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RECLAIMING POLAND'S RIVERINE RESOURCES

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Executive Summary

The overall objective of this project was the development of a verifiable, spatially extensible Geographic Information System model of vegetation, soils, land use, topography, and nitrogen and phosphorus dynamics within the Olawa River watershed in western Poland. We have completed the overall GIS for the watershed, including production of the first comprehensive, digital soil and landuse maps for this area. Other research objectives completed were: publication of a new GIS based biodiversity conservation plan, integration of LANDSAT Thematic Mapper data into the Olawa GIS, and development of a riverine macrophyte GIS for the Olawa watershed. These activities resulted in the training of ten Polish scientist in addition to the Principal Investigators, publication of eight refereed papers, and presentations at four national or international meetings.

We view our two main research accomplishments, that of the *Olawa Watershed GIS* and *Biodiversity Conservation*, as complementary, since ecosystem functioning relative to environmental quality is increasingly being seen as linked to community level biodiversity. Thus, improved management of endangered or threatened species assists in regional efforts to improve water quality and soil conservation. However, of primary importance in the broad spectrum of resource management issues we have become involved in, has been the advancement of technological training in Geographic Information Systems applications. This remains our strongest accomplishment and that which will have the greatest effect on Polish environmental and resource management institutions.

Research Objectives

1) *Olawa Watershed GIS*

Both on-going efforts in natural resources management as well as decisions made in response to sudden changes in environmental conditions make necessary the use of new technology allowing immediate evaluation of threats to, and the state of, natural resources. For example, the worsening state of river water quality (Mysiak 1994) demands the amassing and processing of an enormous amount of different kinds of data.

Geographic Information Systems (GIS), also known as Spatial Information Systems, make possible the creation, preservation, presentation and analysis of spatially relevant data. These data bases and the models built with the help of GIS enable scientists to create new ties between processes and phenomena separated by time and space, ties which are often impossible to create using standard methods. GIS is a technology with a remarkably interdisciplinary character, bringing together the most advanced computer hardware, highly specialized programming and highly qualified personnel (Burrough 1986). GIS finds direct application not only in geographical research, but has become the leading technology in natural resources management, partially replacing traditional methods (Marble 1985, Johnstone et al. 1988, Johnson 1990, Bridgewater 1993, Mertz 1993, Smith and Blackwell 1980).

The goal of this research objective was to develop a GIS model for application to the resource managment efforts in the area of the Olawa River watershed, with particular consideration paid to the quality of the surface water. This area was not chosen by accident, for the Olawa and its tributaries constitute one of the major sources of drinking water for the inhabitants of Wroclaw and its environs, as well as of Strzelin, Olawa, and other, smaller localities. Research has indicated that the natural environment in the region of the Olawa River is severely degraded, and the ways in which the surrounding terrain are being used negatively impact the quality of the surface water.

2) *Biodiversity Conservation*

Rare plant species are becoming extinct at an accelerating rate in Poland. Effective conservation of threatened species will require the acquisition, storage, monitoring and display of diverse ecological data. As environmental stresses have increased, and standard management techniques have become insufficient and cost ineffective, advanced computer based mapping technologies are proving an important tool in understanding and reducing the loss of biodiversity (Marble 1984, Davies et al. 1990). In particular, Geographic Information Systems have significant applications in biodiversity conservation (Johnson 1990). Our objective was to design a GIS for the acquisition and analysis of spatial data within a biological context. In particular, our goal was to assist in the preservation of protected plant species within the civil parish Dobroszyce.

Methods and Results

Olawa Watershed GIS

Database structure

The data that formed the basis for the GIS in the Olawa River region consisted of:

- Landstat TM satellite photographs with a range of 30 x 30 m
- Topographical maps (scale 1:50,000)
- Soil maps (scale 1:25,000)
- Results of water analyses of water in 13 survey control areas
- Methods of watershed management

On the bases of these data were created the following overlays:

- Digital model of the territory
- Soil map
- Land use map
- Hydrological network map
- Transportation network map
- Water quality map of the Olawa

Satellite pictures are generally the main sources for verification and modernization of existing but not always current topographical and topical maps. Our GIS was created using a programming system from Environmental Systems Research Institute (USA) - PC ARC/INFO v.3.4, ARC/INFO v.6.1 and ERDAS Imagine v. 8.1, for the work station SUN Sparc 2.

GIS application

The GIS data base constructed for the Olawa River region allowed us to analyze both real and potential threats to the natural environment. Simultaneously, GIS made possible the quick presentation of the state of the environment, for example of water quality, both to experts and to the general public. It also made it possible to update data almost immediately. Below is presented our application and use of GIS for research purposes.

Figure 1 presents the digital elevation model of the watershed. The northern part of the watershed is characterized by a slight incline from 0 to 3 degrees, but in the southern part the drop off is much larger, reaching 15 degrees. The shape of the land causes the surface run-off which determines the quality of the water to be the greatest in the mountainous part of the river, and therefore in the presence of intensive agricultural activity the most important influence on the pollution levels in the Olawa's waters.

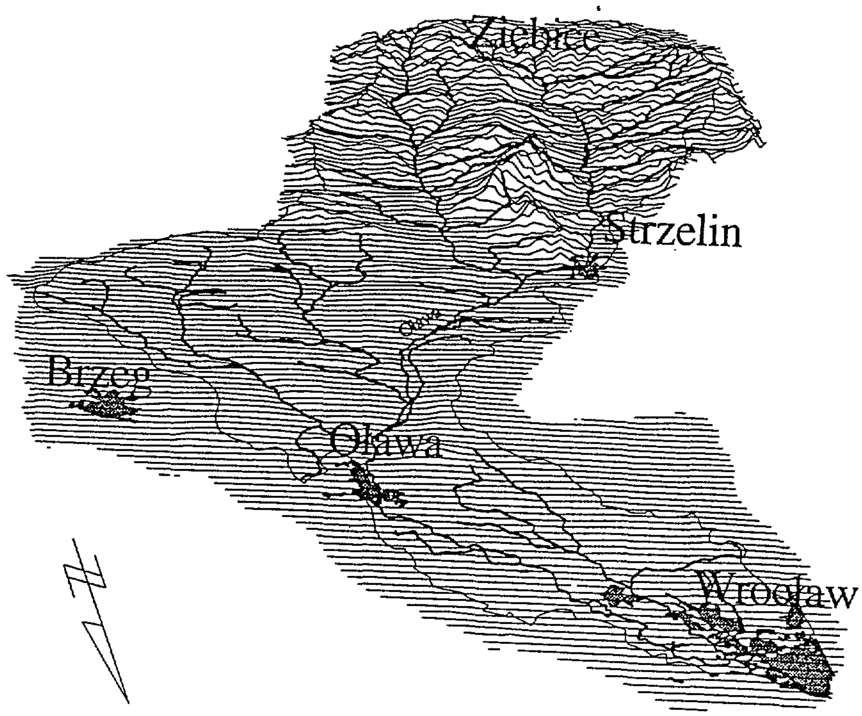

Figure 1 - Digital elevation model for the area of the Olawa River watershed.

Figure 2 illustrates how lands within the watershed are utilized on the basis of existing topographical maps and Landstat TM satellite photographs. The majority of the watershed is used for agriculture. The intensive agricultural activity is the cause of the pollution which in turn is the main cause of poor water quality. Figure 3 shows the phosphorous content in the soil. The highest concentrations of this element are found in the partial watersheds of the Krynka and the Zielona rivers. Similarly, Figure 4 shows nitrogen levels in the soil. These indices reflect the use of the land in the watersheds. Cultivated land constitutes 70% of the Krynka subwatershed and 87% of the Zielona's. The areas with the lowest levels of nitrogen and phosphorous are those directly at the mouth of the Czerna and Cienkowka streams as well as the partial watershed of the Cienkowka. Cultivated lands in these subwatersheds make up 62% and 58% of the areas respectively. Both of these subwatersheds are characterized by the highest degrees of afforestation of all the partial watersheds; 26% and 32% respectively.

Figure 5 presents an example of the use of GIS for the visualization of the present state of the environment. Figure 5a shows the location of the water quality control stations along the Olawa, and Figure 5b illustrates the change in BOD in the river, one of the basic indices by which water quality is judged. Taking into consideration the BOD levels, only in the area 11 km from the source of the river does the Olawa's water satisfy the conditions for Class I water purity. In the remaining sections the levels belong to the II and III Classes. An advantage of using the GIS for the presentation of these data is that it is

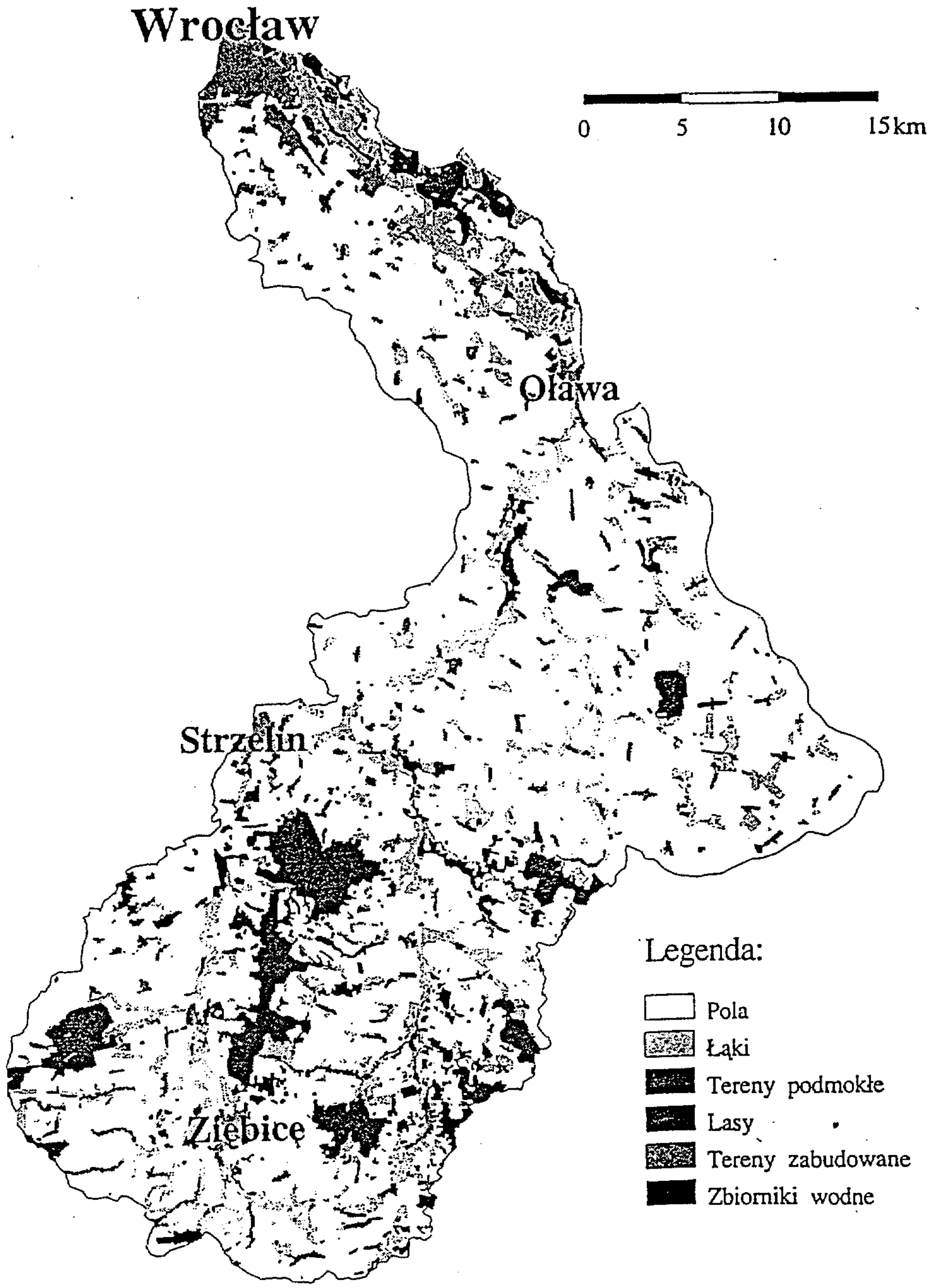

Figure 2. Land use of the territories in the Olawa watershed

pola -fields	lasy - forests
laki - meadows	tereny zabudowane - built-up areas
tereny podmokle - wetlands	zbiorniki wodne - reservoirs

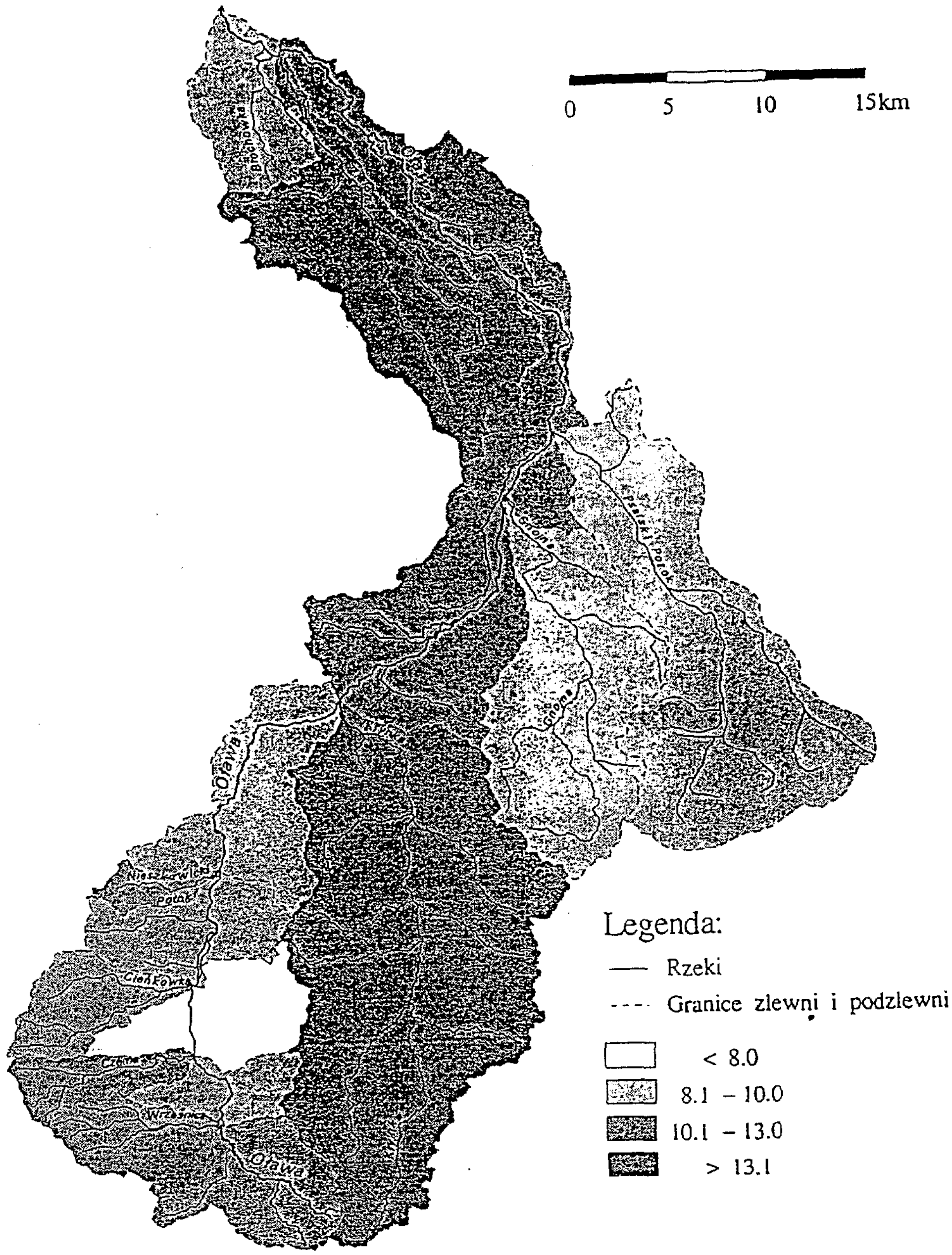

Figure 3. Phosphorous levels in parts of the Olawa watershed
rzeki - rivers, zlewni - watersheds, podzlewni - subwatersheds

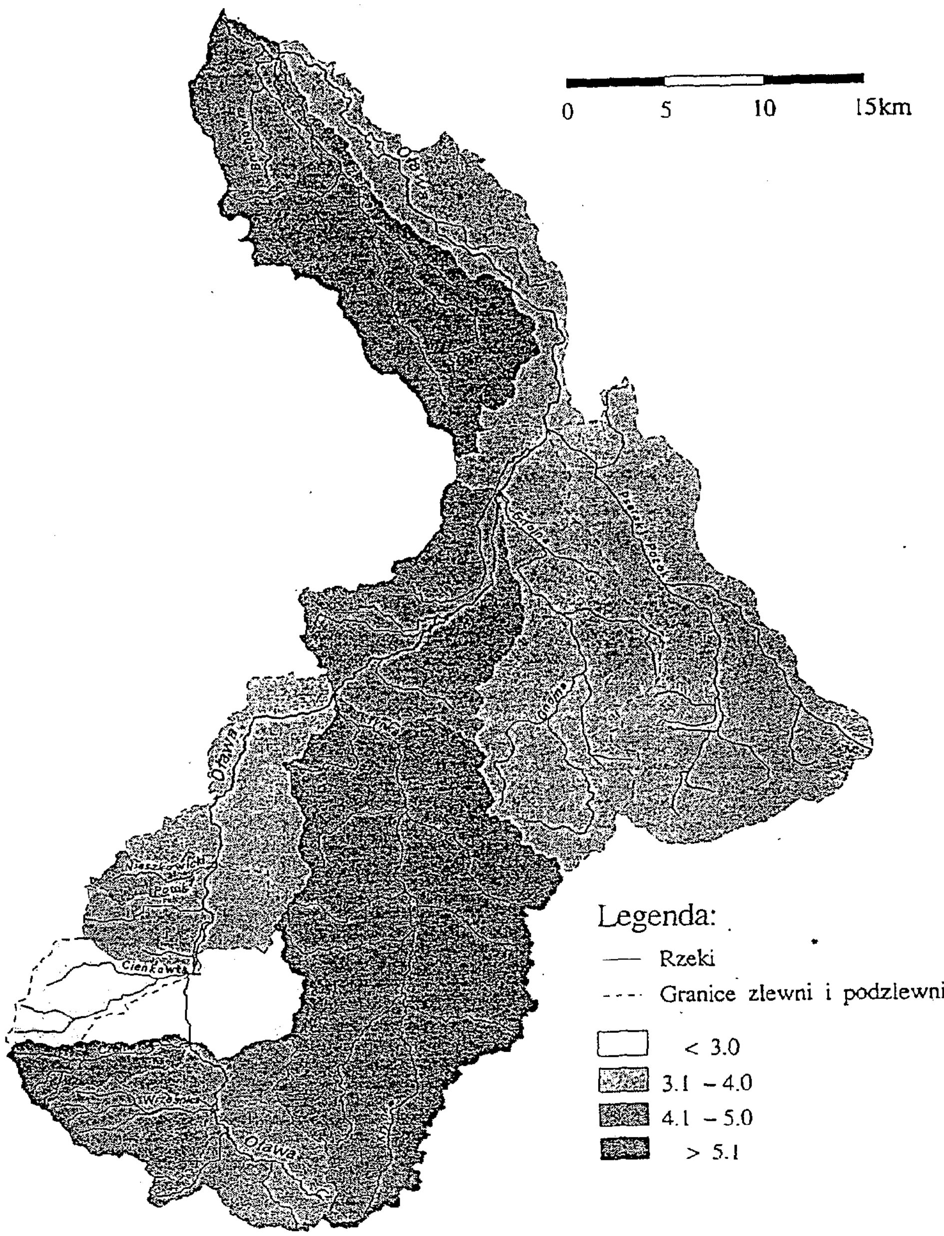

Figure 4. Nitrogen levels in parts of the Olawa watershed

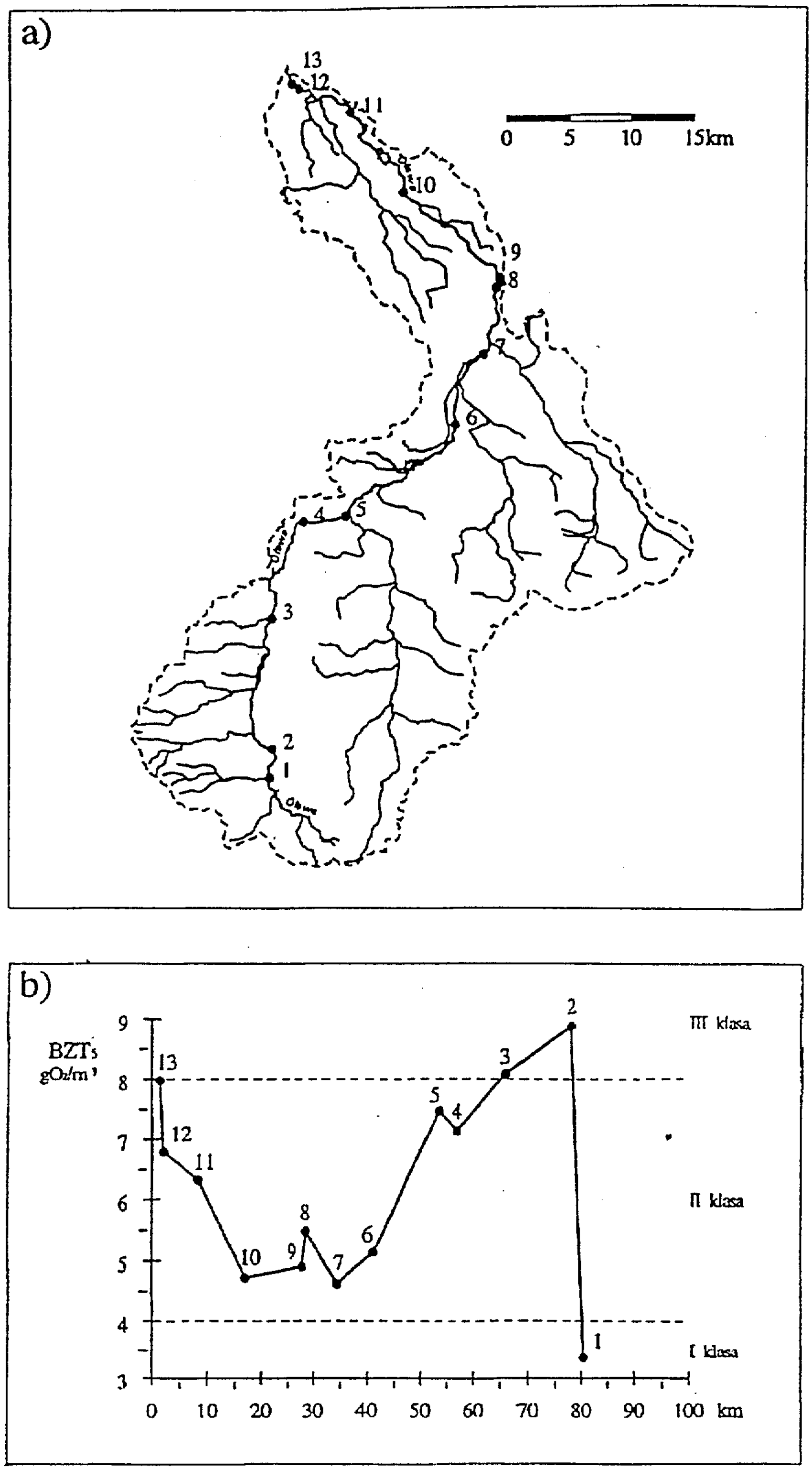

Figure 5. (a) Arrangement of the water quality monitoring stations in the Olawa region (b)changes in BOD values in the waters of the Olawa

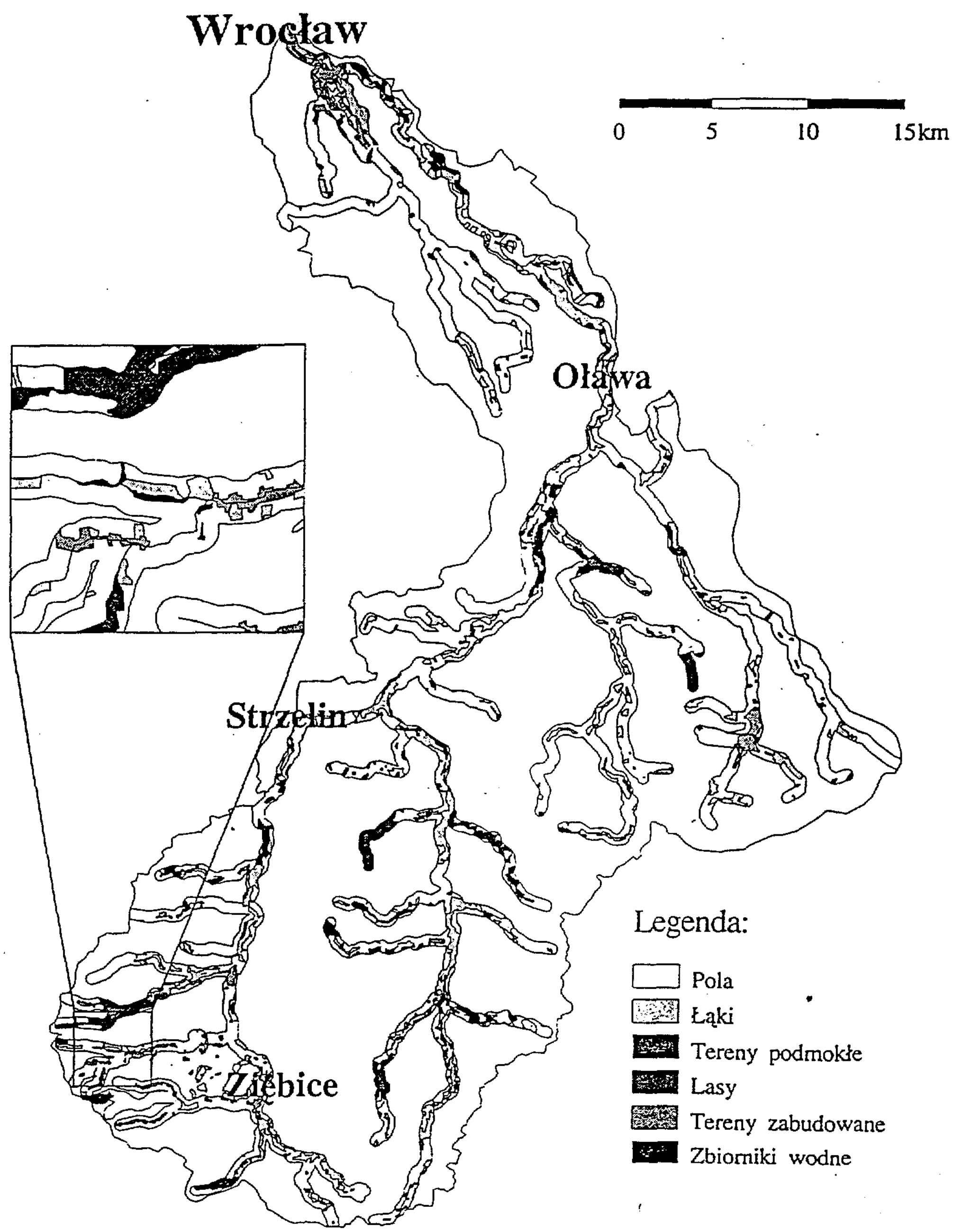

Figure 6. Regions within a buffer of 300m surrounding the main waterways of the Olawa watershed. In the enlargement is the buffer for fragments of the partial watersheds of the Cienkowka and Czerna rivers.

possible to quickly introduce the most current information resulting from water monitoring systems.

As these and other data show, landuse directly bordering the waterways greatly affects water quality (Osborne 1988). For this reason it is important to recognize the conditions that dominate in a particular area and to make special note of the places requiring particular restoration efforts. One of the fundamental advantages of the GIS is that it is possible to quantitatively analyze buffer regions. Figure 6 is a map showing the use of the lands within a 300m buffer surrounding the waterway.

From these maps we can see that the greatest part of this buffer region is cultivated fields (64%) which can cause a severe eutrophication of surface waters. Only 6% of the land in the buffer is bordered by towns or cities. Because the majority of the towns in the watershed region do not have fully efficient sewage treatment facilities (Szyjkowski 1993), they are an additional cause of pollution. Forests make up 10% of the buffer, and wetlands, which are the most valuable from the point of view of preserving water quality, make up less than 2% of the buffer.

Such a system of land use is bound to bring about unwanted, unprofitable changes in the water quality of the Olawa. The area of the buffer requires conservation and restoration measures as quickly as possible. The natural component of the vegetative cover must be preserved as a natural filter for regional pollutants. It is also necessary to allot land to so-called "ecological corridors" which would join together as-yet untainted lands. As funds become acquired, lands intended for cultivation should be purchased or at least be spared intensive fertilization and used as a means of preserving vegetation. In this particular case, it would be necessary to buy up land, or at least change how the land is used, in an area of 186 sq. km.

Biodiversity Conservation

<u>Database design</u>

The biodiversity database incorporates two major components: descriptive data and digital maps. Descriptive data were obtained from a data set compiled by the Department of Nature Protection, Wroclaw Vojevodaship as a local inventory of protected plant species (Dajdok 1993). For each protected plant species found in the area this data set describes the location of each population, major land use category of that location, the local habitat/biotope and accompanying plant species.

Spatial date were entered into the GIS as separate thematic layers by digitizing topographic and soil maps in the scale 1:25,000. The following data layers were used: stream network, transportation network, land use categories, soil types, and species range. For spatial overlays of thematic layers, transportation networks (excluding railroads) were buffered so as to indicate an average road width of 10m. The GIS model was constructed using a SUN Sparc 2 work station running ARC-INFO (Environmental Systems Research Institute).

Study area

The study region is the civil parish of Dobroszyce in south-western Poland (Fig 7). The parish covers an area of 13,174 ha with a population of 5,874. Previous work indicated that two land use categories comprised 90% of the parish: agriculture (50%) and forests (43%)(Rocznik 1993). Table 1 details the land use/habitat distribution determined from the GIS database.

Table 1 Land use/habitat categories evaluated on the basis of analysis of the parish GIS model.

Land category	Area (ha)	% of total area
Agriculture	5507	41.66
Forest	5796	43.84
West forest	52	0.39
Meadow	1324	10.02
Wet meadow	46	0.35
Urban	417	3.15
Water bodies	14	0.11
Orchard	38	0.29
Park	22	0.17
Cemetery	2	0.02

Risk Assessment

Important threats to plant species in this area include environmental disturbances due to agriculture and urbanization, as well as nonpoint-source pollution. In our analysis we distinguished three basic categories of threats: agriculture, urban and transportation. We assumed a minimal distance of 150 m that should be maintained around each population as a safety buffer. This buffer zone was then searched to identify spatial objects belonging to any of the three major threat categories and to calculate their area (= critical area).

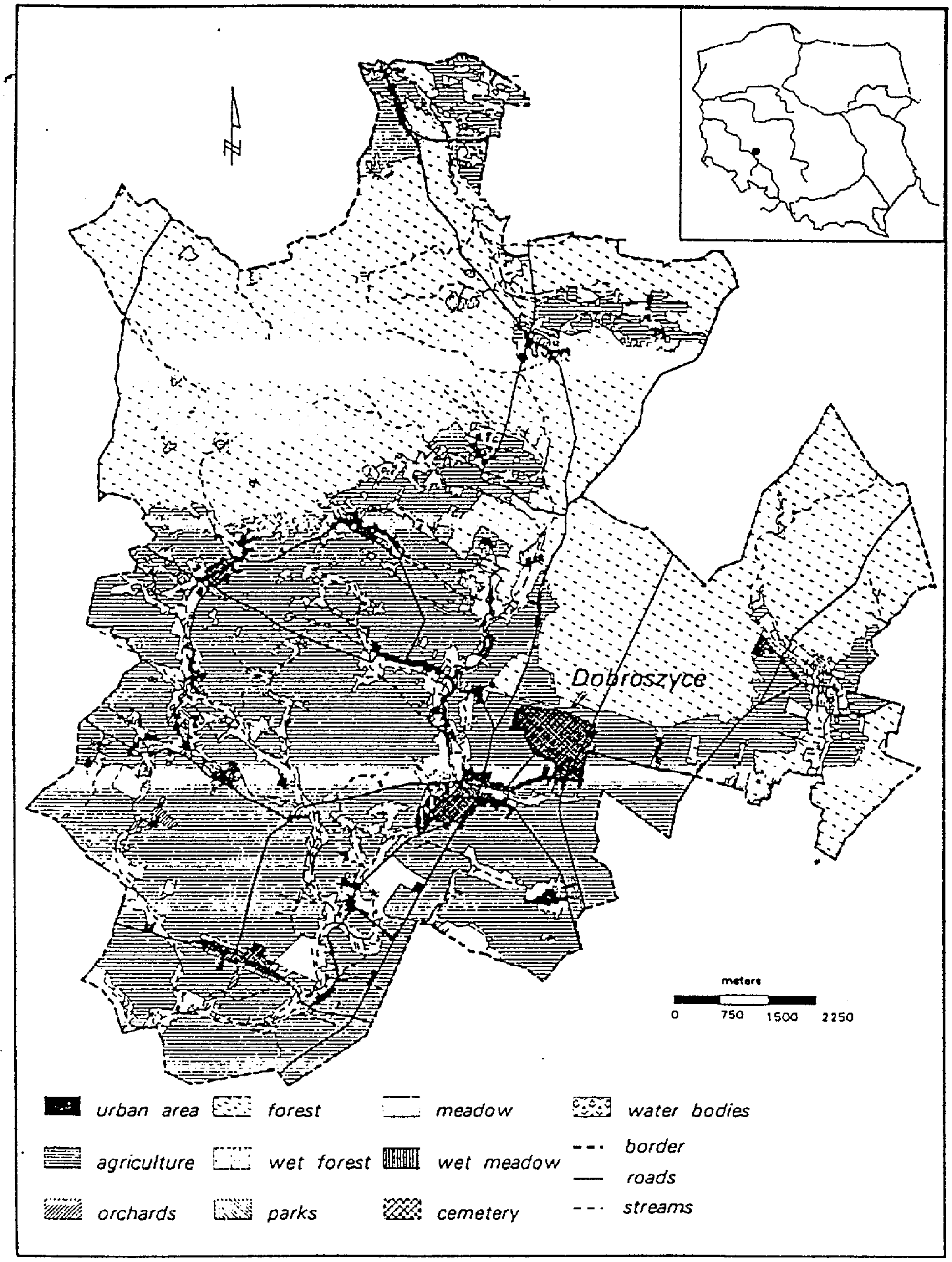

Figure 7. The study area - parish Dobroszyce and landuse/ habitat categories

We used two basic models for risk assessment of the protected species: 1) a qualitative model that tested for the presence/absence of a population within a critical area, and 2) a quantitative model that accounted for the size of each critical area by calculating the degree of habitat degradation (DHD) in each buffer zone:

DHD = TCA/TBA

where:

TCA = total critical area within the buffer zone
TBA = total buffer zone area.

This yields a numerical index, with range 0-1, where one indicates that a population fell completely within a critical area and zero indicates no direct influence from threats. For cost analysis modelling, the vector database was converted to raster structure with a grid resolution of 5m. Land categories were ranked in artificial cost units with the highest cost assigned to urbanized areas and the lowest assigned to habitat types suitable for the species.

Results

The species considered in this study were selected from state protected species listing. Twenty seven plant species were found in the study area occurring in 185 separate populations (Table 2). Three plant species were included in the Red List of Threatened Lichens/Vascular plants of Poland. Each of these species, and seven species not on the Red List occur only in one location in the parish. The most abundant plant species exist in 17 to 29 sites (Fig. 8).

In terms of species rarity (i.e. the ratio: number of populations for a given species/total number of protected species' populations), 37 species are exposed to a high risk of extinction. The spatial overlays of buffered populations and critical areas generated the basic data for risk assessment for the species. Figure 9 summarizes the status of all rare species in the parish in terms of calculated degree of threat. The qualitative data describes the percentage of each species' populations that were present within critical areas, regardless of the size of the affected area. Only five species are not directly endangered (i.e., all populations fell outside of critical areas). Eleven species had all populations fall within the critical areas (=100% threat).

The results present a general view of the environmental risk to which the species were exposed. Eight out of eleven species with the highest threat index occurred only in one location. Further refinement of these data were obtained from the quantitative model wherein the buffered zones around each population were overlain on land use category, the DHD calculated, and DHDs summed for each species (Fig. 9). The results indicate that the most endangered species was *Ornithogalum umbellatum*, for which 80% of the total area of the population buffer zone is under the influence of major threats. This species, which occurs in a single location, is clearly the first candidate for prompt conservation action. *Digitalis purpurea*, for example, also was represented by only one population but was relatively less endangered. A detailed examination of the status of *Viburnum opulus* within the parish is shown in Figure 10. Symbol size indicates the degree of threat for each population. The most important source of threat for this species was agriculture (89%), urban areas and transportation were less important with 7% and 4% threat respectively.

Table 2 Protected plant species recorded in parish Dobroszyce.

Species	Abrv.	No. of populations	Status*
Asarum europaeum L.	Asar	2	†
Centaurium erythraea Rab.	Cent	3	†
Cetraria islandica (L.)Ach.	Cetr	5	†V
Convallaria majalis L.	Conv	13	†
Dactylorchiza majalis (Reich) P.R. Hunt & Summerchayes	Dact	19	†
Daphne mezereum L.	Daph	17	†
Dianthus superbus L.	Dian	1	†V
Digitalis purpurea L.	Digi	1	†
Epipactis purpurata J.E.Sm.	Eppu	1	†R
Epipactis helleborine (L.) Crantz	Epla	3	†
Frangula alnus Mill.	Frn	27	†
Galium odoratum (L.)Scop.	Gali	1	†
Gladiolus imbricatus L.	Glad	1	†
Hedera helix L.	Hede	4	†
Helihrysum arenarium (L.)Moench	eli	1	†
Ledum palustre L.	Ledu	2	†
Leucojum vernum L.	Leuc	1	†V
Listera ovata (L.)R.Br.	List	1	†
Lonicera peryclymenum L.	Loni	7	†
Lycopodium complanatum L.	Lyco	1	†
Lycopodium annotinum L.	Lyan	11	†
Lycopodium clavatum L.	Lycl	8	†
Ornithogalum umbellatum L.	Orni	1	†
Phallus impudicus L. ex Pers.	Phal	6	†
Ribes nigrum L.	Ribe	16	†
Viburnum opulus L.	Vibu	29	†
Vinca minor L.	Vine	3	†

*List of threatened lichens/vascular plants in Poland (Zarzycki et al. 1992)(V-vulnerable, R-rare) State listing of protected species

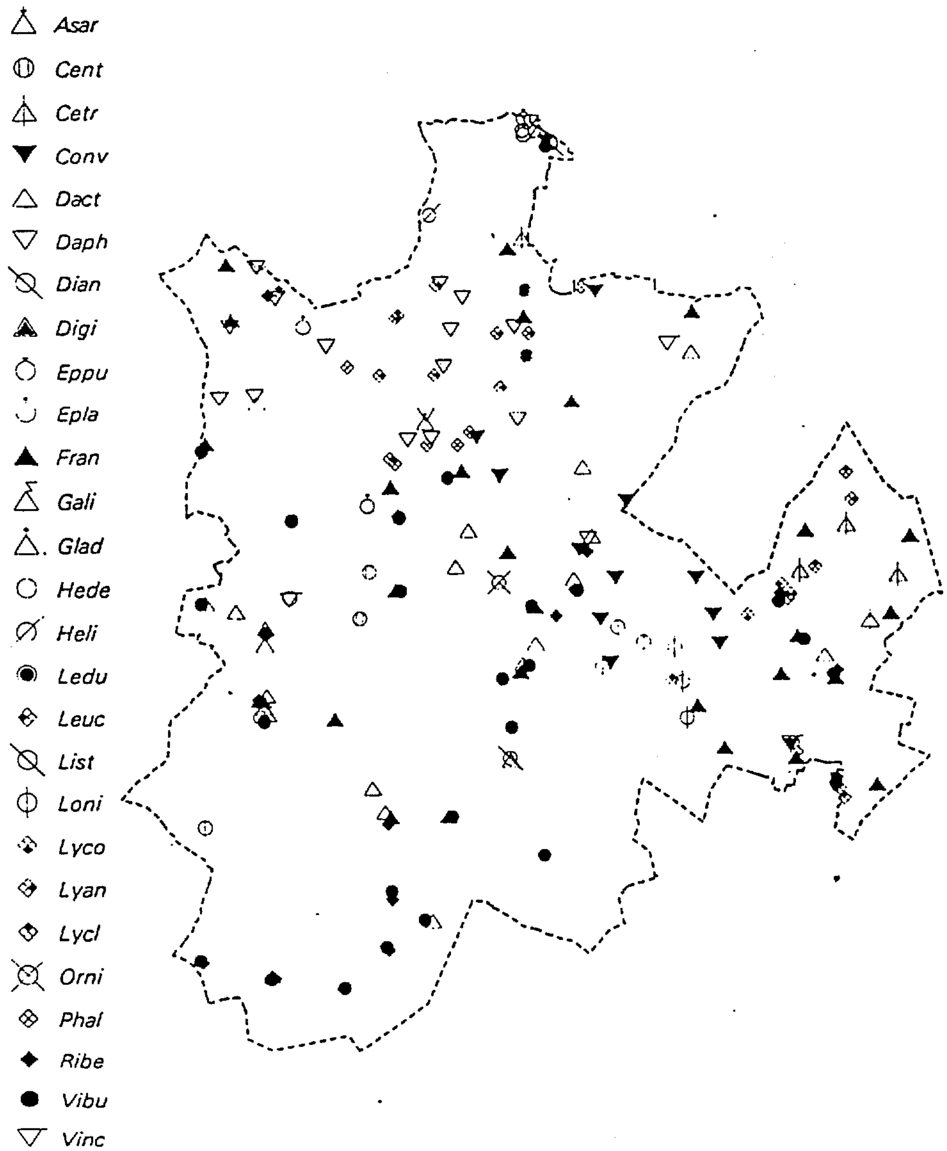

Figure 8. Location of populations of 27 protected species in the parish Dobroszyce.

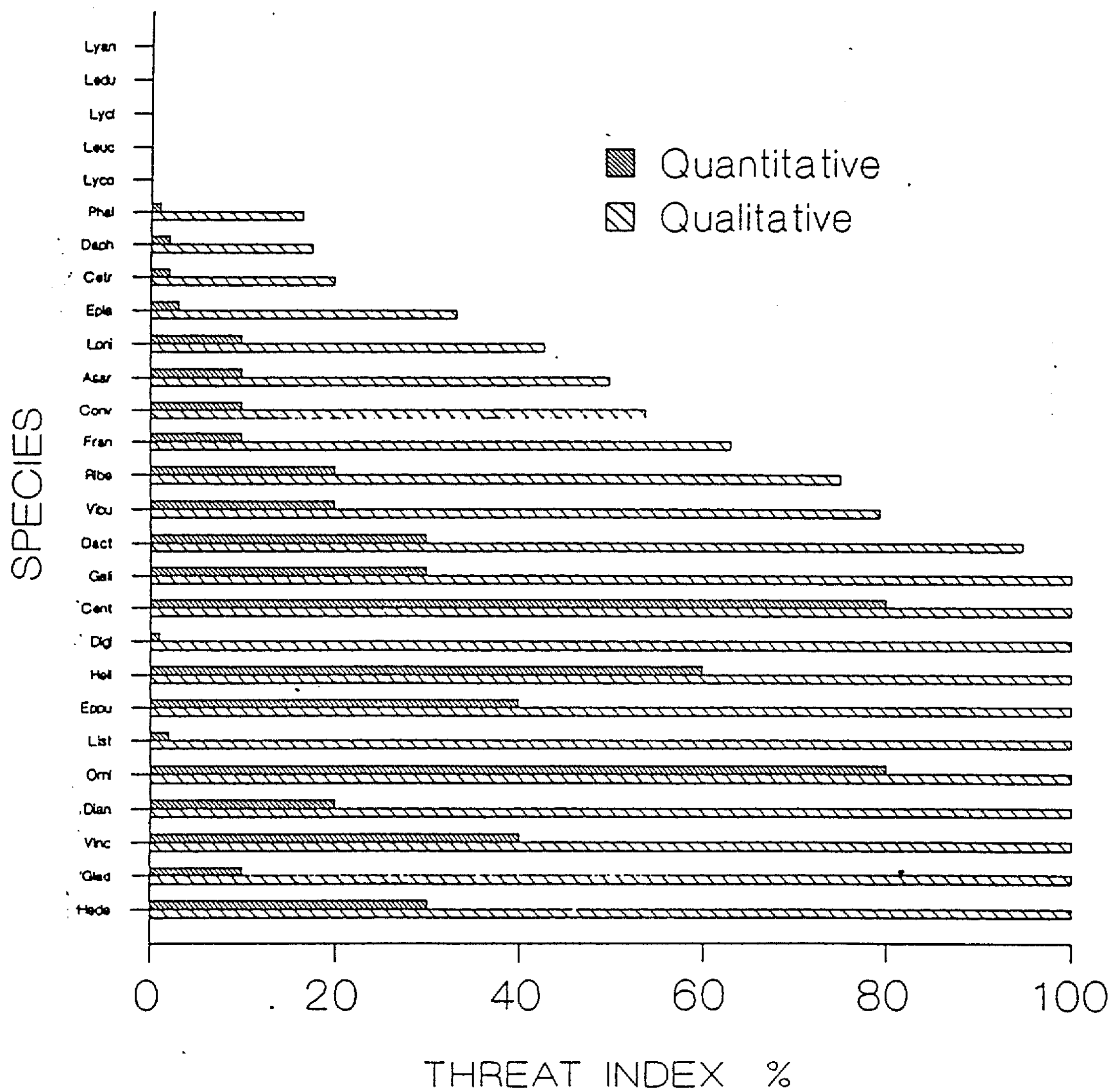

Figure 9. Estimated degree of threat for the studied protected plant species. The values of threat index were obtained by scaling the original qualitative data and DHD values to the range, 0-100.

Local conservation decisions are based not only on ecological criteria but often may require alteration of current habitat structure and hence land acquisition, creating economic considerations as well. Biological and economic considerations must be integrated to obtain realistic and cost effective environmental management (Miller et al. 1987). We modelled the ecological corridor connecting three disconnected populations of *Viburnum opulus* (Fig 10). Our goal was to determine the smallest cost for a conservation corridor among the populations. We modelled a 50m wide zone that fulfilled both the biological needs of the species and required minimal investments into restoration of the area. We assumed that a least cost path should combine the preferred habitat for *Viburnum opulus* (i.e., areas around streams) and should minimize areas that might be difficult to restore or purchase (e.g., urban areas and crop fields). Within the corridor, only six of the areas represented high cost land requiring alteration while the rest of the areas constituted natural habitat for *Viburnum opulus* (Fig. 11). This analysis could help minimize the costs of future conservation management decisions.

Impact, Relevance and Technology Transfer.

Olawa Watershed GIS

Construction of the Olawa River watershed GIS allowed contemporary, on-going activity to improve the state of the environment in this area. This GIS satisfied all of the conditions of relational, open data bases, and it was therefore possible to bring together new types of information. In particular, the concrete realization of the GIS data base in this project made possible the importation of the majority of existing data bases like DBASE, TIGER and ORACLE. It is also possible, in light of fairly low cost, to bring together current information on the changes in the state of the natural environment of the watersheds on the basis of satellite and airplane photographs.

Our examples of the use of the GIS are only a small part of the possibilities of this technology. GIS is also a powerful instrument that can be used to model natural processes (Goodchild et al. 1993). It allows the simulation of many scenarios and the forecasting of effects of management changes, for example changes in water quality caused by increasing surface run-off (this study, Heidtke and Auer 1993). GIS is a technology that has and will continue to serve to improve environmental conservation efforts in Poland.

Biodiversity Conservation

GIS has already proven its utility in the management of environmental data (Miller 1986, Miller and White 1986, Nisbet et al. 1993). Our results in this research objective demonstrate that adding spatial information to simple descriptive data greatly enhance the information content of the database. For our analysis we used a data set from a study that did not anticipate its use in a spatial information system. Yet, the design and creation of GIS for biodiversity conservation is a complex task and one that should have a

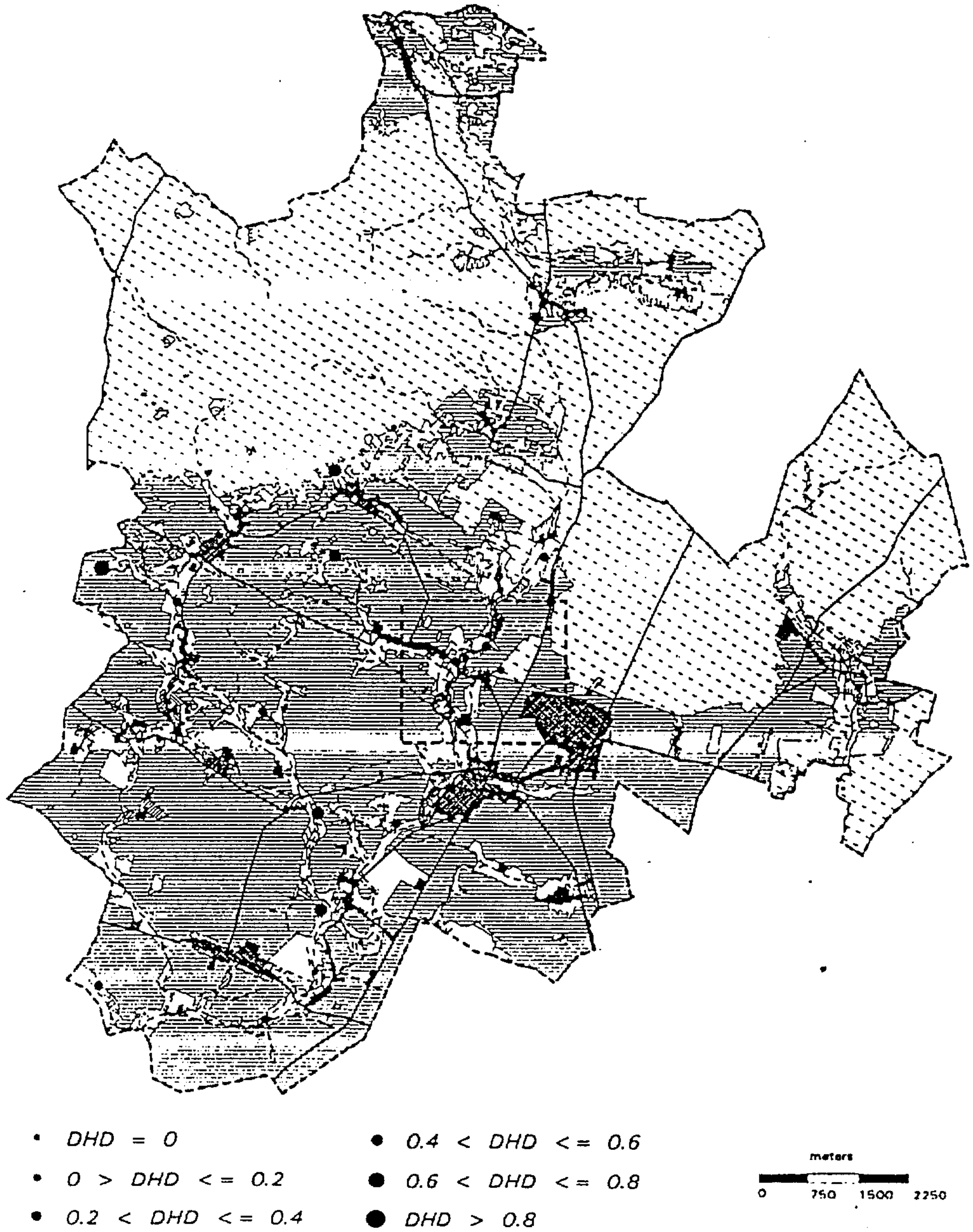

Figure 10. Distribution of populations of *Viburnum opulus* within the parish Dobroszyce. Symbol size indicate the degree of the species habitat degradation. Area highlighted by dashed line was used for least cost simulation. Land use as in figure 7.

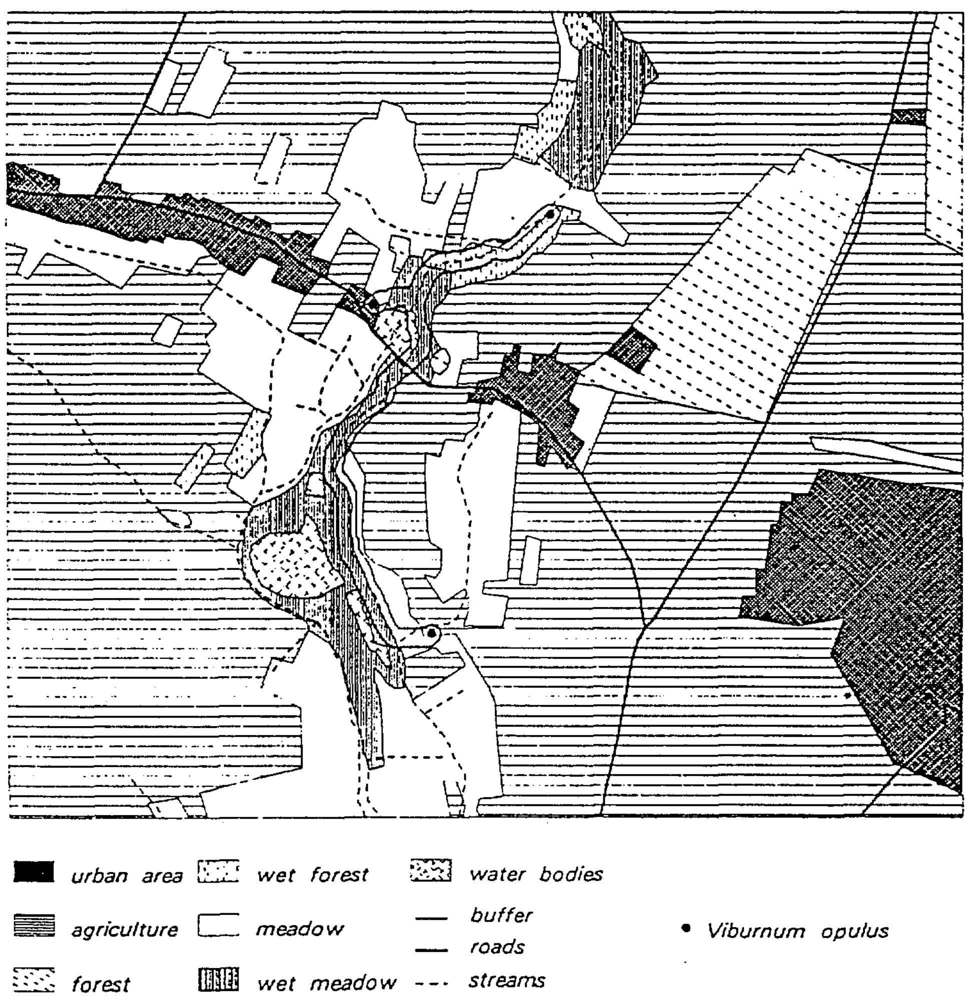

Figure 11. Simulated least cost ecological corridor joining 3 populations of *Viburnum opulus*. Land use categories as in figure 7.

significant impact on the method of data collection and utilization. As inventories of protected plant species are extended over Poland we strongly recommend development of one unified strategy for data acquisition with a GIS for rare plant species conservation the ultimate goal.

Project Activities/Outputs

Meetings

Polish Hydrobiological Society, April 1993. GIS for Olawa watershed. Presented by P. Sendecki at Marshall Foundation sponsored symposium, 'Environmental Partnership for Central Europe'. Wroclaw, Poland

Conference on Geographical Information Systems in Environmental Studies. Organized by: The Institute of Geography, Jagiellonian University, Krakow, Poland, the Department of Geography, Salzburg University, Salzburg, Austria, and the Polish Geographical Society, Warsaw, Poland. 25-27, November, 1993, Krakow, Poland.

GIS in Ecological Studies and Environmental Management. International GRID conference, Warsaw (Sept. 26-28, 1994).

Annual meeting of the Polish Botanical Society, Krakow (June, 1995).

National meeting, 'Climatological problems of environmental conservation in mountain regions', organized by the Institute of Geography, Univ. of Wroclaw, and the Commercial Nature Conservation Bank, 1995. Among participants were Scientific Director of Karkonosze Mountains National Park and Representative of Governmental Institution : National Institute of Forestry

Training

Dr. Zbigniew Boryslawski (1992-1996). Participated heavily in all phases of the research accomplishments. Traveled to Ohio State Univ. where he trained in GIS technology, organized and staffed a new Laboratory of Numerical Methods in Ecology at the Univ. Wroclaw. He has promoted the use of Geographic Information Systems technology in natural resources management within both the University and local municipal and regional governmental agencies. Among other specific activities, Dr Boryslawski developed a GIS for protected areas and in April, 1996, visited the GIS Center in the University of Salzbur where he discussed GIS and natural resources management and presented the results of his work.

Dr. Andrzej Szyjkowski (1992-1995). Dr. Szyjkowski, as director of the regional Institute of Meteorology and Water Management, has provided the project with water quality data and has expanded his laboratory software to include PC ARC/INFO.

Mr Zygmunt Dajdok (1992-1996). Working for Dr. Boryslawski, trained at OSU, became involved with Landsat and map ground truthing, vegetation mapping, and was the principal architect of our research objective in biodiversity conservation.

Ms. Joanna Nalewaja (1993-1994). Trained extensively in UNIX system management, ARC/INFO, and ERDAS based image analysis in Dr. Boryslawski's laboratory.

Mr. Emil Zyszkowski (1993-1996). Mr. Zyszkowski began his GIS training in Dr. Boryslawski's lab, focussing on remote sensing applications in general, and the integration of Landsat TM data with the Olawa GIS in particular. He participated in one week training in use of ERDAS OrthoMax in Warsaw organized by German Comp ecosystems LTD, December 1995, participated in Annual Meeting of Polish Society of Remote sensing held in April 1996 in Szymbark, and gave a short paper on our experience in use this software during the meeting of ERDAS Imagine users in June 1996.

Mr. Piotr Limisiewicz (1994-1995). Mr. Limisiewicz has been involved in the GIS lab with the analysis of groundwater profiles within the Olawa watershed.

Mr. Darek Kladoczny (1994-1996). Mr. Kladoczny specialized in Digital Elevation Models following training in the GIS lab and now pursues a PhD degree.

Mr. Pawel Sendecki (1993-1995). Received a year of graduate training at Ohio State, then became involved in the analysis of aquatic macrophyte communites along the lower Olawa River and adjoining subbasins.

Mr. Andrzej Krukowski (1994). Received GIS training, applied these methods to problems in forest ecology and participated in assessment of subwatershed Riparian Community Index for all streams.

Ms. Krystyna Stoewa (1994-1996). Received training as a UNIX systems administrator in Dr. Boryslawski's lab.

Ms. Joanna Gocol (1995-1996). Ms. Gocol has trained in the use of GIS in the analysis of phytosociological data.

Mr. Jerzy Gotowala (1995). Mr. Gotowala benefitted from laboratory resources for the analysis of GPS devices in geological mapping.

Publications

Boryslawski, Z.R., P.S. Curtis, M.N. DeMers. 1993. The Olawa watershed project: incorporating wetlands and water quality into geographic information systems. In, A. Szyjkowski (ed) Campaign for Biological Restoration of the Olawa River. pp 79-87. Polish Hydrological Society, Wroclaw.

Boryslawski, Z.R., P.S. Curtis, Z. Dajdok, J. Nalewaja. 1993. Linking landscape attributes, wetlands and water quality data through GIS for the Olawa River watershed. In, W. Widacki (ed) GIS for Environment. pp 265-269. Jagiellonian University, Krakow, Poland.

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Boryslawski Z.R., Dajdok Z. 1995 Spatial analysis of endangered plant species. Acta Universitatis Vratislawiensis (in press)

Boryslawski Z.R. Zyszkowski E. 1995. Application of GIS climatological data analysis in Karkonosze Mountains National Park. Proceedings of the Conference "GIS for protected areas" pp.7-21" Kraków

Boryslawski Z.R. 1995 Computer based spatial information systems for nature conservation in the Olawa River watershed. Ochrona Srodowiska (Environment conservation) 2/57:35-42.

Project Productivity

The overall objective of this project was the development of a verifiable, spatially extensible Geographic Information System model of vegetation, soils, land use, topography, and nitrogen and phosphorus dynamics within the Olawa River watershed in western Poland. Over the three year period of this grant, we proposed to incorporate within this GIS landscape, water quality, and wetlands ecosystem data, and to develop a model relating functional aspects of the drainage to observed patterns of river water nitrogen and phosphorus concentration and the integrity of associated wetlands.

We have completed the overall GIS for the watershed, including production of the first comprehensive, digital soil and landuse maps for this area. Collaborative work with the Institute for Meteorology and Water Management (IMWM) resulted in the preliminary integration of water quality monitoring data into the GIS. Other research objectives completed were: publication of a new GIS based biodiversity conservation plan, integration of LANDSAT Thematic Mapper data into the Olawa GIS, and development of a riverine macrophyte GIS for the Olawa watershed.

Key accomplishments over the granting period were:

- The transfer of advanced GIS and computing technology from the U.S. to Poland and the organization of a laboratory at the Univ. of Wroclaw to house this facility.
- The training of the Polish PI, Dr. Boryslawski, and his associates Mr. Zygmunt Dajdok and Mr. Pawel Sendecki, at the Ohio State University.
- Digital database development and model testing.
- Ground truthing of cartographic and remote sensing data.
- Interaction between Polish and American PIs in Poland.
- Publication of eight refereed papers.

We view our two main research accomplishments as complementary, since ecosystem functioning relative to environmental quality is increasingly being seen as linked to community level biodiversity. Thus, improved management of endangered or threatened species assists in regional efforts to improve, for example, water quality or soil conservation. However, of primary importance in the broad spectrum of resource management issues we have become involved in, has been the advancement of technological training in Geographic Information Systems applications. This remains our strongest accomplishment and that which will have the greatest effect on Polish environmental institutions.

Future Work

Several projects are clearly in the future and follow logically from the work accomplished to date. These are:

- Publication of a dedicated volume by the University of Wroclaw summarizing the results of our work over the past 3.5 years.

- Continuation of a joint project with Catholic University Of Leaven, Belgium, and the Dept. of Archeology, University of Wroclaw, on the use of GIS in archeological studies and nature conservation within the Kopanica River Valley, a unique conservation site in Europe. Currently we are digitizing topo maps and ground truthing satellite images.

- A proposal to the Flemish Government for a grant the basis of the Polish - Belgium Scientific agreement was submitted, with the chances for funding being very good.

- Travel to the laboratory of Dr. Susan Ustin, Univ. of California, Davis, by Dr. Boryslawski for the purposes of acquiring advanced remote sensing training.

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