SECOND YEAR ACTIVITIES REPORT EC Contract number ERB IC18 - CT98 – 0262

UNIVERSIDAD NACIONAL DEL CENTRO DE LA PROVINCIA DE BUENOS AIRES (Partner 3)

Scientific Coordinator: Dr. Graciela Ana Canziani

The group at UNCPBA is formed by:

Dr. Graciela Canziani, Professor, Mathematics and Mathematical Ecology,

Ing. Rosana Ferrati, Engineer in Water Resources and Graduate student in Mathematics,

Lic. Paula Federico, Graduate student in Mathematics,

Ing. Ana Canonica, Systems Engineer, (*left the group on Nov. 30, 1999, moving to Buenos Aires*). Diego Ruiz Moreno, advanced student in Computer and Systems Engineering (*joined this group in Nov. 1st, 1999*).

And also by other Faculty members who devote part of their research time collaborating in the project:

M.Sc. M.V. Fernando Milano, Professor, Natural Resources and Sustainability, Facultad de Ciencias Veterinarias,

Dr. Marcelo Gandini, Professor, Ecology, Remote Sensors, Facultad de Agronomía,

Dr. Roberto Sanchez, Professor, Environmental Management, Facultad de Ciencias Humanas.

Professors Canziani, Milano and Sanchez, together with other researchers of the University, have presented a proposal for the creation of an interdisciplinary research group called *Centro de Investigacion y Desarrollo en Ecosistemas*, which is currently under study by the authorities. Hence, Dr. Canziani and her group no longer participate in NUCOMPA's activities.

As stated this group participates in the development of several different tools and models to be used by other project partners:

i.Hydrological models

ii.Dynamic vegetation maps

- iii.GIS to organize in systematic form data provided by previous and present studies on the region
- iv.Population models for several species of macrovertebrates that are particularly important relative to the management of resources.

General Comments

Initially we were able to keep the pace of our work within the work plan and timetable of our project in spite of delays due to the difficulties in having access to historical data records. Some problems we encounter are due to fact that some information is simply <u>non</u> <u>existent</u>. This affects mainly the hydrological models. We already mentioned the problems

due to lack of complete or sufficiently long data series regarding hydrometeorological variables, and the scarcity of data records taken from within the system boundaries.

Regarding the other models, we are expecting field data collections by other partners that have not been completed as yet, particularly in regard to the *marsh deer* and *capybara* species, such as vital rates and population parameters. We are planning on an aerial census for *marsh deer* and *capybara* that will enable us to better tune the parameters in our population models relating, when possible, some of them to habitats.

Some delays in the completion of the GIS were due to missing information in the topographic maps which created problems with the digitalization. Also, the cartographic projections were different from the system used in the satellite images, which forced us to find algorithms that would translate everything into a unique system. We encountered some problems in the georeference of the satellite images due to the fact that they were simulated and errors were introduced that prevented a reasonable overlap of the layers.

One difficult problem originates with the proximity of the wetlands to the Yacyreta Dam on the Parana River, which is separated from the Ibera system by a stretch of sandy sediments of a width of 4 to 12 Km. We believe that the data showing a significant increase in the water levels, which produced a clear change in the water regimes of the Ibera system, can be explained by the fact that the water level at the dam, higher than water level in Ibera, is causing a large inflow into the Ibera system. This means that the need for scientific evidence through the collection of hydrogeological data (wells, permeability of soils, etc.) is **urgent**. Moreover, it is necessary that the authorities acknowledge the need for political measures, such as suspending the plans of further increasing the water level at the dam, in order ensure that the Ibera ecosystem will not disappear.

The point is that any attempt to model the hydrology of system, which is the driving force of the wetland, is hindered by the fact that the control seems to be run by factors that are not possible to predict.

The tasks to be developed by this group and numerous and time consuming, so there is a need for more people working on them. We are trying to involve advanced students in short duration specific tasks. We have obtained the collaboration of Lic. Laura Moreno, from Facultad de Agronomía, who has helped with the digitalization of the topographical maps and the correction of the coordinates of the simulated SAC-C satellite images provided by CONAE. Currently we are hosting an undergraduate student of Geography, Paula Pagano, who is developing her final training work on GIS with us.

Results

GIS and vegetation maps

We are working on the development of several layers in the GIS, including the soil map and the topographic map. We are also analyzing changes in the system by comparing historical satellite images and new images provided by CONAE. As previously stated, our project has been included as part of the SAC-C mission carried on by the National Commission for Spatial Activities (CONAE) together with NASA and European Spatial Agencies. The launch of satellites SAC-C and EO-1, which belong to the Morning Watch Constellation, was delayed several times by NASA, but it was recently confirmed that it will take place next November 16 from Vandemberg Air Base, California. In the meantime, CONAE is providing us with simulated images, which allow us to perform some of the analysis that we programmed.

A SAC–C simulated satellite image was used to define different landscapes as a basis for the modeling of habitat and the dynamics of vertebrate species in the Iberá macro-system. Landscapes definition was carried out using field data and the image (175 m. spatial resolution). We achieved the definition of seven different habitats that will be used in the population model analysis of vertebrate species. Our methodology was based on homogeneous polygons definition on the field through the utilization of GPS data and location of vegetation censuses on a topographic map. This resulted in the definition of seven distinct habitats (lagoons, tidelands, weedlands, and 4 types of dammedlands; see fig. 1) with different characteristic of vegetation coverage and anegability corresponding to different habitat suitability for vertebrate species (Table 1) (Waller 1999 per. com.). Recently, our colleagues Beccacesi and Waller provided more information on species specific habitats that will be incorporated as refinements to this classification.

CLASS DISTRIBUTION FOR SELECTED AREA				
	Class	# samples	Percent	Class reliability
1	Lagoons	68111	3.0	99.9
2	Embalsado 1	52624	2.3	64.3
3	Embalsado 2	213950	9.5	95.8
4	Embalsado sph.	137723	6.1	71.4
5	Estero	65163	2.9	98.6
6	Malezal	1090909	48.4	85.1
7	Crop land	568777	25.3	100.0
8	Embalsado 4	55005	2.4	94.0
	TOTAL	2252262	100.0	

Table 1

The confusion between different habitats is acceptable: it is within a range between 92.5 % and 100% for five habitats, and 50 to 66% for two very similar types of dammedlands, with an overall class performance of 98.6%. Therefore SAC - C images appear as a good option to define landscapes in vast zones and of low environmental variability as Ibera and similar wetland systems given their spatial and spectral resolution.

We are using two Landsat images, a 1986 image provided by CONAE and a 1998 image provided by the National Director for Fauna and Flora, in order to establish changes in land use in the Ibera region. As mentioned before, this is being done by an undergraduate

student in Geography, Paula Pagano, who is developing her final training work on GIS with us.



Figure 1: Habitat delimited by maximum likelihood method.

Hydrological Models

The hydrogeological behavior of the Ibera system is not known. The only quantified study done to this date is the one performed by INCyTH in 1981. At that time, there existed

underwater divide at the N and the E of the system, separating Ibera from the Parana River and the Aguapey bassin. The transfer between the Esteros del Ibera and the Esteros de Batel-Batelito was studied in 1978-1979. Some 194 phreatimeters, 92 piezometers, and 24 limnimetric scales were used for establishing monthly results that helped define the ridge line of underground waters, the hydraulic gradients, the runoff directions, and the differentiated behavior accordingly to general geological characteristics. The conclusions of this study show that during this period the flux was stable, with piezometric values of 60 and 74 m., a ridge line running through Tabay-Santa Rosa- San Carlos, and two discharge areas: an Eastern area contributing to Ibera, and a Western area as principal underground collector.

The underground contribution to Ibera, estimated using the Darcy formulation along the 120Km. separating Concepcion from Loreto, was 9.46 Hm³/year, which seems not significant relative to surface contributions. From Concepcion towards the South, the flux is inverted.

The behavior of the system under the present conditions,-- excess of water--, is not known. Our analysis of the data presented in different occasions to the authorities, both at EBY and at the Ministry of Social Affairs and Environment, has been considered the first quantified evidence of unexpected processes that need further investigation. As a consequence, it was accepted that it is essential to perform a new hydrogeological study, both qualitative and quantitative, given the magnitude of the changes observed in the last ten years.

The analysis was possible thanks to our recent acquisition (July 2000) of two sets of precipitation records from within the boundaries of the Ibera system, which allowed us to calculate a surface water balance that shows very clearly that there is an underground influx of extraordinary magnitude that is currently driving the water levels of the system.

Hydrometeorological Annual Balance at system level

This is the initial approach that permitted an estimation of the magnitude of the underground influx.

<u>Asumptions</u>: The system as a whole behaves as a response function whose main characteristic is storage. The main input variables are precipitation and evapotranspiration demand, the main output is the Corriente River. The relationship between surface and underground waters is unknown, since they can behave as input or output at different locations and time. As a first approach, considering an annual time step, we consider storage as the state variable of the system:

Equations:

$$\begin{split} \Delta S &= PA + EA + VSA \\ \Delta S &= \Delta GW + \Delta SW \end{split}$$

where:

 ΔS : annual variation of total storage (surface and underground) PA: annual precipitation

EA: total losses due to evaporation and evapotranspiration VSA: annual volume of surface runoff Δ t: 1 year



The graph show the years of excess and of deficits after discounting potential evapotranspiration from annual precipitation data.



The preceding graph shows the moving average of deficits and excess. It shows a change towards increase since 1968 that corresponds to the tendency observed for the whole Del Plata Bassin.

Hydrometeorological Monthly Balance at system level

It is important to note that this monthly step water balance was possible due to the acquisition of two independent data sets from within the borders of the Ibera system. The first was provided by the owner of Estancia San Juan Poriahu, through Tomas Waller. The second set was obtained after our participation at the Meeting organized by EBY at Ituzaingo last August, provided by Lic. Adolfo Fulquet.

The annual surface water balance explains, as first approximation, the observed monthly average levels at Ibera lagoon (ref. previous report). In order to determine the reasons for the abrupt increase observed in the period 89-90, we calculated a monthly step water balance model using precipitation data from San Juan Poriahu, Yacyreta, and Colonia Pellegrini, computing evapotranspiration with monthly mean temperature data from



meteorological stations located at Posadas, Mercedes and Corrientes (Thiessen poligons), and monthly mean volumetric flow rates at Rio Corriente computed by EVARSA and provided by SERNAH.

The missing temperature data from 1991-94 was replaced by monthly mean values from the period 1960-90. The selected periods correspond to those where all variables were available: 1977-1979, 1987-1988, and 1990-1998.

The absence of data in the period 1989-90, in which the most important change occurred, lead us to search for alternative analysis tools. We analyzed the runoff percentage, the rate Q/P, which made evident the difference in the behavior of the system. During the period



1977-79, the rate Q/P has an average value of 0.2, that is 20% of rainfall runs off through the Corriente River. During the period 1987-88, the average decreases to 0.1, or 10% of total rainfall. Since 1990, the rate increases dramatically, reaching at times values above the unit, with an average of 044, or 44% of rainfall running off through the river. This means that there is **an input of water into the system that does not come from rainfall**.



The following graph pictures the behavior of the system for the data series of 1976-1983 and 1990-1997. The values of the monthly mean volumetric flow rates of Rio Corriente at Paso Lucero are plotted against the hydrometric levels of Ibera Lagoon at Colonia Pellegrini. It is clearly seen that the system is storing a much larger volume of water. The question now is until what limit the Ibera system can hold larger volumes of water and which will be the cost in terms of biota and sediments.

The data needed in order to obtain a continuous function for water balance over the longest period are the volume of water output at Paso Lucero. If we fill in data assuming the worst conditions, that is runoff percentage Q/P equal to 0.1 (10%) we obtain, in the following graph, the comparison between calculated (red) and observed (blue) water level at Ibera.

Once again there is an unexplained difference since 1989, that call for an underground input to the system.



We were attempting the construction of a model based on finite elements method that may help us calculate the flow of water from the Parana River at Rincon Santa Maria. We do not expect Ente Binacional Yacyreta, which controls the dam over the Parana River, to provide the necessary data for the parametrization of the model. In fact, the meetings that took place in Ituzaingo (EBY) and in Buenos Aires (Ministry of Social Affairs and Environment) helped made clear that there is an urgent need for serious hydrogeological research in order to gather the lacking information.

Ecological Models

We expect to complete in the following months the task of verifying the parameters that are used in the *Capybara* models. The first approach was done using data published in research journals and from information gathered from personal communications with experts in these species, mainly Prof. Ruben Quintana (University of Buenos Aires, now at Harvard University). We analyzed the sensitivity and elasticity of the model with respect to these parameters. Next we will validate the models and later tune them using field data provided by partners. We expect to complete the process in the next few months, depending on the availability of field data. As we anticipated, there are some difficulties in the determination of stage or size dependent fertility and survival rates because of a lack of specific studies, but we are estimating them from published data from other regions.

We have also been working on a cellular automata model for the analysis of spatial distribution patterns. The results are promising, and the output is easy to interpret by any user. We are working on cellular automata that includes the definition of different quality indices and local variations in resolution. We expect to use such an approach for the analysis of movement patterns for the *Marsh deer* and *Capybara* populations over the region already identified as the appropriate habitat for the species.

Scientific Exchange

In the month of December 1999, we had the visit in Tandil of Prof. Joao Meyer, partner from UNICAMP, who shared the teaching of a Graduate Course on Finite Elements Method, and taught a Seminar on Finite Differences Method.

During four weeks in March 2000, the *Fifth Course on Mathematical Ecology, including an Introduction to Environmental Economics* took place at the **International Center for Theoretical Physics (ICTP)** in Trieste, Italy. Prof. Graciela Canziani (UNICEN) was one of the Directors of the Course, while Professors Claudio Rossi (Siena), Charles Perrings (York), Vincent Hull (LabRoma), and Dr. Steven Loiselle (Siena) were Lecturers. Prof. Joao Meyer (UNICAMP) contributed with material for a Workshop on Pollutant Dispersion. One lecture, shared by Prof. Canziani and Dr. Loiselle, was devoted to the Ibera Project. Participants Manuela de Castro (UFRGS), Paula Federico and Diego Ruiz Moreno (UNICEN) presented three communications on partial results obtained within the frame of this project.

In June took place in Buenos Aires the *Second Project Workshop*, organized at **Universidad del Salvador**, in which all our group members were present, and collaborators attended at least during some days. Besides presenting some detailed talks on the progress of our research for all partners, we presented a short general overview for

invited public. We also participated in an open presentation for the public of Mercedes, Province of Corrientes, organized by Fundacion Ibera at the Town Hall.

In July, Dr. Canziani gave a conference in an organized session on New Trends in Mathematical Ecology during the 3^{rd} . World Congress of Non Linear Analysts held at the **University of Catania**, Italy, and organized by IFNA.

In early August, the **Entidad Binacional Yacyreta** organized at Ituzaingó an "open" session previous to the meeting of a *Panel of Experts* who were to analyze the problem of flow of water from the dam lake to the Ibera system. Although our group did not receive an official invitation to participate in the session, the Director of the *Instituto Correntino del Agua* asked us to accompany their delegation and communicate our results to the Panel Members. Mr. Ruiz Moreno was in charge of the presentation and later participated in informal meetings with other participants which led to a fruitful exchange of information.

Also in August, took place in Quebec City, Canada, the *Millenium Wetland Event*. Two members of our group, Rosana Ferrati and Marcelo Gandini, communicated results. Ms. Ferrati received full support for her participation from the **Society of Wetland Scientists**.

In September, Paula Federico participated in a Habitat Evaluation Procedures (HEP) course organized by the *Centro de Zoología Aplicada*, *Universidad Nacional de Cordoba*. This proved to be extremely useful in the definition of habitat quality indexes in our metapopulation models, and allows us to be in touch with other researchers working on this problem.

Dr. Canziani was invited to participate in a *Technical Workshop on the GEF-UNDP ARG/00/G41 Proyect* organized at San Juan Poriahu, Prov. of Corrientes. This meeting gathered researchers working in all projects currently being developed in the Ibera region, members of national and local NGOs, and provincial government officials, in order to discuss different ways of action that would lead to the conservation of the Ibera ecosystem, considering in particular the threat of an increase of the water levels of the Yacyreta dam.

Also, the **Secretaria de Desarrollo Sustentable y Politica Ambiental** organized this month a Workshop on the *Environmental Impact of the Yacyreta Dam*, which gathered researchers in several different fields carrying on investigations on subjects related to the area. Dr. Canziani was invited to give a talk on the results obtained in regard to the Ibera system. The Workshop contributed to an enhanced knowledge of both the scientific evidence and the problems encountered, opening the path for future research. One positive point is the awareness of government officials regarding the dangers of decision making on public works without the support of previous environmental impact assessment.

Recently, we have submitted an abstract, on the most recent results obtained on the analysis of the problem of an inflow of water that has changed the behavior of the Ibera system since 1989, to the *Conferencia Internacional Electronica sobre Economía del Agua*, Sección Técnica IV: Agua, Energia y Medio Ambiente. organized by Iberdrola and RedIRIS.es. (http://agua.rediris.es/conferencia iberdrola 2000). Selected manuscripts will be published in CD format.

Publication of Results

COMMUNICATIONS

Metapopulation Dynamics under Density Dependent Disturbances. I: An Analytical Approach.

P. Federico, G.A. Canziani

Fifth Course on Mathematical Ecology with an Introduction to Environmental Economics, ICTP, Trieste, Italia, del 28 de Febrero al 24 de Marzo de 2000.

Metapopulation Dynamics under Density Dependent Disturbances. I: A Cellular Automata Approach

D. Ruiz Moreno, P. Federico, G.A. Canziani

Fifth Course on Mathematical Ecology with an Introduction to Environmental Economics, ICTP, Trieste, Italia, del 28 de Febrero al 24 de Marzo de 2000.

GIS-based object-oriented hydrological model as a tool for the analysis of population dynamics

R. Ferrati, G.A. Canziani, C. Rossi Millenium Wetland Event (<u>http://www.cqvb.qc.ca/wetland2000</u>), Québec, Canada, 6-12 August, 2000.

Landscapes definition for vertebrate modeling in a wetland M.L. Gandini, A. M. Canonica, P. Federico Millenium Wetland Event (<u>http://www.cqvb.qc.ca/wetland2000</u>), Québec, Canada, 6-12 August, 2000.

El Proyecto INCO DC "The Sustainable Management of Wetland Resources in Mercosur"

G. Canziani.

Taller Impacto Ambiental de la Represa Yacyreta, organized by Secretaria de Desarrollo Sustentable y Politica Ambiental, Ministerio de Accion Social y Medio Ambiente. October 27, 2000.

Modelos de balance hidrico para analizar el cambio de regimen en un humedal sujeto a perturbaciones antropicas y climaticas

R. Ferrati, D. Ruiz Moreno, G. Canziani

Conferencia Internacional Electronica sobre Economía del Agua, Sección Técnica IV: Agua, Energia y Medio Ambiente.(<u>http://agua.rediris.es/conferencia iberdrola 2000</u>) organized by Iberdrola and RedIRIS.es in November 2000.

Análisis de modelos metapoblacionales desde la perspectiva analítica.

P. Federico

IV Encuentro de Matematica "Mar y Sierras", organized by Universidad Nacional del Centro and Universidad Nacional de Mar del Plata, November 1-2, 2000.

Análisis de modelos metapoblacionales desde la perspectiva de autómatas celulares. D. Ruiz Moreno, P. Federico, G. Canziani.

IV Encuentro de Matematica "Mar y Sierras", organized by Universidad Nacional del Centro and Universidad Nacional de Mar del Plata, November 1-2, 2000.

TALKS IN SECOND PROJECT WORKSHOP

Vegetation maps from satellite images for the Iberá macrosystem

M. Gandini

Hydrometeorological data analysis and simple hydrological models.

R. Ferrati,

Capybara life history and models

P. Federico,

Introducing space into population dynamics: cellular automata and GIS.

D. Ruiz Moreno,

Linking GIS, dynamic vegetation maps, hydrological models, and population models. G. Canziani.

CONFERENCES

Aggregated Community Models Age and Stage Structured Models I Age and Stage Structured Models II Mathematical Modeling of Complex Ecosystems: A case study.

G.A. Canziani

Fifth Course on Mathematical Ecology with an Introduction to Environmental Economics, ICTP, Trieste, Italia, del 28 de Febrero al 24 de Marzo de 2000.

Analytic and Cellular Automata approaches to metapopulation dynamics.

G.A. Canziani

The Third World Congress of Nonlinear Analysts (IFNA), Catania, Italia, del 19 al 26 de Julio de 2000.

PUBLICATIONS

P. Federico, G.A. Canziani. (2000) *Population Dynamics through metapopulation models: When do cyclic patterns appear?*. Seleta do XXII Congressso Nacional de Matematica Aplicada e Computacional (J.M. Balthazar, S.M. Gomes, A Sri Ranga, Eds.). Tendencias em Matematica Aplicada e Computacional 1(2):85-99. ISBN 85-86883-02-06

MANUSCRIPTS IN PREPARATION

Modelos de balance hidrico para analizar el cambio de regimen en un humedal sujeto a perturbaciones antropicas y climaticas

R. Ferrati, D. Ruiz Moreno, G. Canziani

To be submitted to the Proceedings of the Conferencia Internacional Electronica sobre Economía del Agua, Sección Técnica IV: Agua, Energia y Medio Ambiente. (http://agua.rediris.es/conferencia_iberdrola_2000)

Climatic change and human influence in a neotropical wetland in Argentina R. Ferrati, G. Canziani, C. Rossi To be submitted to Regional Environmental Change (Springer-Verlag)