Laboratorija za ekologiju biljaka

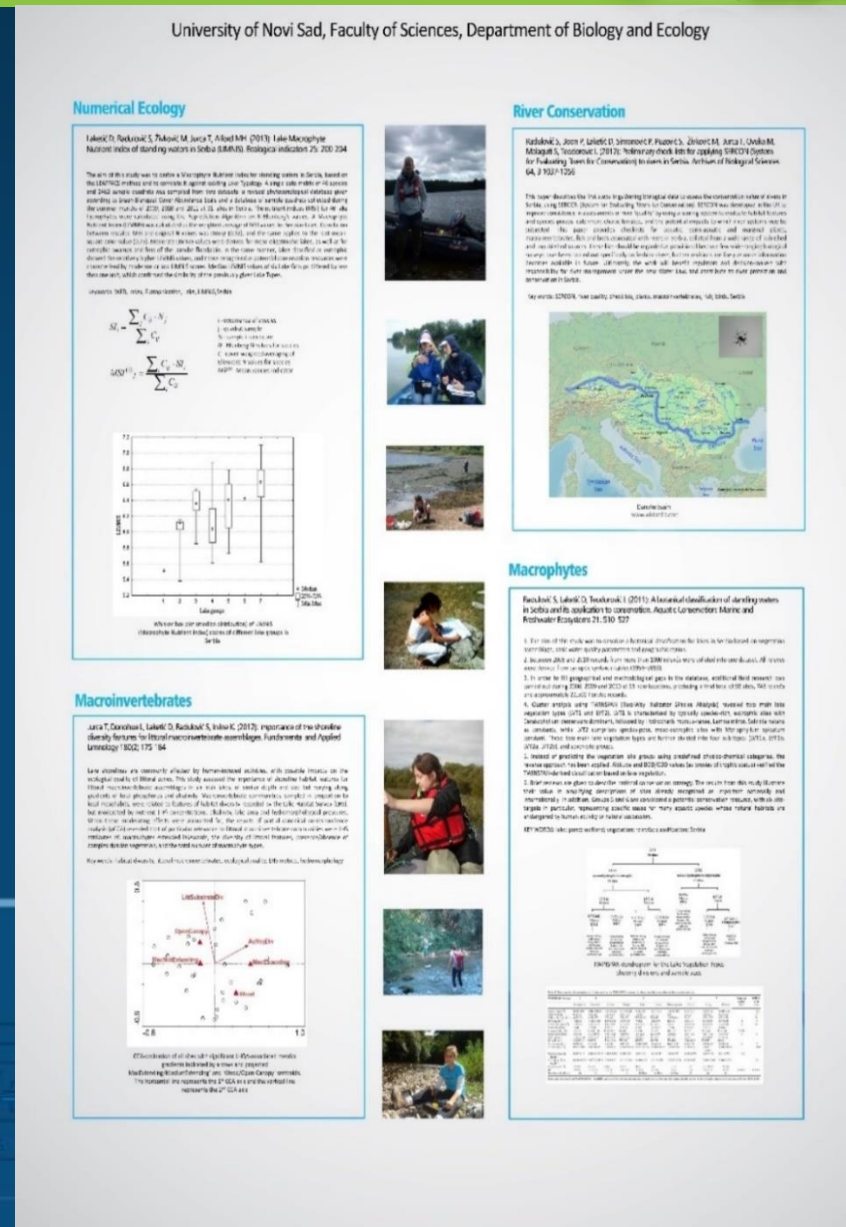
Katedra za ekologiju i zaštitu životne sredine
Departman za biologiju i ekologiju

1. Prof Snežana Radulović

2. Doc Dušanka Cvijanović (ex Laketić)

3. Milica Živković, Asistent, PhD student

4. Maja Novković, istraživač pripravnik, stipendista Ministarstva, PhD student



Projekti /poslednji period

2015 Monitoring kvaliteta životne sredine u AP Vojvodini u 2015. godini, Pokrajinski sekretarijat za urbanizam, graditeljstvo i zaštitu životne sredine, Dr Božo Dalmcija

2013-2015. FP7 SOLUTIONS (For Present and Future Emerging Pollutants in Land and Water Resources Management) ENV.2013.6.2-2 Toxicants, environmental pollutants and land and water resources management, Dr Ivana Teodorovic

2011-2015. DANUBIUS-RI (International Centre for Advanced Studies on River-Sea Systems), Biosense, Dr Adrian Stanica

2013-2014. FP7 DANCERS (Building Excellence in the Danube Region) Dr Vesna Bengin Crnojević

2012-2017. COST TD1209 European Information System for Alien Species, Dr Helen Roy

2011 SERCON System for Evaluating Rivers for Conservation network, Secretariat for Environment protection of Voivodina, Serbia, Dr Snežana Radulović

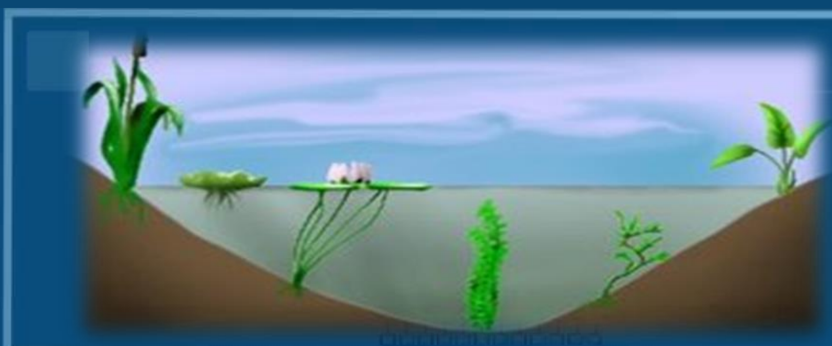
2010-2015. Biosensing Technologies and Global System for Long-Term Research and Integrated Management of Ecosystems, MNTR 043002, Dr Miroslav Vesković

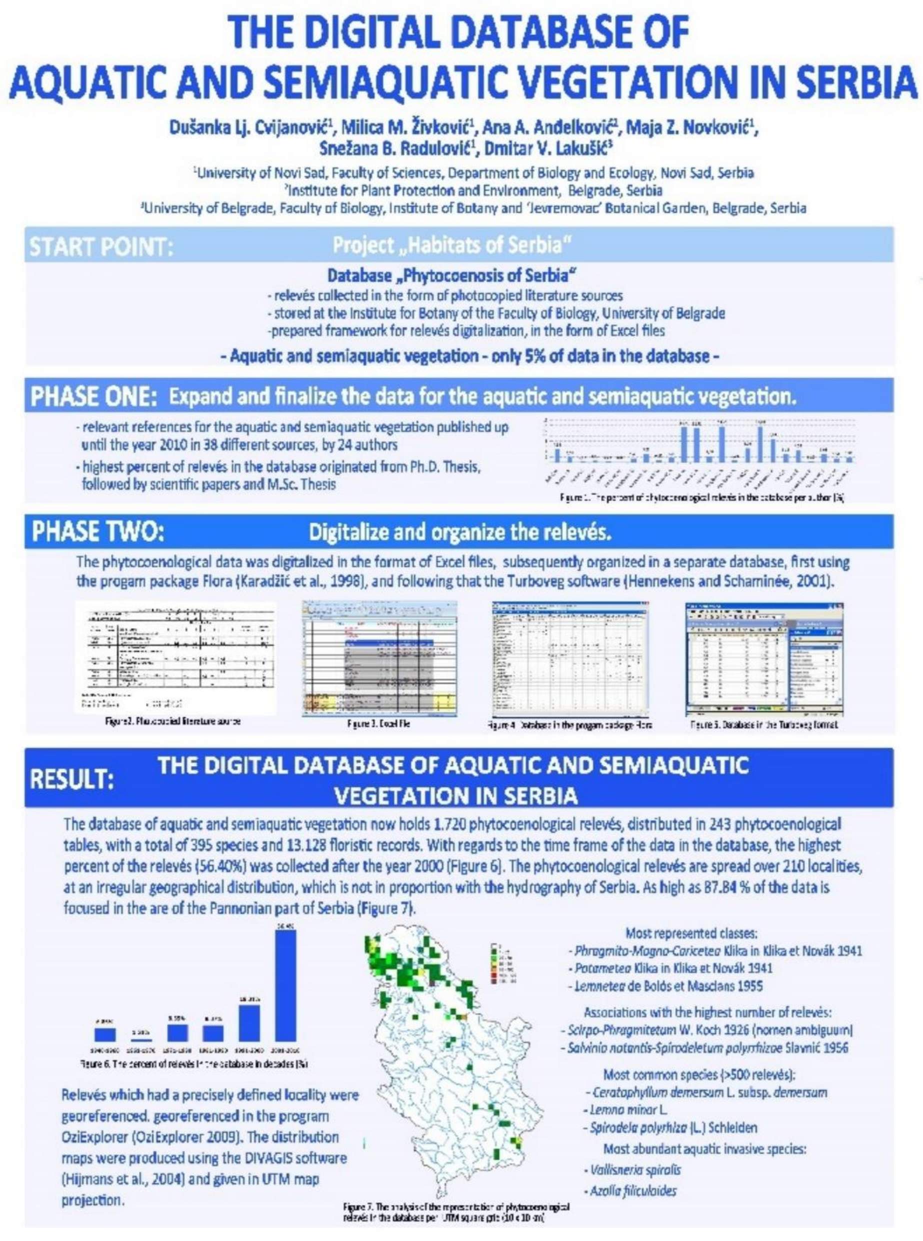
2010-2011. Invasive Species of Voivodina (Serbia) Secretariat for Environment protection of Voivodina, Serbia, Dr Pal Boža

2009-2011. EU Neighbouring Programme Romania-Serbia: Eco-status of the River Tamiš, 06SER02/03/007-8, Contractor City of Pancevo Dr Ivana Teodorović

2008-2009. SERCON (System for Evaluating Rivers for Conservation) River Jegricka case study JP Vode Vojvodine, Dr Snežana Radulović

Digitalizacija/Baze podataka





THE DIGITAL DATABASE OF AQUATIC AND SEMIAQUATIC VEGETATION IN SERBIA

Dušanka Lj. Cvijanović[1], Milica M. Živković[1], Ana A. Anđelković[2], Maja Z. Novković[1], Snežana B. Radulović[1], Dmitar V. Lakušić[3]

[1]University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology, Novi Sad, Serbia
[2]Institute for Plant Protection and Environment, Belgrade, Serbia
[3]University of Belgrade, Faculty of Biology, Institute of Botany and 'Jevremovac' Botanical Garden, Belgrade, Serbia

START POINT: Project „Habitats of Serbia"

Database „Phytocoenosis of Serbia"

- relevés collected in the form of photocopied literature sources
- stored at the Institute for Botany of the Faculty of Biology, University of Belgrade
- prepared framework for relevés digitalization, in the form of Excel files

- Aquatic and semiaquatic vegetation - only 5% of data in the database -

PHASE ONE: Expand and finalize the data for the aquatic and semiaquatic vegetation.

- relevant references for the aquatic and semiaquatic vegetation published up until the year 2010 in 38 different sources, by 24 authors
- highest percent of relevés in the database originated from Ph.D. Thesis, followed by scientific papers and M.Sc. Thesis

Figure 1. The percent of phytocoenological relevés in the database per author (%)

PHASE TWO: Digitalize and organize the relevés.

The phytocoenological data was digitalized in the format of Excel files, subsequently organized in a separate database, first using the progam package Flora (Karadžić et al., 1998), and following that the Turboveg software (Hennekens and Schaminée, 2001).

Figure 2. Photocopied literature source

Figure 3. Excel file

Figure 4. Database in the program package Flora

Figure 5. Database in the Turboveg format

RESULT: THE DIGITAL DATABASE OF AQUATIC AND SEMIAQUATIC VEGETATION IN SERBIA

The database of aquatic and semiaquatic vegetation now holds 1.720 phytocoenological relevés, distributed in 243 phytocoenological tables, with a total of 395 species and 13.128 floristic records. With regards to the time frame of the data in the database, the highest percent of the relevés (56.40%) was collected after the year 2000 (Figure 6). The phytocoenological relevés are spread over 210 localities, at an irregular geographical distribution, which is not in proportion with the hydrography of Serbia. As high as 87.84 % of the data is focused in the are of the Pannonian part of Serbia (Figure 7).

Figure 6. The percent of relevés in the database in decades (%)

Relevés which had a precisely defined locality were georeferenced. georeferenced in the program OziExplorer (OziExplorer 2009). The distribution maps were produced using the DIVAGIS software (Hijmans et al., 2004) and given in UTM map projection.

Figure 7. The analysis of the representation of phytocoenological relevés in the database per UTM square grid 10 x 10 km

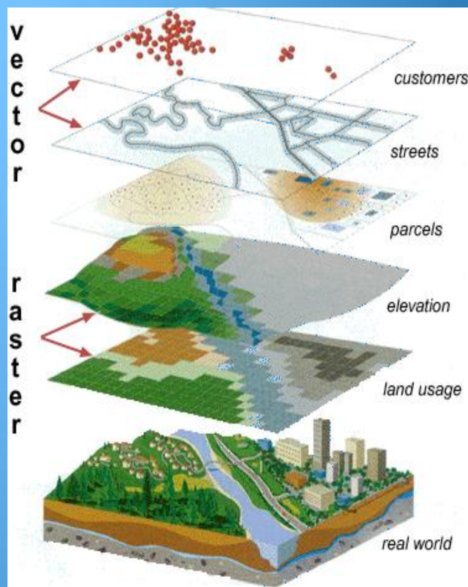
Most represented classes:
- *Phragmito-Magno-Caricetea* Klika in Klika et Novák 1941
- *Potametea* Klika in Klika et Novák 1941
- *Lemnetea* de Bolós et Masclans 1955

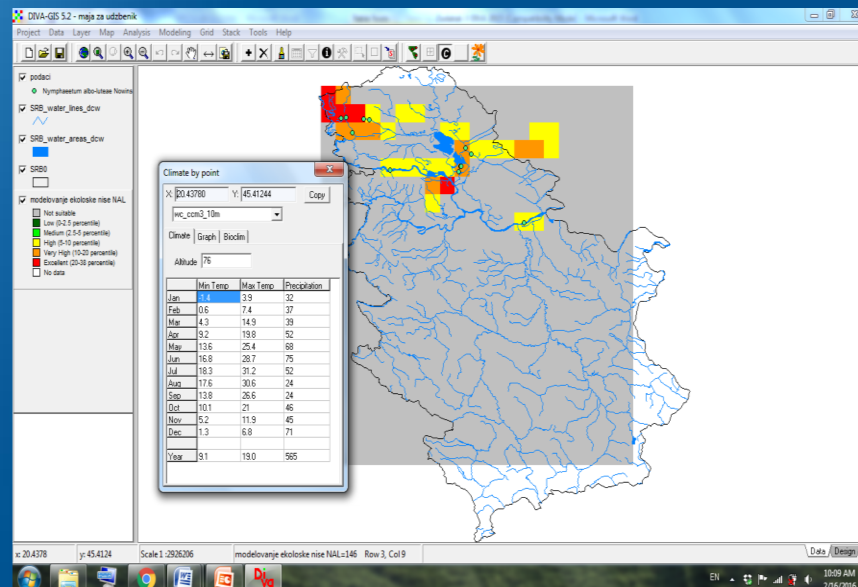
Associations with the highest number of relevés:
- *Scirpo-Phragmitetum* W. Koch 1926 (nomen ambiguum)
- *Salvinio natantis-Spirodeletum polyrrhizae* Slavnić 1956

Most common species (>500 relevés):
- *Ceratophyllum demersum* L. subsp. *demersum*
- *Lemna minor* L.
- *Spirodela polyrhiza* (L.) Schleiden

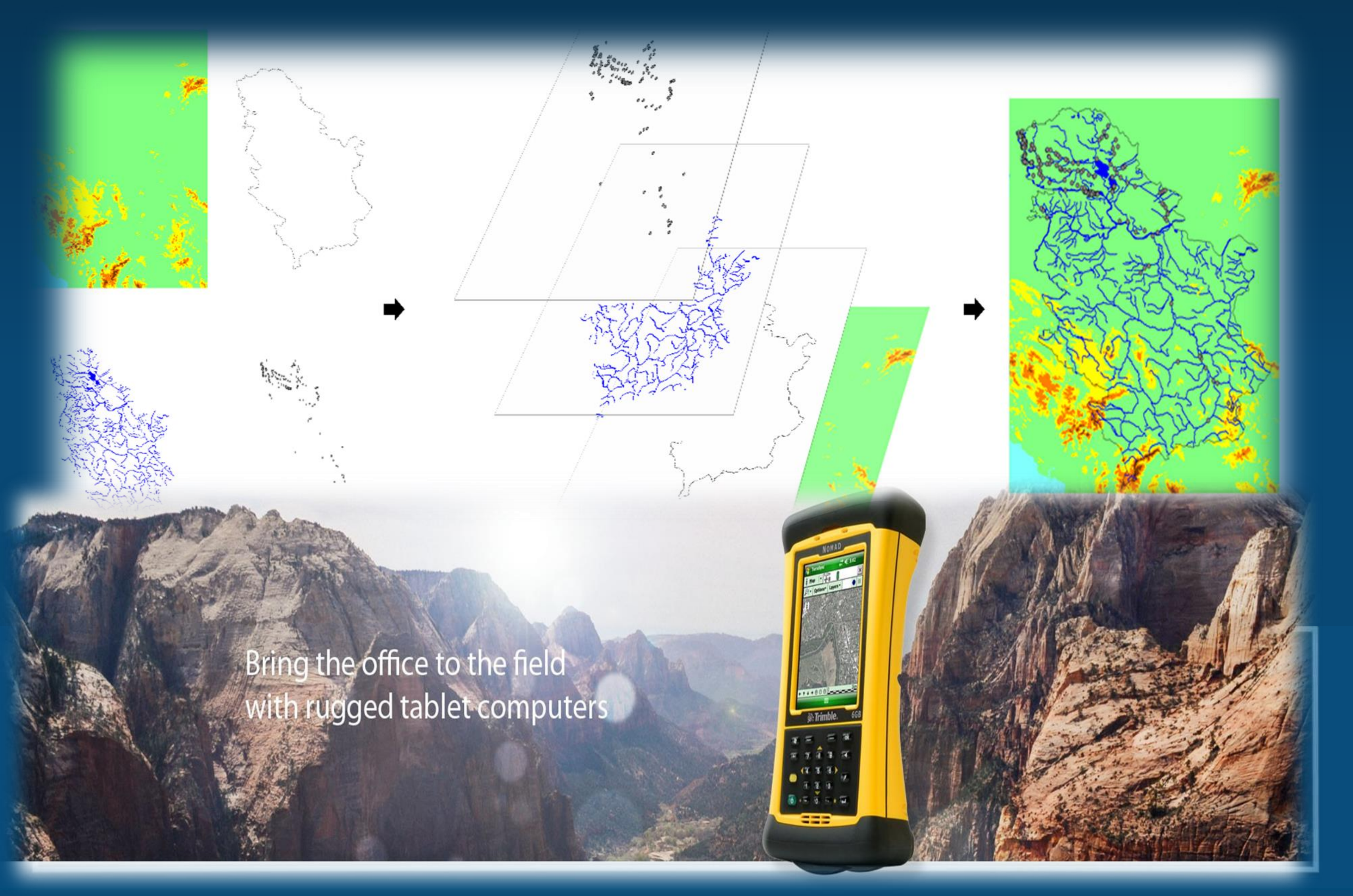
Most abundant aquatic invasive species:
- *Vallisneria spiralis*
- *Azolla filiculoides*

GIS – Remote sensing

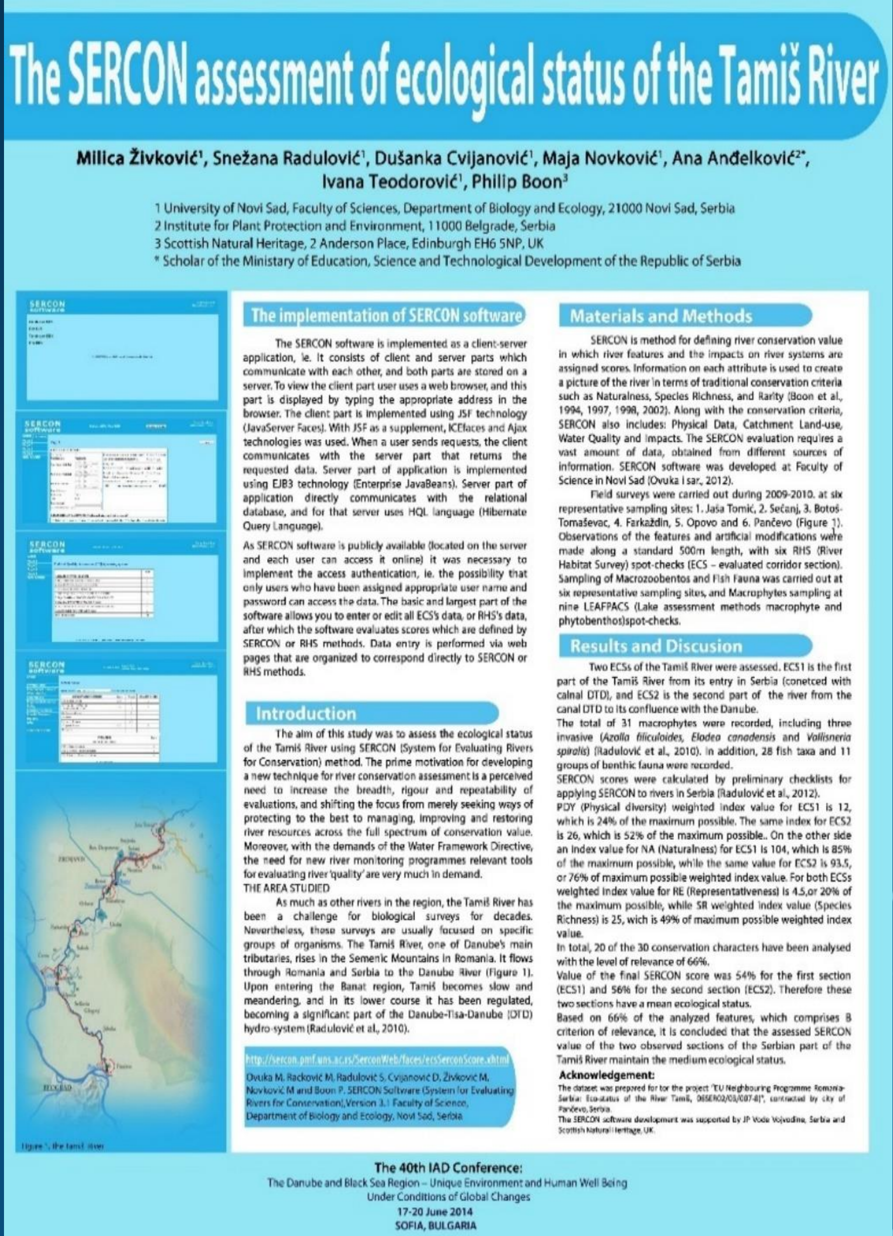




Diva GIS / Google Earth Pro / Trimble Nomad GPS comp



Ovuka M, Racković M, Radulović S, Cvijanović D, Živković M, Novković M and Boon P. SERCON (System for Evaluating Rivers for Conservation), Software Version 3.1 (2012-2015)



The SERCON assessment of ecological status of the Tamiš River

Milica Živković[1], Snežana Radulović[1], Dušanka Cvijanović[1], Maja Novković[1], Ana Anđelković[2*], Ivana Teodorović[1], Philip Boon[3]

1 University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology, 21000 Novi Sad, Serbia
2 Institute for Plant Protection and Environment, 11000 Belgrade, Serbia
3 Scottish Natural Heritage, 2 Anderson Place, Edinburgh EH6 5NP, UK
* Scholar of the Ministary of Education, Science and Technological Development of the Republic of Serbia

The implementation of SERCON software

The SERCON software is implemented as a client-server application, ie. It consists of client and server parts which communicate with each other, and both parts are stored on a server. To view the client part user uses a web browser, and this part is displayed by typing the appropriate address in the browser. The client part is implemented using JSF technology (JavaServer Faces). With JSF as a supplement, ICEfaces and Ajax technologies was used. When a user sends requests, the client communicates with the server part that returns the requested data. Server part of application is implemented using EJB3 technology (Enterprise JavaBeans). Server part of application directly communicates with the relational database, and for that server uses HQL language (Hibernate Query Language).

As SERCON software is publicly available (located on the server and each user can access it online) it was necessary to implement the access authentication, ie. the possibility that only users who have been assigned appropriate user name and password can access the data. The basic and largest part of the software allows you to enter or edit all ECS's data, or RHS's data, after which the software evaluates scores which are defined by SERCON or RHS methods. Data entry is performed via web pages that are organized to correspond directly to SERCON or RHS methods.

Introduction

The aim of this study was to assess the ecological status of the Tamiš River using SERCON (System for Evaluating Rivers for Conservation) method. The prime motivation for developing a new technique for river conservation assessment is a perceived need to increase the breadth, rigour and repeatability of evaluations, and shifting the focus from merely seeking ways of protecting to the best to managing, improving and restoring river resources across the full spectrum of conservation value. Moreover, with the demands of the Water Framework Directive, the need for new river monitoring programmes relevant tools for evaluating river 'quality' are very much in demand.

THE AREA STUDIED

As much as other rivers in the region, the Tamiš River has been a challenge for biological surveys for decades. Nevertheless, those surveys are usually focused on specific groups of organisms. The Tamiš River, one of Danube's main tributaries, rises in the Semenic Mountains in Romania. It flows through Romania and Serbia to the Danube River (Figure 1). Upon entering the Banat region, Tamiš becomes slow and meandering, and in its lower course it has been regulated, becoming a significant part of the Danube-Tisa-Danube (DTD) hydro-system (Radulović et al., 2010).

http://sercon.pmf.uns.ac.rs/SerconWeb/faces/ecsSerconScore.xhtml

Ovuka M. Racković M. Radulović S. Cvijanović D. Živković M. Novković M and Boon P. SERCON Software (System for Evaluating Rivers for Conservation),Version 3.1 Faculty of Science, Department of Biology and Ecology, Novi Sad, Serbia

Figure 1, the tamiš river

Materials and Methods

SERCON is method for defining river conservation value in which river features and the impacts on river systems are assigned scores. Information on each attribute is used to create a picture of the river in terms of traditional conservation criteria such as Naturalness, Species Richness, and Rarity (Boon et al., 1994, 1997, 1998, 2002). Along with the conservation criteria, SERCON also includes: Physical Data, Catchment Land-use, Water Quality and Impacts. The SERCON evaluation requires a vast amount of data, obtained from different sources of information. SERCON software was developed at Faculty of Science in Novi Sad (Ovuka I sar., 2012).

Field surveys were carried out during 2009-2010. at six representative sampling sites: 1. Jaša Tomić, 2. Sečanj, 3. Botoš-Tomaševac, 4. Farkaždin, 5. Opovo and 6. Pančevo (Figure 1). Observations of the features and artificial modifications were made along a standard 500m length, with six RHS (River Habitat Survey) spot-checks (ECS – evaluated corridor section). Sampling of Macrozoobentos and Fish Fauna was carried out at six representative sampling sites, and Macrophytes sampling at nine LEAFPACS (Lake assessment methods macrophyte and phytobenthos)spot-checks.

Results and Discusion

Two ECSs of the Tamiš River were assessed. ECS1 is the first part of the Tamiš River from its entry in Serbia (conetced with calnal DTD), and ECS2 is the second part of the river from the canal DTD to its confluence with the Danube.

The total of 31 macrophytes were recorded, including three invasive (*Azolla filiculoides, Elodea canadensis* and *Vallisneria spiralis*) (Radulović et al., 2010). In addition, 28 fish taxa and 11 groups of benthic fauna were recorded.

SERCON scores were calculated by preliminary checklists for applying SERCON to rivers in Serbia (Radulović et al., 2012).

PDY (Physical diversity) weighted index value for ECS1 is 12, which is 24% of the maximum possible. The same index for ECS2 is 26, which is 52% of the maximum possible.. On the other side an index value for NA (Naturalness) for ECS1 is 104, which is 85% of the maximum possible, while the same value for ECS2 is 93.5, or 76% of maximum possible weighted index value. For both ECSs weighted index value for RE (Representativeness) is 4.5,or 20% of the maximum possible, while SR weighted index value (Species Richness) is 25, wich is 49% of maximum possible weighted index value.

In total, 20 of the 30 conservation characters have been analysed with the level of relevance of 66%.

Value of the final SERCON score was 54% for the first section (ECS1) and 56% for the second section (ECS2). Therefore these two sections have a mean ecological status.

Based on 66% of the analyzed features, which comprises 8 criterion of relevance, it is concluded that the assessed SERCON value of the two observed sections of the Serbian part of the Tamiš River maintain the medium ecological status.

Acknowledgement:

The dataset was prepared for tor the project 'EU Neighbouring Programme Romania-Serbia: Eco-status of the River Tamiš, 0...', contracted by city of Pančevo, Serbia.

The SERCON software development was supported by JP Vode Vojvodine, Serbia and Scottish Natural Heritage, UK.

The 40th IAD Conference:
The Danube and Black Sea Region – Unique Environment and Human Well Being Under Conditions of Global Changes
17-20 June 2014
SOFIA, BULGARIA

http://sercon.pmf.uns.ac.rs/SerconWeb/

SERCON software

You are logged in as
Marko Ovuka (Logout)

Select RHS which you want to edit

Kutinska reka_RHS 2_selo Krastavče, date:14/04/2014
Kutinska reka_RHS 3_Gadžin han, date:15/04/2014
Kutinska reka_RHS 4_Taskovići, date:15/04/2014
Kutinska reka_RHS 5_(prva)Kutina, date:15/04/2014
Lepenica_RHS 1_Dragobraća, date:26/02/2014
Lepenica_RHS 2_Kragujevac, date:02/04/2014
Lepenica_RHS 3_blizina Cvetojevca, date:02/04/2014
Lepenica_RHS 4_Badnjevac, date:02/04/2014
Lepenica_RHS 5_Batočina, date:02/04/2014
Lim_RHS 1_Brodarevo, date:22/01/2015
Lim_RHS 2_Prijepolje (Kolovrat), date:22/01/2015
Lim_RHS 3_pre Bistrice, date:22/01/2015
Lim_RHS 4_Priboj, date:22/01/2015
Mlava_RHS 1_Žagubica, vrelo Mlave, date:20/01/2015
Mlava_RHS 2_Izvarica (Ribare), date:20/01/2015
Mlava_RHS 3_Gornjak (Gornjačka klisura) , date:20/01/2
Mlava_RHS 4_Leskovac, date:21/01/2015
Mlava_RHS 5_Petrovac na Mlavi, date:21/01/2015
Mlava_RHS 6_Trnavče, date:22/01/2015
Mostonga_RHS 1_Gakovački put, date:14/08/2014

Edit RHS | Edit terrain data | Delete RHS

Exit

SERCON software

Working on RHS: *Mlava_RHS 2_Izvarica (Ribare)* | Edit basic RHS data

You are logged in as Marko Ovuka (Logout)

- HOME (no save)
- Page 1
- Page 2
- Page 3
- Page 4
- RHS SCORE

Page 2

Save

Spot-check 1 is at: ○ upstream end ○ downstream end of site (tick one box)

E. PHYSICAL ATTRIBUTES (to be assessed across channel within 1m wide transect)

When boxes 'bordered', only one entry allowed	1GPS	2	3	4	5	6GPS	7	8	9	10GPS	
LEFT BANK	Ring EC or SC if composed of sandy substrate										
Material	EA	EA	EA	EA	EA	EA	EA	EA	EA	EA	
Bank modification(s)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	NK NO RS RI PC pc(b)	
Marginal & bank feature(s)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	NV NO EC (EC) SC (SC)	
CHANNEL	GP- ring either G or P if predominant										
Channel substrate	(G)F	(G)F	(G)F	(G)F	(G)F	(G)F	(G)F	(G)F	(G)F	(G)F	NV BE BO CO GP (G)P
Flow-type	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	
Channel modification(s)	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	NK NO CV RS	

sercon.pmf.uns.ac.rs/SerconWeb/faces/rhsPage1.xhtml#

SERCON software

Working on ECS: *Findhorn ECS 1*
Country: Scotland, Area: N Scotland
Edit basic ECS data

RHS in this ECS: Findhorn RHS site 2, date:04/08/2011
Edit this RHS

You are logged in as Marko Ovuka (Logout)

- HOME (no save)
- Physical data
- Catchment Land-use
- Water Quality
- Naturalness
- Representativeness
- Rarity
- Species Richness
- Special Features
- Impacts
- AFIs
- SERCON SCORE

Physical Data

Save

PD 1. Location of ECS

Grid reference for the upstream limits of the ECS:	57° 31' 41.12" N	3° 40' 13.473" W
Grid reference for the downstream limits of the ECS:	57° 37' 48.708" N	3° 37' 55.995" W
Grid reference for the mid-point:	57° 34' 22.857" N	3° 38' 57.808" W
Altitude at mid-point of ECS:	24.0 m	
Altitude of source of river:	850.0 m	
Distance from source of mid-point of ECS:	89.7 km	
The number(s) of the OS 1:50,000 map(s) on which the ECS appears:	27	
Hydrometric area within which the ECS lies:	007. Findhorn Group	

PD 2. Length of ECS

The length of the river channel within the ECS: 21.0 km

HOME (no save)
Page 1
Page 2
Page 3
Page 4
RHS SCORE

I. BANK PROFILES Use √ (present) or E (≥ 33% banklength)

	L	R		L	R
Vertical/undercut	√		Resectioned (reprofiled)		
Vertical with toe			Reinforced - whole		
Steep (≥45)			Reinforced - top only		
Gentle	E	E	Reinforced - toe only		
Composite			Artificial two-stage		
Natural berm			Poached bank		
			Embanked		
			Set-back embankment		

J. EXTENT OF TREES AND ASSOCIATED FEATURES *record even if <1%

TREES (tick one box per bank)

	Left	Right
None	☐	☐
Isolated/scattered	☐	☐
Regularly spaced, single	☐	☐
Occasional clumps	☐	☐
Semi-continuous	☐	☐
Continuous	☑	☑

ASSOCIATED FEATURES (tick one box per feature)

	None	Present	E(≥33%)
Shading of channel	○	○	●
*Overhanging boughs	○	○	●
*Exposed bankside roots	○	●	○
*Underwater tree roots	○	●	○
Fallen trees	●	○	○
Large woody debris	●	○	○

K. EXTENT OF CHANNEL AND BANK FEATURES (tick one box for each feature) *record even if <1%

	None	Present	E(≥33%)		None	Present	E(≥33%)
*Free fall flow	●	○	○	Exposed bedrock	●	○	○
Chute flow	●	○	○	Exposed boulders	●	○	○
Broken standing waves	●	○	○	Vegetated bedrock/boulders	●	○	○
Unbroken standing waves	○	○	●	Unvegetated mid-channel bar(s)	●	○	○

Species richness

Save

SR 1. Aquatic and Marginal Macrophytes

River Macrophyte Survey check-list::

Species	Present	Species	Present
Achillea ptarmica	☑	Marchantia polymorpha	☐
Alisma lanceolatum	☐	Marsupella sp(p).	☐
Alisma plantago-aquatica	☐	Mentha aquatica	☐
Alopecurus geniculatus	☐	Menyanthes trifoliata	☐
Amblystegium fluviatile	☑	Molinia caerulea	☐
Angelica sylvestris	☑	Montia fontana	☑
Apium inundatum	☐	Myosotis scorpioides	☐
Apium nodiflorum	☐	Myosoton aquaticum	☐
Batrachospermum sp(p).	☐	Myrica gale	☐
Berula erecta	☐	Myriophyllum alterniflorum	☐
Bidens cernua	☐	Myriophyllum spicatum	☐
Bidens tripartita	☐	Nardia sp(p).	☐
Blindia acuta	☑	Nardus stricta	☐
Bolboschoenus maritimus	☐	Narthecium ossifragum	☐
Brachythecium plumosum	☑	Nitella sp(p).	☐
Brachythecium rivulare	☑	Nuphar lutea	☐
Brachythecium rutabulum	☑	Nymphaea alba	☐
Bryum pseudotriquetrum	☐	Octodiceras fontanum	☐
Butomus umbellatus	☐	Oenanthe crocata	☐
Calliergon cuspidatum	☑	Oenanthe fistulosa	☐

Sercon Score

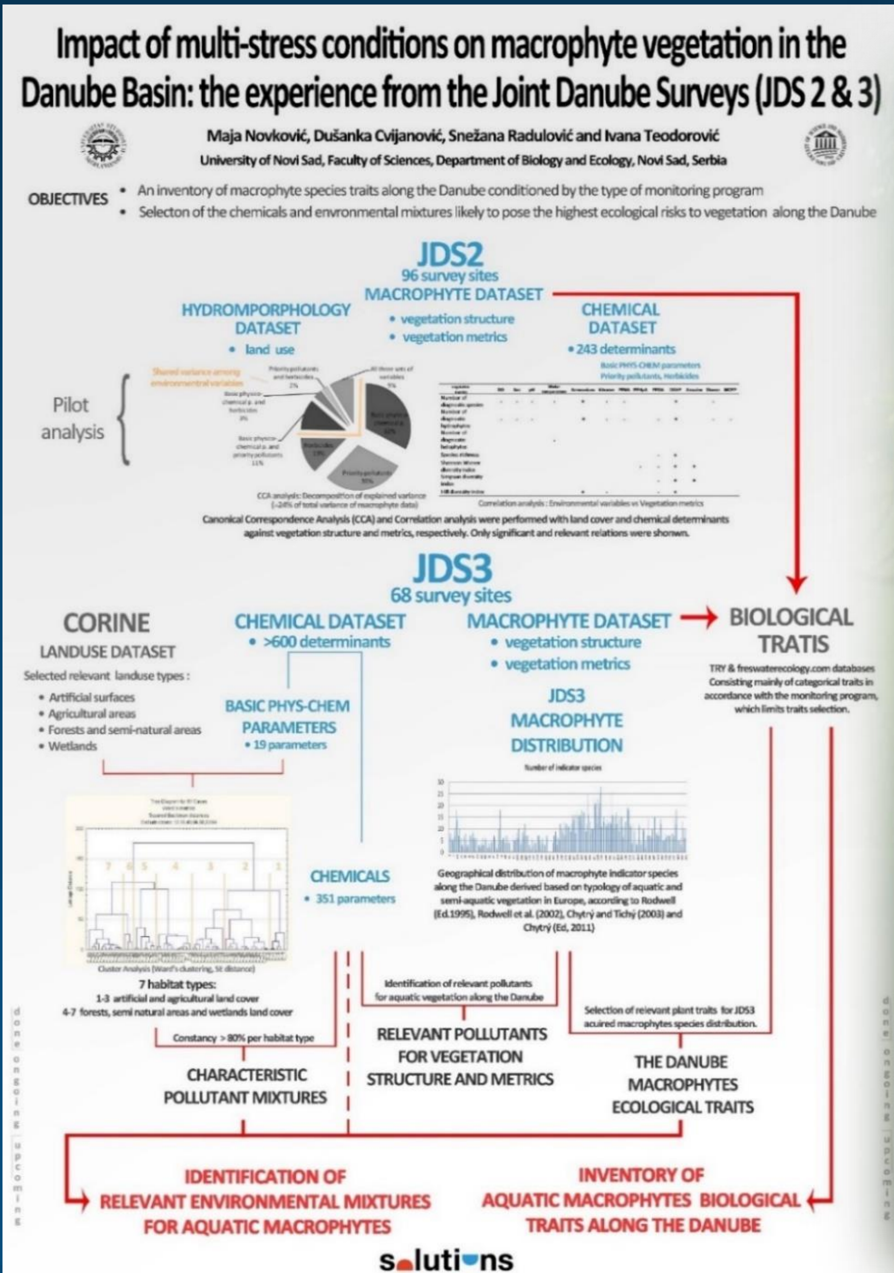
RHS in this ECS: Findhorn RHS site 2, date:04/08/2011 **Review this RHS report**

CONSERVATION CRITERIA	Score	Weight	QUALITY BANDS
PDY: Physical Diversity	92 a*	3	A
NA: Naturalness A (NA 1-6) Naturalness B (NA 7-10)	84 a 59 a*	5 1.5	A C
RE: Representativeness	4	3	E
RA: Rarity	44 a*	2	C
SR: Species Richness	49 a*	2.5	C
SF: Special Features	68 a*	1	A
IM: Impacts	26 a*		B

SUBSCORES	Score
PHYSICAL DIVERSITY	
PDY 1: Channel Substrates	5
PDY 2: Flow-types and Habitat Features	5
PDY 3: Structure of Aquatic Vegetation	1
NATURALNESS	
NA 1: Planform and River Profile	5
NA 2: Extent of Channel and Bank Engineering	5
NA 3: Channel and Bank Features NA 3a: Habitat Quality Assessment NA 3b: Habitat Modification Class	 0 4

Can we <u>REALLY</u> detect **how much stress to aquatic vegetation** in large rivers comes **from chemical pollutants in multi-stress conditions**?

FP7 Solutions / SETAC 2015



Joint Danube Survey ICPDR

68 survey units

Aquatic vegetation data
345 sample quadrats
- vegetation structure
- macrophyte richness and production

JDS 3 macrophyte.xlsx
Matrice final 30 7.xlsx

Chemical data
600 chemical determinants
- determinant concentration

JDS 3 chem data for BQE final.xlsx
Matrice final 30 7.xlsx

Methods

Chemical data

- Heavy metals
- PAHs
- Herbicides
- Pharmaceutical products
- Industrial and personal care products
- Basic PHY-CHEM attributes

(285 determinants)

Land Use data

Cluster analysis

CCA

Aquatic vegetation data

Macrophyte functional groups
(75 indicator species)

Results: preliminary CCA analysis

Basic PHY-CHEM parameters	**Dissolved Oxygen** **Nitrates** **Chlorophyll-a**
Heavy metals	**Arsenic** **Mercury**
PAHs	**Fluoranthene*** **Naphthalene*** **Benzo(b)fluoranthene*** **Benzo(k)fluoranthene***
Herbicides	**Methabenzthiazuron** **Dinoterb** **Metolachlor ESA** **Terbutylazine-2-hydroxy**
Pharmaceutical products	**Triazolam** **Tramadol** **EDDP (met. of Methadone)** **Phenacetin** **Bromazepam**
Industrial and personal care products	**Nicotine** **Sucralose** **PFHpA***

Significant and relevant determinants for aquatic vegetation

(LambdaA higher than 0.1)

(* priority substances)

Results: CCA analysis

Basic PHY-CHEM parameters	15.3 %
Heavy metals	8.7 %
PAHs	12.43 %
Herbicides	16.76 %
Pharmaceutical products	23.55 %
Industrial and personal care products	14.99 %
	41.09 %

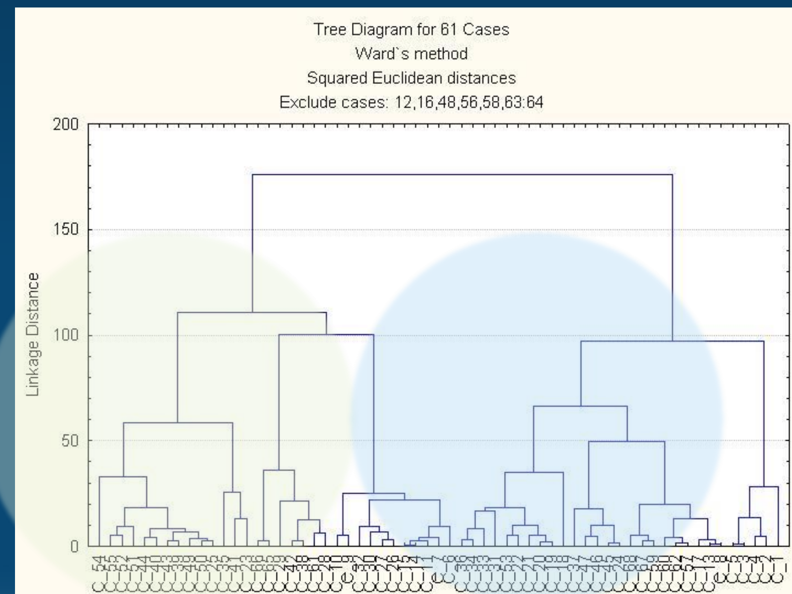
Of Total Variance for macrophyte assemblages
(Without Covariance)

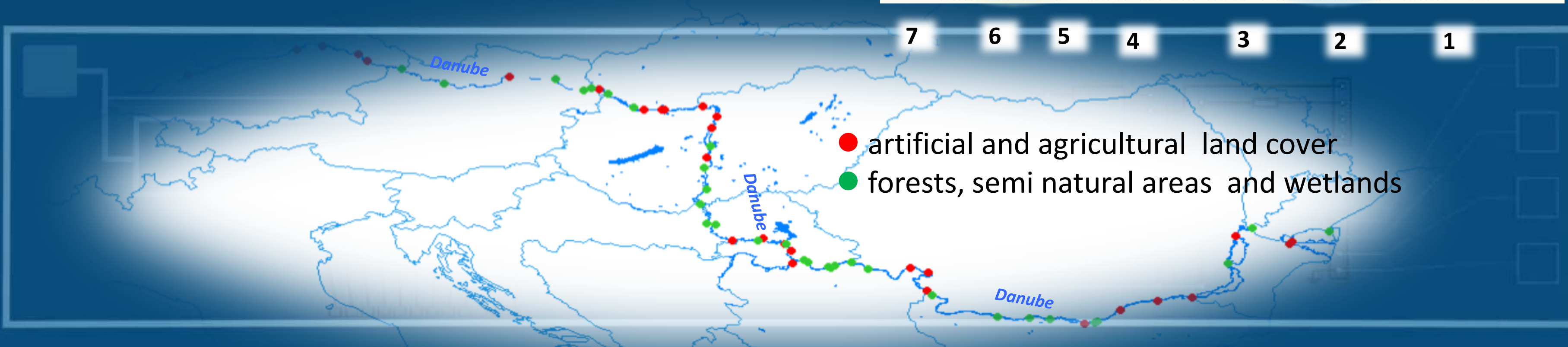
Results: cluster analysis

According to: land cover types & basic PHY-CHEM parameters

I ● artificial and agricultural land cover (**1-3**)

II ● forests, semi natural areas and wetlands (**4-7**)





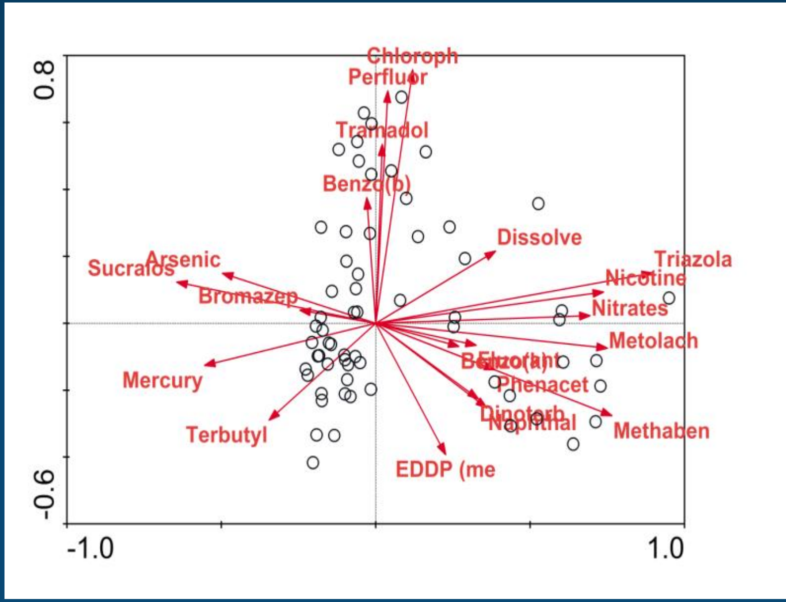
Results: covariance calculation

Pharmaceutical products ↔ Herbicides: 12.48 %

Pharmaceutical products ↔ Industrial and personal care products: 10.57 %

Herbicides ↔ Industrial and personal care products: 9.06 %

Covariance



Results: additional CCA analysis

first level of clustering

two subsets → CCA → unfriendly table

Stronger response of macrophyte assemblages to environmental variables was obtained.

Variable	Cluster 1 (% of T.V.)	Cluster 2 (% of T.V.)	All samples (% of T.V.)
Arsenic (As)	10.75		4.06
Benzo(b)fluoranthene	2.29	3.24	1.91
Benzo(k)fluoranthene		6.47	3.35
Bromazepam	2.52	5.93	3.59
Chlorophyll-a	6.86	6.20	4.30
Dinoterb	2.06	6.74	2.87
Dissolved oxygen	5.26	8.63	5.26
EDDP	8.24	3.51	4.06
Fluoranthene	3.66	5.12	3.35
Mercury (Hg)	5.03	7.82	5.02
Methabenzthiazuron	8.69	11.33	8.61
Metolachlor ESA	9.38	9.71	7.89
Naphthalene	3.66		3.11
Nicotine	10.52	7.28	7.89
Nitrates (NO3-N)	10.07	7.01	6.93
PFHpA	6.41	2.97	3.59
Phenacetin		9.44	4.30
Sucralose	8.69	8.09	6.22
Terbutylazine-2-hydroxy	5.49	4.58	4.30
Tramadol	6.86	3.78	3.83
Triazolam	12.13	12.68	10.76

Conclusion

Detected group of most significant chemical determinants in water for macrophyte assemblages along the Danube and quantified its *in situ* effects.

STILL

Could not distinguish different mixtures of pollutants for distinctive habitat types due to partitioning of datasets.

Macrophyta Trait Based Approach - from concept to reality

Najčešće korištene metode obrade podataka u ekologiji vegetacije su

Cocktail metod

TWINSPAN metod

Detrendovana korespodentna analiza (DCA)

Corispodentna analiza (CA),

Canonijska korispodentna analiza (CCA)

Detrendovana kanonijska korispodentna analiza (DCCA)

Analiza glavnih komponenti (PCA)

Nemetričko multidimenziono skaliranje (NMDS).

Vegetacijska baza podataka

Serija istraživanja Dunava

Internacionalne komisija za zaštitu Dunava

Joint Danube Survey 2 ekspedicija

Joint Danube Survey 3 ekspedicija

Relevantne tabele:

Tabela sa podacima Vegetacijia

Tabela sa podacima Hemija


Poland
Germany
Czech Republic
Regensburg
Ulm
Passau
Donaueschingen
Wien
Bratislava
Slovakia
Ukraine
Austria
Budapest
Switzerland
Hungary
Moldova
Romania
Italy
Slovenia
Croatia
Novi Sad
Galati
Izmail
Braila
Tulcea
Sulina
N
Beograd
Orsova
Bosnia
Bucuresti
Ruse
Serbia
150 km
Black Sea
Sofia
Bulgaria
Albania
Turkey
Greece
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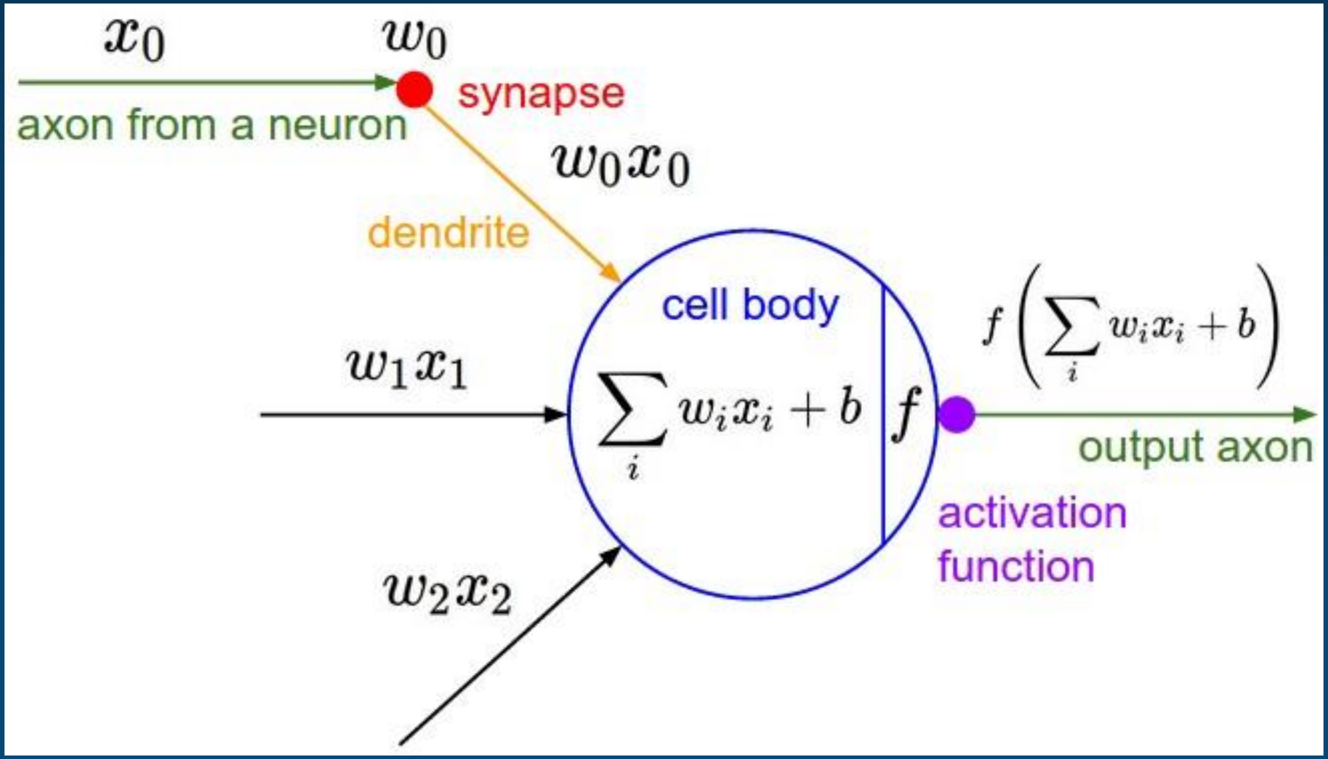


x_0
w_0
synapse
axon from a neuron
$w_0 x_0$
dendrite
cell body
$w_1 x_1$
$\sum_i w_i x_i + b$
f
$f\left(\sum_i w_i x_i + b\right)$
output axon
activation function
$w_2 x_2$

Training algorithms

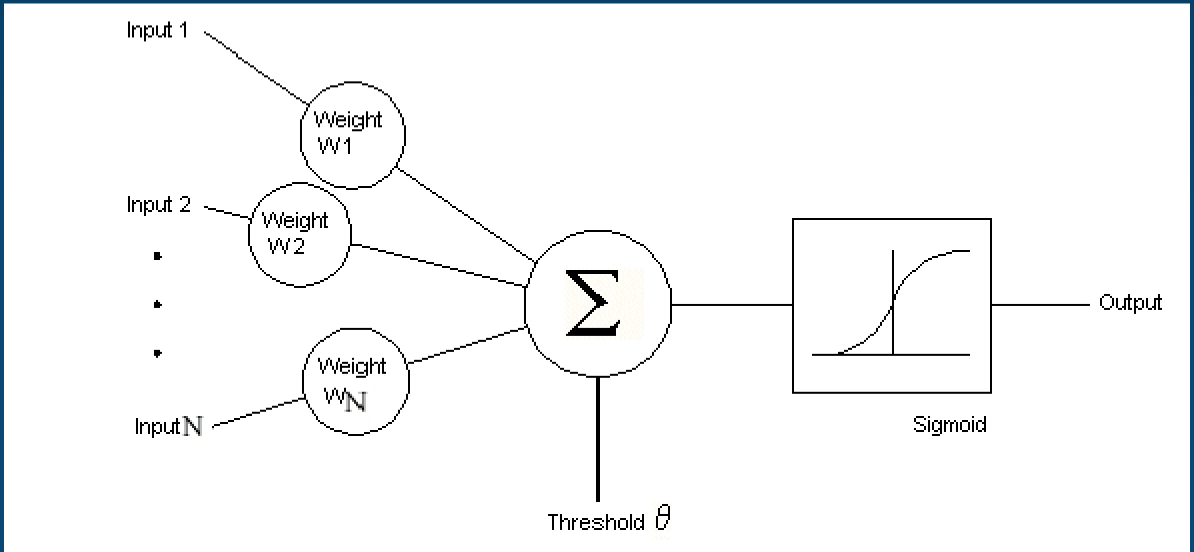
ANN (Artificial Neural Networks)

Veštačke neuronske mreže

Gruba aproksimacija bioloških neuronskih mreža

Sistem za paralelno računanje

Procesna sposobnost je data u vidu veza između procesnih jedinica (neurona)



Akvatična i semiakvatična vegetacija

Kolone – vegetacijske vrste: 69

Redovi – snimci za ispitivanje: 175

Podela Dunava	snimak	Aco cal	…	Car ama	Cer dem	…	Wol arr	Zan pal
1	1	0.00	…	30.19	0.00	…	0.00	52.83
1	2	0.00	…	0.00	0.00	…	0.00	11.43
1	3	0.00	…	0.00	1.89	…	0.00	0.00
⋮	⋮	⋮		⋮	⋮		⋮	⋮
6	173	0.00	…	0.00	0.00	…	0.00	0.00
6	174	0.00	…	0.00	0.00	…	0.00	0.00
6	175	0.00	…	0.00	0.00	…	0.00	0.00

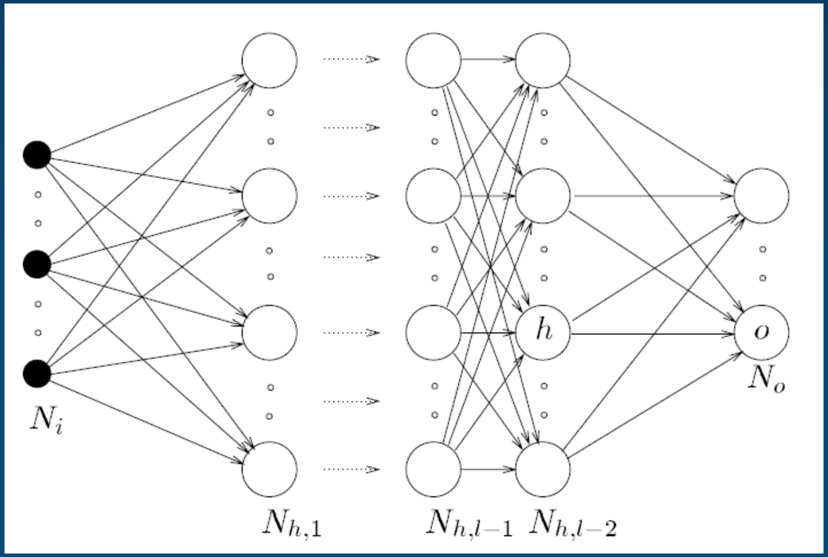
Veštačke neuronske mreže

Dva osnovna načina povezivanja procesnih jedinica:

Mreže sa propagacijom signala unapred (Feed-Forward)

Rekurentne mreže

Višeslojna neuronska mreža



Obučavanje propagacijom greške unazad

Dovoljan samo jedan skriveni sloj

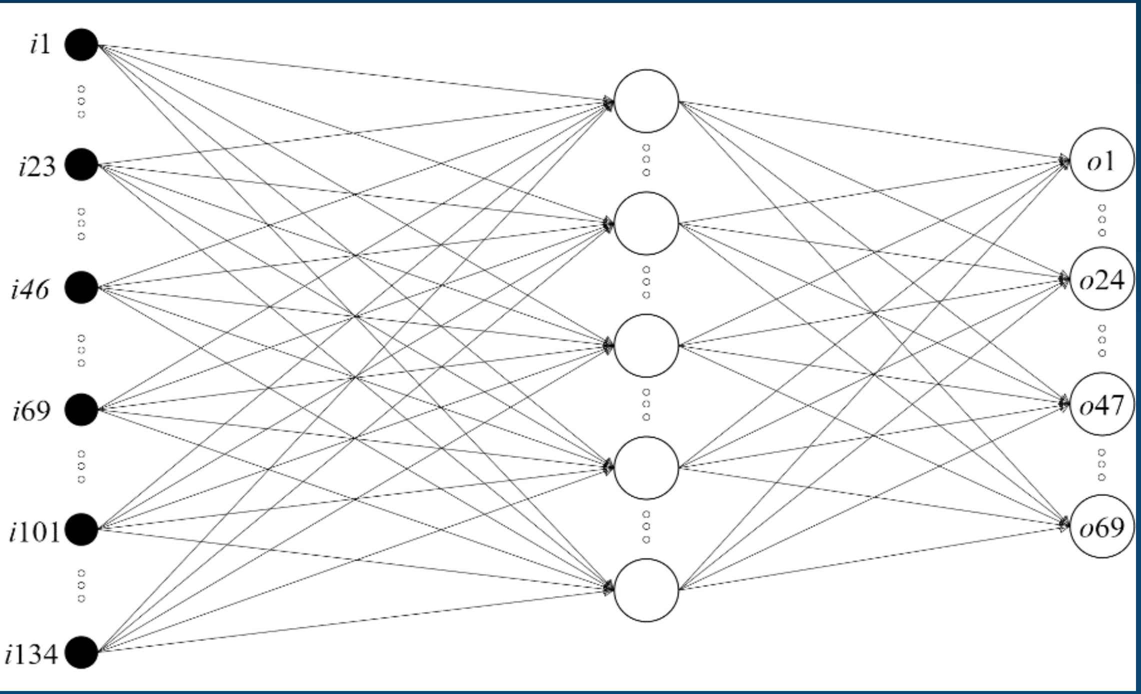
U većini slučajeva jedinica aditivno doprinosi svojim izlazom ulazima jedinica sa kojima je povezana. Ukupan ulaz predstavlja težinsku sumu:
Pozitivni težinski faktori predstavljaju ekscitirajuće a negativni inhibirajuće veze. Jedinice sa pravilom propagacije (2.1) nazivaju se sigma jedinice. Postoje i sigma-pi jedinice kod kojih je pravilo aktivacije:. Obično se *yjm* skaliraju težinskim faktorima pre množenja.

$$s_k(t) = \sum_j w_{jk}(t) y_j(t) + \theta_k(t) \ . \qquad \textbf{(2.1)}$$

$$s_k(t) = \sum_j w_{jk}(t) \prod_m y_{j_m}(t) + \theta_k(t) \ .$$

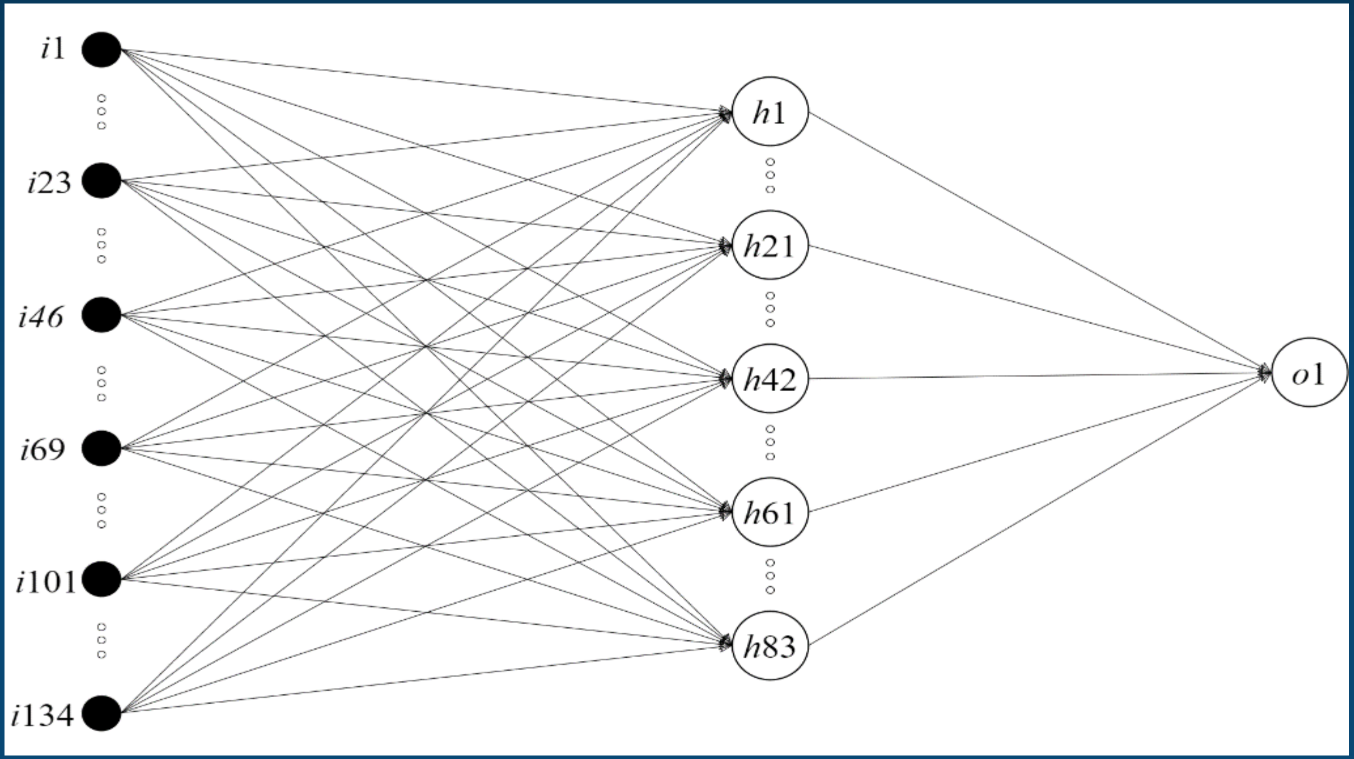
Model veštačke neuronske mreže

Prvi pristup:



Model veštačke neuronske mreže

Drugi pristup:



Formiranje obučavajućeg skupa

Kompletirati skup ulaznih podataka

Linearno skaliranje vrednosti

Izbacivanje nekonzistentnih uzoraka

Podela Dunava	snimak	Bentazon	…	Alkalinity	…
1	3	0.009	…	3.800	…
1	4	0.009	…	3.800	…
1	5		…	3.500	…
⋮	⋮	⋮		⋮	
6	173	0.008	…	2.500	…
6	174	0.008	…	2.500	…
6	175		…	2.500	…

Kolone – odabrane supstance: 134

Sačinjena na sledeći način

Nije izvršeno merenje – prazna ćelija u tabeli

Izvršeno merenje – realna vrednost

Ispod limita detekcije – realna 0 nula vrednost

Ispod limita kvantifikacije – realna vrednost limita kvantifikacije

Izbacivanje nekonzistentnih uzoraka

Četiri slučaja poređenja snimaka:

Male promene na ulazu - male promene na izlazu

Male promene na ulazu - velike promene na izlazu

Velike promene na ulazu - male promene na izlazu

Velike promene na ulazu - velike promene na izlazu

	X1	X2	X3	Y1
Inicijalni uzorak	0	0	0	**0**
1. uzorak	0	0	0.01	**0**
2. uzorak	0	0	0.01	**1**
3. uzorak	0	1	1	**0**
4. uzorak	1	0	1	**1**

Mentha aquatica L.

Naziv kolone:	Men aqu		
Broj ulaza:	134	134+1	
Sekcija:	All	1,2,3	4, 5, 6
Max greška:	4.849	1.700	3.078
Min greška:	0.000	0.000	0.000
Izbačeno uzoraka:	%3	%6	%0
Min:	0.000	0.000	0.000
Max:	66.674	66.674	5.197
Average:	1.046	1.954	0.063
SD:	7.216	9.905	0.570
Broj uzoraka:	175	92	83

Željena vrednost:	0
Izlaz neuronske mreže:	0.000177428
Apsolutna greška:	0.000177428

Željena vrednost:	47.06
Izlaz neuronske mreže:	47.78350747
Apsolutna greška:	0.723507474

Željena vrednost:	50.017
Izlaz neuronske mreže:	48.76010181
Apsolutna greška:	1.256898195

Željena vrednost:	2.775
Izlaz neuronske mreže:	1.283237058
Apsolutna greška:	1.491762942

Lemna minor L.

Naziv kolone:	Lem min		
Broj ulaza:	134	134+1	
Sekcija:	All	1,2,3	4, 5, 6
Max greška:	3.433	4.020	2.420
Min greška:	0.000	0.000	0.000
Izbačeno uzoraka:	%38	%38	%25
Min:	0.000	0.000	0.000
Max:	72.734	72.734	58.742
Average:	9.517	12.382	6.431
SD:	14.526	16.945	10.579
Broj uzoraka:	175	92	83

Željena vrednost:	8.33
Izlaz neuronske mreže:	4.896537414
Apsolutna greška:	3.433462586

Željena vrednost:	25
Izlaz neuronske mreže:	24.83352315
Apsolutna greška:	0.166476854

Željena vrednost:	15.342
Izlaz neuronske mreže:	15.37735214
Apsolutna greška:	0.035352145

Željena vrednost:	43.096
Izlaz neuronske mreže:	42.4718253
Apsolutna greška:	0.624174703

Željena vrednost:	30
Izlaz neuronske mreže:	30.11582075
Apsolutna greška:	0.115820746

Ceratophyllum demersum L.

Naziv kolone:	Cer dem		
Broj ulaza:	134	134+1	
Sekcija:	All	1,2,3	4, 5, 6
Max greška:	3.745	1.738	3.618
Min greška:	0.000	0.000	0.001
Izbačeno uzoraka:	%53	%33	%55
Min:	0.000	0.000	0.000
Max:	100.00	81.806	100.000
Average:	17.326	7.775	28.209
SD:	19.928	14.069	20.103
Broj uzoraka:	175	92	83

Željena vrednost:	3.03
Izlaz neuronske mreže:	1.291645422
Apsolutna greška:	1.738354578

Željena vrednost:	21.248
Izlaz neuronske mreže:	21.95990728
Apsolutna greška:	0.711907284

Željena vrednost:	15.426
Izlaz neuronske mreže:	14.05368703
Apsolutna greška:	1.372312966

Željena vrednost:	6.38
Izlaz neuronske mreže:	6.719082275
Apsolutna greška:	0.339082275

Verifikacija

Neuronska mreža može se smatrati obučenom:

Apsolutna greška po testu uzorku nije veća od 1

Broj izbačenih uzoraka manji od 50%

Tri demonstrativne vrste:.

1 ***Mentha aquatica L.*** 2

2. *Lemna minor L.*

3. *Ceratophyllum demersum L. 123*

Dva slučaja

Obrada za ceo tok Dunava 3

Obrada za segmente

Primena analize glavnih komponenti

Izvršena nad ulaznim podacima

Redukcija sa 134 na 17 ulaza

Izmenjena neuronska mreža

ANN master rad rezulati.docx

Mentha aquatica L. - PCA

	Mentha aquatica L.					
Naziv kolone:	Men aqu			Men aqu - PCA		
Broj ulaza:	134	134+1		17	17+1	
Sekcija:	All	1,2,3	4, 5, 6	All	1, 2, 3	4, 5, 6
Max greška:	4.849	1.700	3.078	1.539	1.550	2.516
Min greška:	0.000	0.000	0.000	0.000	0.000	0.000
Izbačeno uzoraka:	%3	%6	%0	%2	%4	%0
Min:	0.000	0.000	0.000	0.000	0.000	0.000
Max:	66.674	66.674	5.197	66.674	66.674	5.197
Average:	1.046	1.954	0.063	1.046	1.954	0.063
SD:	7.216	9.905	0.570	7.216	9.905	0.570
Broj uzoraka:	175	92	83	175	92	83

Lemna minor L. - PCA

	Lemna minor L.					
Naziv kolone:	Lem min			Lem min - PCA		
Broj ulaza:	134	134+1		17	17+1	
Sekcija:	All	1,2,3	4, 5, 6	All	1, 2, 3	4, 5, 6
Max greška:	3.433	4.020	2.420	3.431	3.332	2.610
Min greška:	0.000	0.000	0.000	0.000	0.000	0.000
Izbačeno uzoraka:	%38	%38	%25	%29	%26	%19
Min:	0.000	0.000	0.000	0.000	0.000	0.000
Max:	72.734	72.734	58.742	72.734	72.734	58.742
Average:	9.517	12.382	6.431	9.517	12.382	6.431
SD:	14.526	16.945	10.579	14.526	16.945	10.579
Broj uzoraka:	175	92	83	175	92	83

Ceratophyllum demersum L. - PCA

	Ceratophyllum demersum L.					
Naziv kolone:	Cer dem			Cer dem - PCA		
Broj ulaza:	134	134+1		17	17+1	
Sekcija:	All	1,2,3	4, 5, 6	All	1, 2, 3	4,5, 6
Max greška:	3.745	1.738	3.618	1.562	2.112	2.236
Min greška:	0.000	0.000	0.001	0.000	0.000	0.016
Izbačeno uzoraka:	%53	%33	%55	%51	%32	%53
Min:	0.000	0.000	0.000	0.000	0.000	0.000
Max:	100.00	81.806	100.000	100.000	81.806	100.000
Average:	17.326	7.775	28.209	17.326	7.775	28.209
SD:	19.928	14.069	20.103	19.928	14.069	20.103
Broj uzoraka:	175	92	83	175	92	83

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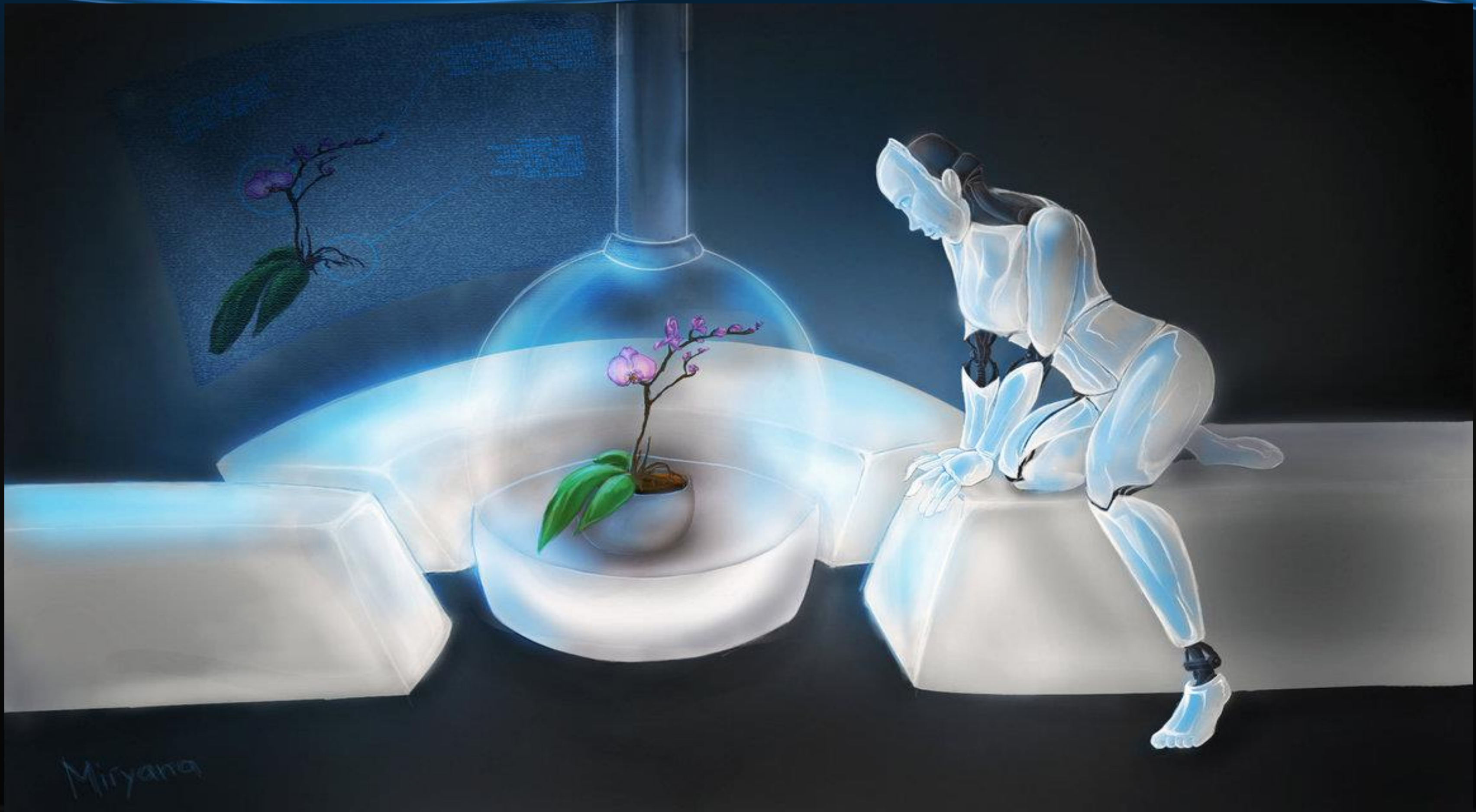
Miryana