all studied landscapes.

The total, as well as the average score decreases with the landscape complexity, more obvious in the case of islands, in which case were analyzed very simple landscape (2nd order, scale as in Vadineanu et al., 2001).

Table I Results of the functional analyses in Fundu Mare Island. More details about the islands structure and ecosystem types can be found in Iordache et al. (1997).

Key role										x	
Relative surface of the ecosystem in the landscape (0 to 1)	0.025	0.284	0.037	0.037	0.103	0.010	0.005	0.299	0.198	0.002	
Ecosystem/landscape	Shores	Planted levee	Natural levee	Natural internaldepression	Planted internaldepression	Natural external depression	Isolated depression	Marshes	Lakes	Chanels	Fundu Mare Isl.
ecological functions											Weighted av.
Short term water retention	3	2	2	3	3	3	3	3	3	3	2.7
Long term water retention	0	0	0	2	2	2	3	3	3	3	1.8
Sediment retention	0	3	3	3	3	3	3	2	2	0	2.4
Nutrients retention	0	3	3	3	3	3	3	2	2	0	2.4
Nitrogen export by denitrification	2	2	3	3	3	3	3	3	2	2	2.5
Nutrient export by land use	0	3	2	2	3	0	2	2	0	0	1.9
Provision of overall habitat structural diversity	2	2	3	3	2	3	3	3	3	3	2.6
Microsites for invertebrates	3	2	3	3	2	3	3	3	3	3	2.6
Microsites for fish	3										3.0
Microsites for reptiles and amphibians	0	2	3								2.6
Microsites for birds	3										3.0
Microsites for large mammals	3										3.0
Microsites for plants	2	2	3	3	2	3	3	3	3	0	2.6
Biomass production	2	3	3	3	3	3	3	3	3	3	3.0
Biomass import and export through physical processes	3	2	2	0	0	0	0	0	2	3	1.1
Biomass export through harvesting	0	3	2	2	3	0	0	2	3	0	2.5

Table II Results of the functional analyses in the studied landscapes. The meaning of the marked functions and main findings are pointed out below the table.

	Islands								**Riparians**					**Diked**	
Function / Landscape and complexity	Fundu Mare 5	Calnov`\ 4	P`p`dia 4	Sect. O. Popa 3	Carabulea 3	Cenghina 3	Talchia 2	Calafatul Mic 2	Cx. Rast 5	Ciuperceni 4	Gura Gârlu\ei 3	G@cov 3	Arceru 3	Potelu	Arceru
Short term flooding water retention	2.7	2.5	2.6	2.4	2.0	2.0	2.7	2.1	2.2	2.5	2.4	2	2	0	0
Long term flooding water retention*	1.8	1.1	0.8	0.6	0.0	0.4	0.0	0.0	2.5	1.5	0.7	0.2	0.8	0	0
Sediment retention	2.4	2.1	2.2	1.5	2.9	1.5	3.0	1.8	1.7	2.1	2.7	1.1	1.2	0	0
Nutrients retention	2.4	2.1	2.3	1.2	2.8	1.6	2.3	2.0	2.6	2.1	1.9	1.8	2	0	0
N export by denitrification	2.5	2.6	2.2	3.0	2.7	2.0	0.6	0.0	2.8	1.8	2.0	2.6	2.4	2	2
N export by land use	1.9	1.4	1.6	1.3	0.0	1.2	0.0	0.0	2.1	2	2.7	2	2	3	0
Maintaining general habitat diversity	2.6	2.5	2.8	2.7	2.3	2.3	0.0	0.0	2.5	2.1	2.0	2	1.4	0.2	2
Maintaining local conditions for macroinvertebrates	2.6	2.7	2.3	2.9	2.9	2.4	0.8	2.0	3.0	1.2	2.0	2.4	1.4	0.4	2
Maintaining local conditions for fishes	3.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5	0	0.0	0	0.4	0	2
Maintaining local conditions for amphibian and reptiles	2.6	2.4	2.8	3.0	3.0	2.0	0.0	0.0	2.6	1.8	2.0	2.5	1.2	0.1	3
Maintaining local conditions for birds	3.0	2.1	2.0	3.0	2.0	2.0	3.0	2.0	3.0	0.4	0.0	0.9	2	0	2
Maintaining local conditions for mammals	3.0	3.0	3.0	3.0	3.0	2.0	0.0	0.0	3.0	0	0.0	0	0	0	0
Maintaining plant diversity	2.6	2.1	2.4	2.9	2.0	2.4	0.6	2.0	2.8	0.4	0.6	0.8	2.2	0.4	2
Vegetal biomass production	3.0	3.0	2.8	2.9	2.5	3.0	0.6	3.0	3.0	2.4	2.9	2.8	2.6	3	3
Import and export of biomass by physical processes	1.1	0.8	0.9	0.9	2.4	0.8	2.1	2.0	0.02	0.1	0.1	0	0.6	0	0
Anthropic export of biomass**	2.5	2.1	1.7	1.3	0.0	1.2	0.0	0.0	2.1	3	2.7	3	3	3	2
Total Score	39.7	32.5	32.4	32.6	30.5	26.8	15.7	16.9	36.4	23.4	24.5	24.1	25.2	12.1	20.0
Average score	2.48	2.03	2.03	2.04	1.91	1.68	0.98	1.06	2.3	1.5	1.5	1.5	1.6	0.8	1.3

Score at ecosystem level: 0 = function not performed, 2 = function performed to a low degree, 3 = function definitely performed
Score at landscape level = average weighted at the relative area of the ecosystem

Main findings:

- the marked functions seem to be directly related with landscape heterogeneity
- nutrient retention functions are not directly related with land surface and landscape heterogeneity

One can see that the functions associated to the maintenance of species diversity are strongly influenced by the elimination of very complex landscapes. Nutrient retention is related to landscape complexity only in the case of some mechanisms, such as export by denitrification. That means that for the recovering of the nutrient retention service one could rehabilitate many small landscapes, as well as a few very large landscape. However, this solution would not lead to the recovery of the species diversity maintenance function, which require a different strategy, consisting in the reconstruction of large and complex landscapes.

The assessment of the diked landscapes shows a low degree of functions performance, only the biomass export through harvesting being comparable with the natural landscapes. The effects of landscape changes in LDRS are illustrated in table III. The most affected functions (actually services), of the LDRS were those dealing with the production of renewable biological resources and the water purification, because they are dependent on the wetlands surface and were directly influenced by the structural changes, besides which can be added the maintenance of regional microclimate, dependent on the extent of flooded areas. The function of biodiversity maintenance was better preserved due the remained natural systems.

Table III Qualitative assessment of the main functions performed by wetlands in LDRS, in terms of performance classes Reference (Rf), current (Cr), and landscapes codes as in Vadineanu et al. (2001) ***Legend***: - = the function is not performed, xx = the function is being performed to a small degree, xxx = the function is definitely being performed.

	Dominant in Rf state		**Dominant in Cr state**	
Function / ecological component	**Island (6)**	**Riparian system (6)**	**Diked area**	**Riparian system (3)**
Short time water retention	xxx	xxx	-	xxx
Long time water retention	xxx	xxx	-	xx
Sediment retention	xxx	xxx	-	xx
Nutrient retention	xxx	xxx	-	xx
Nitrogen export by denitrification	xxx	xxx	xx	xx
Nutrient export by land use	xxx	xxx	xxx	xx
Provision of overall habitat structural diversity	xxx	xxx	xx	xx
Microsites for invertebrates	xxx	xxx	xx	xx
Microsites of fishes	xxx	xxx	xx	-
Microsites for reptiles and amphibians	xxx	xxx	xx	xx
Microsites for birds	xxx	xxx	xx	xx
Microsites for large mammals	xxx	xxx	-	-
Maintans biodiversity at: i. regional scale	xxx	xxx	-	xx
Maintains biodiversity at: ii. European scale	xx	xx	-	-
Biomass production	xxx	xxx	xxx	xx
Biomass import and export through physical processes	xx	xx	-	xx
Biomass export through harvesting	xxx	xxx	xxx	xx
Anthropic input of energy and nutrients	*low*	*low*	*high*	*low*

Discussion

The limits of the assessment at local landscape level comes from ignoring the functions which depends on the relationships between LDRS components. For instances, the low average score of the simple islands analyzed (like Talchia and Calafatul Mic) might suggest a minor role. However, in the context of the fluvial dynamic (erosion and sedimentary processes) the simple systems play a very important role, they being at the origin of complex landscapes (Amoros and Petts, 1993). A second limit comes from the relationships between functions, which are not pointed out by the used procedure. For example, sediment retention is associated with the retention of many toxic substances. The function of toxic substances retention is not considered by the procedure, though it could affect functions depending on trophodynamic modules, through ecotoxicological effects. The assessment of the degree to which the toxic substances retention affects other functions is partial gap of the existing knowledge base (Iordache, 2001), and needs extra research to be performed.

Despite these limitations, the qualitative functional analyses provided important information for the reconstruction strategy of LDRS. Other needed information was provided by the quantitative analyses of very important functions (flood water retention, sediment retention, and nutrient retention). Quantitative results of the functional analyses were reported by Cristofor et al. (2001). For instance, the current LDRS was found to retain 70.8 kt/year N, and 5.8kt/year P. The quantitative results allowed the estimation of the needed surface to be restored in order to reach goals related to nutrient input reduction into Black Sea (Vadineanu, 2000). In the scenario of 120000ha of wetlands to be restored in the Danube floodplain (upstream of the Delta), the location of the potential restoration sites is proposed in figure 1. The location is based on the results of the qualitative functional analyses, GIS analyses of local landscapes, and field inspections (details in Cristofor, 2001).

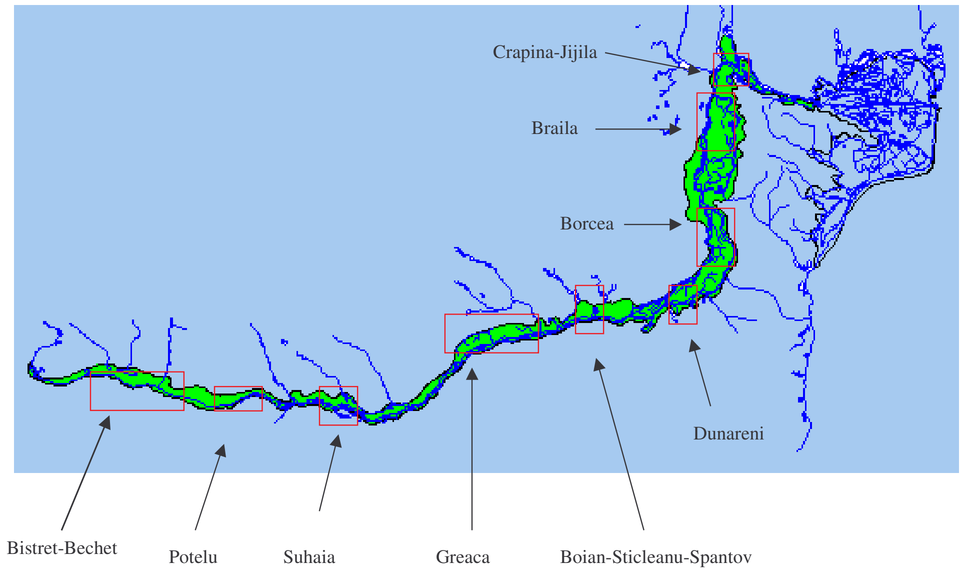

Figure 1 Potential restoration sites in the LDRS.

Conclusions

- the nutrient retention functions are not related to the complexity of the studied landscapes;
- the maintenance of habitats diversity functions are related to the complexity of the studied landscapes;
- if one wants to recover the hole range of resources and services produced by the reference LDRS, large and complex landscapes should be restored;
- based on the results of qualitative, and quantitative functional analyses, as well as on the results of GIS analyses and field inspections, a set of potential restoration sites was proposed in LDRS, upstream of the Delta.

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