

1 Project Title, Project Number, Principal Investigator, Key Words

LAND USE CHANGE IN THE *RIO DE LA PLATA* BASIN:
LINKING BIOPHYSICAL AND HUMAN FACTORS TO UNDERSTAND TRENDS,
ASSESS IMPACTS, AND SUPPORT VIABLE STRATEGIES FOR THE FUTURE

CRN 2031

PI: Esteban Jobbágy

KEYWORDS: land use / land cover, Plata Basin, South America, ecohydrology, carbon cycling, social impacts and drivers.

WEBPAGE: <http://platabasin.unsl.edu.ar>

2 Project Funding

The CRN team has presented proposals related to the Plata Basin project goals to several funding agencies of national and international scope (Table 1). During year 3 of the project the team has received ~178000 USD from the following agencies: Fundación MAPFRE (Spain), CONICET and Secretaria de Ciencia y Técnica (Argentina), and INIA (Uruguay). We received 4 small contributions (< 5000 USD) of funds derived from agreements with individual farmers and farmer associations such as AACREA and AAPRESID for in-farm research carried by CoPIs Noellemeyer and Jobbágy. It is important to remark that for the first time, in year 3, a new generation of IAI scientist is receiving funds. Drs Bert, Nosetto, and Piñeiro, all trained as PhD and postdoc students during the first two years of IAI have received their first grants as PIs. Funds obtained during year one (900 K), two (500 K) and and three (180 K) add up to 1580 K USD and represent a 160% counterpart on the five year budget of CRN 2031.

Table 1. Additional funding obtained by CRN 2031 CoPIs in year 3 (2008-2009)

Granting Institutions	Grant type	Grant code	Starting date	Ending date	CRN members involved	Role	Amount (USD)(*)
Fundación MAPFRE (Spain)	Ayudas a la Investigación 2009	MAPFRE-Alcaraz	jan-09	jan-10	Paruelo - Alcaraz D	PIs	21000
CONICET (Argentina)	Proyecto de Investigación Plurianual	PIP	feb-09	feb-11	Piñeiro G - Bert F	PIs	79800
Instituto Nacional de Tecnología Agropecuaria (Uruguay)	Proyectos de Investigación	INIA-Ernst	jul-09	jul-11	Piñeiro G - Jobbágy - Jackson	Co-Pis	21000
Secretaria de Cs & Tecnica - La Agencia (Argentina)	Proyectos de Investigación y Desarrollo para la Radicación de Investigadores	PIDRI-UNSL27	mar-09	mar-11	Nosetto M	PI	56900
TOTAL							178700

* only the amount allocated to CRN members is indicated

3 Research Activities and Findings

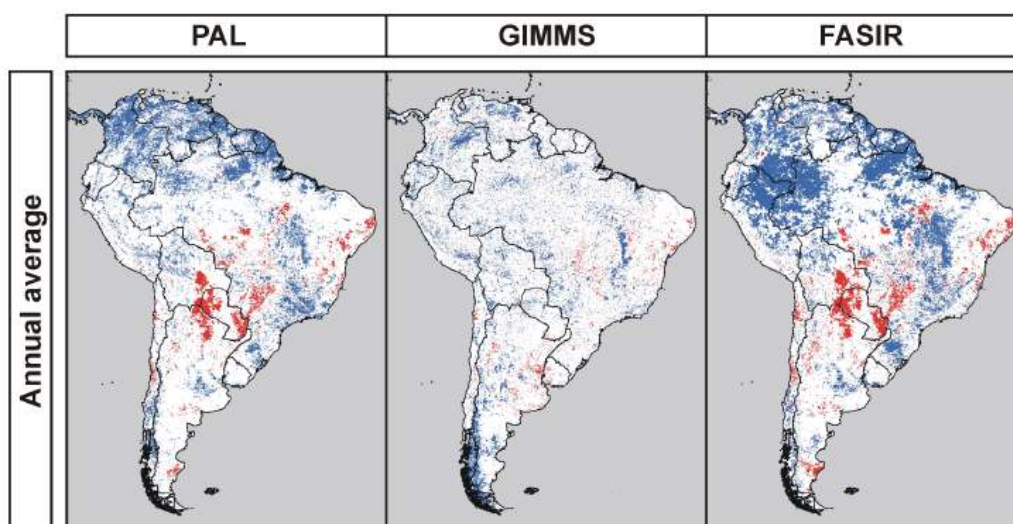
3.1. Description of activities

Here we introduce some of the major findings of our team during the last three years of the project. Under the broad goal of understanding land use change patterns, drivers and impacts in the Plata Basin, we progressed on issues of both high regional relevance and universal scientific interest. In most cases our research has been integrated into the decision making processes or discussions by farmers/foresters, policy makers, NGOs and other stake holders. We highlight three TOPICS that resulted the avenues of highest progress and introduce other relevant work at then end of this section.

TOPIC 1 – Improving satellite-based characterizations of ecosystem functioning

Over the last decades, remote sensors provided a valuable service to land use and global change scientists. Generally, visual interpretation of images and digital classifications, have been the most common approaches, yet below the full potential of remote sensing tools. The description of bio-physical attributes and processes, particularly those linked to carbon, water and energy exchange are of great value and our team has worked expanding their usability (Paruelo 2008 – **Ecosistemas**).

Figure 1. Trends of average annual NDVI, commonly used to estimate net primary production, in South America for the FASIR, GIMMS and PAL series based on NOAA-AVHRR data (1982-1999 period). White, blue, and red pixels displayed no trends, significant increases, and significant decreases; respectively. Note that PAL and FASIR, but not GIMMS detect NDVI declines in deforested areas of Paraguay, Argentina, and Bolivia.



Green indexes, based on red and infrared reflection data, help characterize primary productivity. To explore the possibilities and limitations of three commonly used NOAA-AVHRR NDVI series (PAL, GIMMS and FASIR) to detect ecosystem functional changes

in the South American continent, we performed pixel-based linear regressions of several NDVI variables for the 1982-1999 period. Several differences arose in terms of the sign, extent and location of changes. FASIR detected the highest proportion of changing pixels (32.7%) and independent evaluations suggest contrasting accuracy in the detection of known ecosystem changes in Eastern Paraguay and Uruguay River margins (Baldi et al. 2008 – **Sensors**).

While PAL and FASIR series detected those changes, they were ignored by GIMMS. Although the technical explanation of differences remain unclear and need further exploration, we found that the evaluation of this type of remote sensing tools should not only be focused at the level of assumptions (i.e. physical or mathematical aspects of image processing), but also at the level of results (i.e. contrasting observed patterns with independent proofs of change). Based on these results we improved an online platform for detection, discussion and communication of ecosystem changes in South America (LechuSA – <http://lechusa.unsl.edu.ar>). Our team is currently exploring the performance of a very recent updated NOAA-AVHRR product, the LTDR series, which, if having acceptable precision, will be able to expand the period of analysis to the present.

One of the key goals of our team, in interaction with CRN 2094, is to provide a dynamic characterization of land cover changes that could feed regional climate models. The classical approach for this task has been to (a) assign fixed biophysical attributes to each relevant land cover type, (b) describe land cover type changes and (c), based on (a) and (b) represent biophysical changes of the surface into models. We are exploring a “bypass” approach in which biophysical attributes such as albedo, leaf area, and evapotranspiration, and their seasonal variation are directly loaded into models, based on remote sensing estimates and without passing through the land cover description stage necessarily. This approach is promising and has the additional benefit of providing functional characterizations of ecosystems that could feed many other dynamic analyses of ecosystem changes, including those focused on water and carbon cycles.

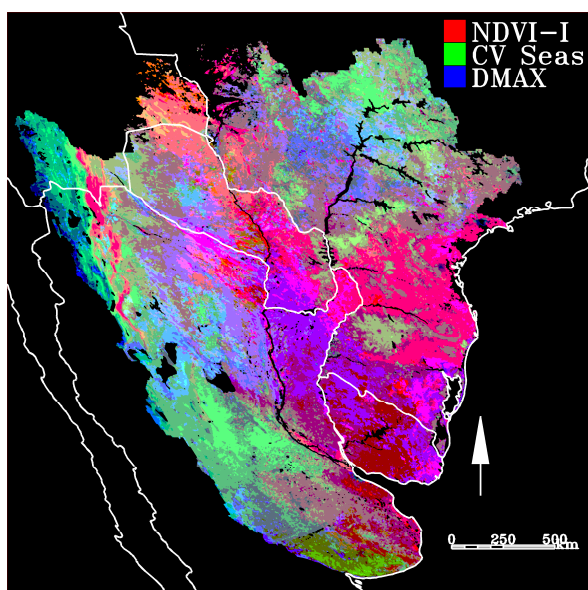


Figure 2. Ecosystem Functional Types of La Plata Basin based on three descriptors of the seasonal dynamics of the NDVI estimated from MODIS images for the 2000-2006 period. NDVI-I (NDVI annual integral, CV_Seas (annual coefficient of variation), DMAX (Date of the Maximum NDVI). Maps of changes of these variables through time provide a direct biophysical inputs into dynamic regional climate-vegetation/land cover models

Additional functional attributes of ecosystems explored through remote sensing (MODIS data) by our team include the detection of vegetation fires, a quantification of their released energy and the impact on subsequent vegetation growth (Di Bella et al. 2008 – Ecosistemas, Verón et al. in preparation).

We also apply LANDSAT imagery to quantify flooded areas and GRACE satellite data (gravimetric measurements) to assess water storage shifts at the regional / sub-continental scale (Aragon y Jobbágy in preparation).

- Di Bella, C.M., Posse, G., Beget, M.E., Fischer, M.A., Mari, N.A., Veron, S. 2008. La teledetección como herramienta para la prevención, seguimiento y evaluación de incendios e inundaciones. *Ecosistemas* 17:39-52.
- Paruelo, J.M. 2008. La caracterización funcional de ecosistemas mediante sensores remotos. *Ecosistemas* 17:4-22
- Baldi G, MD Nasetto, R Aragón, F Aversa, JM Paruelo, EG Jobbágy. 2008. Long-term satellite ndvi data sets: Evaluating their ability to detect ecosystem functional changes in South America. *Sensors*, 8:5397-5425

TOPIC 2 – Land use and climate change mitigation: Opportunities and costs

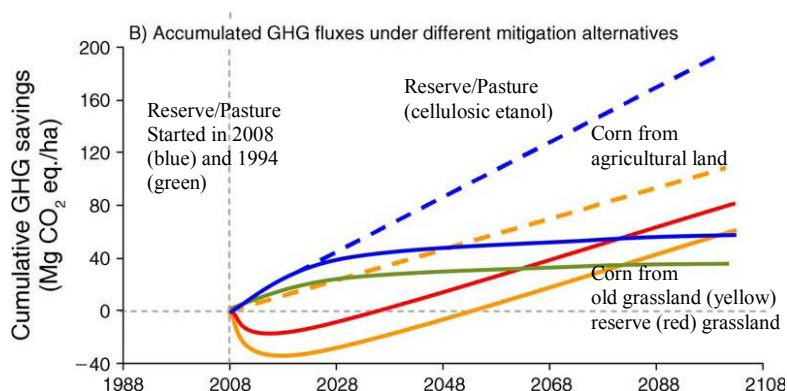
Under combined pressures of higher global food demand, raising local energy needs, and climatic shifts; stakeholders involved in land use decision in the Plata Basin receive multiple and often contradictory signals on what the most profitable and locally and globally desirable land uses are. Understanding the effects of different land use types and change trajectories on the carbon cycle, including primary production, biomass burning, and net greenhouse gas (GHG) release, is crucial.

We assessed the net GHG mitigation benefits of two competing uses of grasslands: corn for ethanol and grassland recovery/preservation. Depending on prior land use, our analysis shows that C releases from soil after planting corn for ethanol may, in some cases, completely offset C gains attributed to biofuel generation for at least 50 years. More surprisingly, based on our comprehensive analysis of 142 soil studies, soil C sequestered by setting aside former agricultural land was greater than the C credits generated by planting corn for ethanol on the same land for 40 years and had equal or greater economic net present value (Piñeiro et al. 2008 – **Ecological Applications**).

Figure 1. Greenhouse gas savings through time under different grassland use trajectories. Reserves involve agricultural land set-aside for conservation and grazing (Piñeiro et al. 2009 – Ecological Applications).

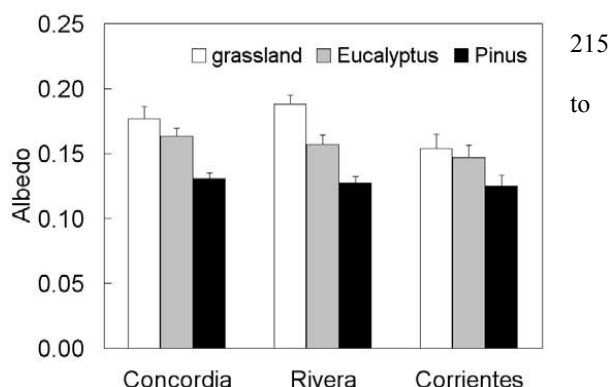
Grazing is a major economic activity and driver of changes in grasslands. We

evaluated the effects of domestic grazing on C belowground storage by comparing 15 grazing-exclosure pairs across grasslands of Uruguay and Argentina. Grazing exclusion effects interacted with landscape positions. In uplands soils C stock increased by ~10 Tn C/Ha after exclusion, while a decrease of the same magnitude was observed in flooded and rocky soils. C stock in roots declined with the exclusions at all site. Results support the notion that N cycling is the ultimate control of N stocks and its retention in root biomass and volatilization by herbivore depositions are some of the major regulators associated with



grazing. Strategies to store C in pastures and grasslands will benefit with the knowledge of this patterns (Piñeiro et al. 2008 - **Global Biogeochemical Cycles**).

Figure 2. Comparison of shortwave albedo for grassland and forest stands across Argentina and Uruguay. Landsat images (2000–2005) on three seven dates were used (Jackson et al. Environmental Research Letters).



From different angles our team approached the process of grassland afforestation, an expanding land use change strongly debated as an option for GHG mitigation. We improved the assessment of tree planting effects on climate by adding to the C cycling effects a view on their impacts on albedo and ultimately on radiative forcing. Tree plantations in humid areas of the basin displayed lower albedo than grasslands, with lowest values seen in pine stands (30% decline compared to grasslands). Results highlight the need of a full radiative assessment of plantations when climate change mitigation is considered (Jackson et al. 2008 – **Environmental Research Letters**). Besides their net climate change mitigation impacts, tree plantations established in grasslands can influence water and nutrient cycles. We evaluated these effects in small watersheds and flat sedimentary areas with shallow groundwater. On average, water yield decreased by 50% in small grassland watersheds that were afforested (Farley et al. 2008 – **Water Resources Research**). In Uruguay this came with significant declines in water pH and cation concentrations, in agreement with a general trend of soil acidification that is most marked under Eucalypt stands (Berthrong et al 2009 – **Ecological Applications**). On flat sedimentary areas of subhumid climate (precipitation < 1150 mm/yr), tree plantations caused strong water and soil salinization (Nosetto et al. 2008 – **Global Biogeochemical Cycles**). Many of our findings on the “side-effects” of tree plantations that target C sequestration were included in Chapter 9 (Forestry) of the last IPCC report on Climate Change Mitigation of which the PI was a coauthor.

- Baldi G, Nosetto M, Jobbágy E. 2008. El efecto de las plantaciones forestales sobre el funcionamiento de los ecosistemas sudamericanos. **Ambiència**, 4:23-34
- Berthrong ST, EG Jobbágy, RB Jackson. A global meta-analysis of soil exchangeable cations, pH, carbon, and nitrogen with afforestation. **Ecological Applications**, in press
- Farley KA, G Piñeiro, SM Palmer, EG Jobbágy, RB Jackson. 2008. Stream acidification and base cation losses with grassland afforestation. *Water Resources Research*, 44, W00A03, doi:10.1029/2007WR006659
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- Nosetto MD, EG Jobbágy, T Toth, RB Jackson. 2008. Regional patterns and controls of ecosystem salinization with grassland afforestation across a rainfall gradient. **Global Biogeochemical Cycles**, 22-10.1029/2007GB003000
- Piñeiro G, EG Jobbágy, J Baker, B Murray, RB Jackson. 2008. Set-Asides Can Be Better Climate Investment than Corn-Ethanol. **Ecological Applications**, 19:277-282
- Piñeiro G, JM Paruelo, EG Jobbágy, M Oesterheld, RB Jackson. 2009. Effects on belowground C and N stocks along a network of cattle exclosures in temperate and subtropical grasslands of South America. **Global Biogeochemical Cycles**, 23: doi:10.1029/2007GB003168

TOPIC 3 - Ecosystem-Groundwater interactions in the Chaco-Pampa plains

A vast fraction of the Plata Basin is occupied by aeolian sediments producing in most of the area an extremely flat plain with very poor surface water networks. In this context groundwater is the major hydrological component of the water cycle with an important role as a water resource for people and ecosystems and as factor of disturbance through flooding and salinization.

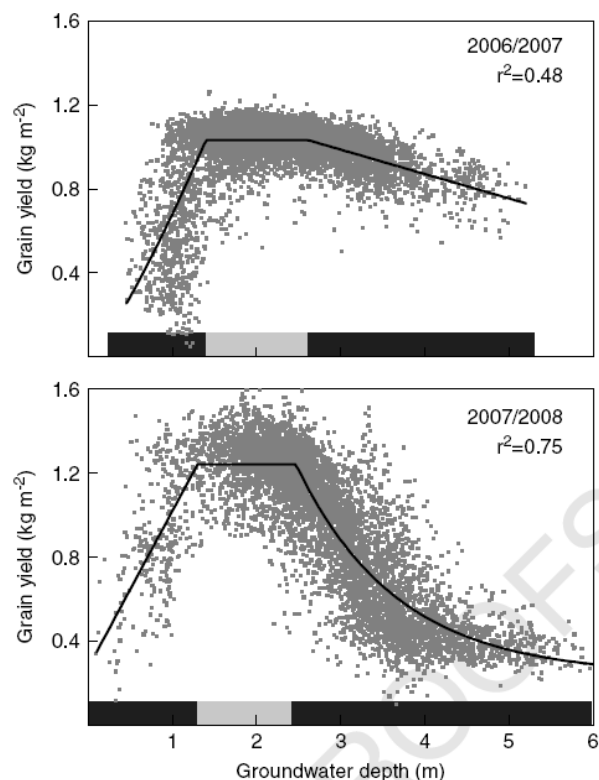
In the more humid part of these plains (Pampas), groundwater tends to be shallow and highly coupled with ecosystems and, for this reason, to human decisions on their management. We examined the reciprocal coupling between vegetation, climate, and groundwater depth in agricultural fields of the Pampa that had shallow water tables characteristic of the region (0–10 m depth). In such situations, ground water may help (water provision), harm (water logging), or have no influence on plant productivity. Understanding how climate and vegetation influence this relationship requires ecological data, such as leaf-area, rooting depth, and phenology, and hydrological data, such as rainfall variation across years and controls on lateral flow.

Figure 3. Relationships of corn yields and groundwater depth in the inland Pampas of Argentina for the relatively wet 2006–2007 (upper panel) and dry 2007–2008 (lower panel) growing seasons. Lower horizontal gray bars show the optimum yield zone.



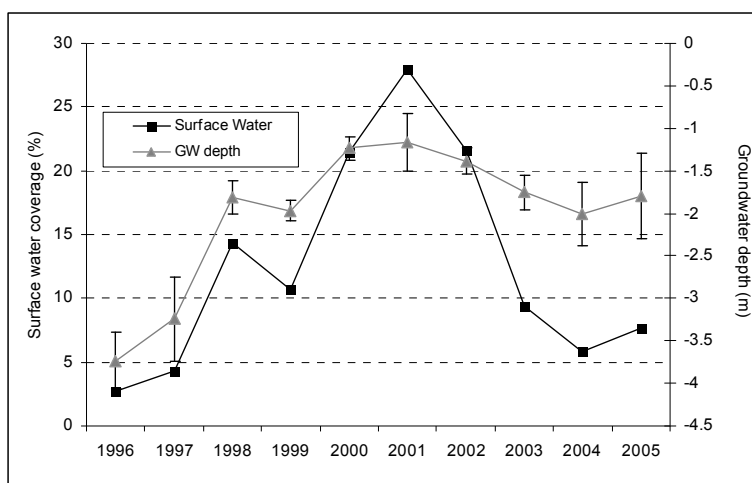
Figure 4. Construction of a groundwater monitoring borehole in a wheat plot. A simple augering protocol has been developed and published in a farmers magazine (Jobbágy & Noretto 2008 – **Revista CREA**) and is now applied consistently by farmers in different areas of the Pampas.

We combined high-resolution data on corn, soybean, and wheat yields with topographic maps and groundwater-depth sampling of 18 monitoring wells and nine boreholes to identify those groundwater depths which optimized crop yields across years. Through two growing seasons, the optimum groundwater depth ranges were 1.4–2.5 m for corn, 1.2–2.2 m for soybean and only 0.7–1.6 m for the shallower-rooted winter-season wheat plants (Noretto et al. 2009 – **Field Crops Research**). Shallower water-table levels were associated with sharply dropping yields, most likely as a consequence of waterlogging and



salinity. Deeper water table levels were accompanied by steady declines in yield until ground water was no longer accessible to plants. Direct groundwater use by crops also increased groundwater salinity up to levels that sometimes hindered further uptake and reduced growth.

Figure 5. Surface and ground water storage changes throughout the last flooding cycle of the Pampas. Surface water coverage obtained through remote sensing, groundwater level data obtained from a compilation of records by farmers and local agencies (Aragón & Jobbágy in preparation)



These relationships explain the stability of yields in some areas of the Pampas and are a valuable tool for crop and risk management in farm. An intense outreach and discussion activity of our team in forums like AACREA and AAPRESID meetings (major farmer associations), help us to transform this information into useful tools.

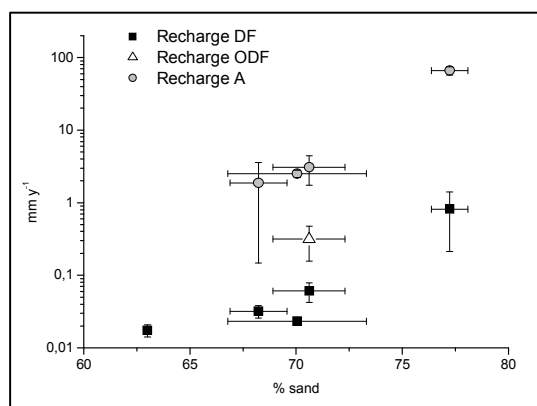
We described regional flooding cycles associated to groundwater level raises based on remote sensing observations of surface water coverage and on an extensive compilation of water table level records for multiple points in the western Pampas. The last flooding cycle in the western Pampas increased water coverage from 3 to 27% (1997-2001) and water table elevation by 2.5 m, producing a net water storage gain of ~800 mm. Two important aspects of flooding are its high inertia regarding rainfall (cumulative response, which facilitates prediction) and a threshold dynamic involving high lateral water transport (once water coverage exceeds 20%, small bodies start coalescing into very extensive ones increasing hydraulic connectivity) (Aragon et al. – in preparation).

Flooding in the region was mirrored by a decline of cultivation. Although cause-effect links are not fully resolved, data for the last 25 years (Viglizzo et al. 2008 – **HESS**) and modelling exercises based on a code developed by our team (VEGNAP, Contreras et al. in preparation) suggest that the replacement of pastures by annual crops could have favored flooding. Our estimates of water storage show a good correlation with those provided by the GRACE satellite system, suggesting that this could be a promising tool for groundwater monitoring in the region.

In the drier section of the plains (Chaco-Espinal) groundwater is deeper and saltier and likely to be sensitive to agricultural expansion, as suggested by similar examples from the Sahel and Australia. There, we have explored the effect of dry forest replacement by annual croplands on water balance and groundwater recharge.

Deep soil sampling (> 7m deep), remote sensing data, and, more recently geoelectrical profiling showed that very subtle declines of annual evapotranspiration ET in cultivated areas have been sufficient to generate deep groundwater recharge and salt migration. At same sites salt accumulation under natural forests is >1kg/m². Less than 3 decades of agriculture were enough to leach this salt load to groundwater (Jobbágy et al. 2008 – **Ecología Austral** and Santoni et al. in preparation). In the last decade several hydrological symptoms of increased recharge and salt mobilization showed up in the surface at several locations around the Chaco-Espinal including Eastern Paraguay, the Santa Fe-Santiago del Estero border, and San Luis. We are organizing this evidence and linking it with our plot stand studies.

Figure 6. Groundwater recharge estimates based on chloride mass balances for Dry forests (DF), overgrazed dry forests (ODF) and agricultural land (A) in the Espinal of San Luis. Sites are plotted according to their average texture. Recharge analyses were based on 3 or more > 7 m deep soil profiles at each stand.



- Jobbágy EG y MD Nasetto. 2008. Pautas y criterios para el monitoreo de niveles freáticos en sistemas de producción agrícola pampeanos. **Revista CREA** Feb 2008:32-38.
- Jobbágy EG, MD Nasetto, CS Santoni, G Baldi. 2008. El desafío ecohidrológico de las transiciones entre sistemas leñosos y herbáceos en la llanura Chaco-Pampeana. **Ecología Austral**, 18:305-322
- Nasetto MD, EG Jobbágy, GA Sznaider, RB Jackson. 2009. Reciprocal influence between crops and shallow ground water in sandy landscapes of the Inland Pampas. **Field Crops Research**, 113: 138-148
- Portela, SI, AE Andriulo, EG Jobbágy, MC Sasal. Water and nitrate exchange between cultivated ecosystems and groundwater in the Rolling Pampas. **Agriculture, Ecosystems & Environment**, en prensa.
- Viglizzo EF, EG Jobbágy, LV Carreño, FC Frank, R Aragón, L Oro, VS Salvador. 2009. The dynamics of cultivation and floods in arable lands of central Argentina. **Hydrol. & Earth System Sc.** 13, 491-502

Other areas of progress

Soil carbon

More activities within the project are tackling soil organic carbon (SOC) responses to land use. Graduate student Darío Ceballos (CoPI Schlichter) is exploring the effects of drainage and poplar plantation establishment on the wetlands of the Parana Delta. This system has very high initial soil organic matter contents (15-20 %) but the transformation of its hydrological regime favors oxic conditions that drive it down to 4-6 %. One of the main challenges of this work has been the description of soil strain (volume shifts), crucial for the calculation of SOC balances. Ceballos is combining this work with the assessment of C and nutrient stocks changes in the soil + biomass compartments. The land use change being studied is gaining importance all over the Delta region and may not only affect the carbon balance but the capacity of the wetland to provide ecosystem water services.

Under the supervision of Dr. Piñeiro, Paola Ecclesia is exploring the dynamics of SOC cycling under a very unique and relevant setting. In Misiones - Argentina, in the grassland-rainforests, Ecclesia has identified four land use change trajectories: Rainforest to pine

plantation, rainforest to C4 pasture, natural C4 grassland to pine plantation, natural C4 grassland to C4 pasture. This setting is allowing our team to understand how woody-herbaceous transitions in general shape SOC stocks and through what mechanisms (e.g. below/above ground allocation shifts, litter quality changes). Some of the transitions allow SOC fluxes estimates with the combination of C isotopic data (already collected and processed) and the use of simple analytical models. Results were presented the meeting of the Asociación Argentina de Ecología.

Being supervised by Dr. Coutinho and Jobbágy, Fabiano Baleiro, from EMBRAPA and Gervasio Piñeiro from UBA are progressing with a literature survey and synthesis task focused on the description of SOC stock shifts under the most common land use trajectories of the basin, particularly forest to crop, forest to pasture, grassland to crop, grassland to tree plantation, and sugar cane under different settings.

In Universidad de La Pampa, Germán Morazzo, directed by Noellemeyer is characterizing and identifying substances that are present in soil organic matter which can be used as biomarkers in order to clarify mechanisms of chemical stabilization of soil organic matter. Along with C fractionation and stable isotopic techniques, this approach will help to obtain more dynamic characterizations of SOC changes and their underlaying mechanisms.

Atmospheric depositions

The lack of data on atmospheric inputs of inorganic species in the Basin, particularly N and Cl ones, limits many of the biogeochemical and hydrological possibilities of our team. We undertook the task of characterizing them with simple network for 24 months in order to obtain a first set of values. This year we are closing our continued measurements of atmospheric deposition over a network of sites across a transect that goes from the Atlantic coast in Uruguay to the desert in Mendoza. In this network we have been collecting bulk and wet deposition of mayor ions (Na, Mg, Ca, K, Cl, P, S, Br). This network is unique in its kind in the Rio de la Plata basin, thus gives the first insights about elements deposition in the region. These data is important for monitoring changes in atmospheric deposition due to shifts in land uses in the region and biogeochemical modeling. Laboratory analyses are almost finished and we are preparing a manuscript. Preliminary results were presented in the Meeting of the Argentinean Ecology Association last year and before in the American Geophysical Union meeting

Deforestation and river flow in Paraguay

This activity is central to our goal of favouring capacity building in Paraguay. After a search process we contacted Andres Wehrle for the development of this activity. Wehrle, a researcher at Universidad Nacional de Asunción, has a strong consulting experience on hydrological issues and good links with ITAIPU and the national water agency of Paraguay. We have set as our first goal the achievement of a PhD degree by Wehrle in the coming 4 years. In March of 2008 Wehrle has started the PhD program in Universidad Nacional de Santa Fe, one of the best available institutions for studies in hydrology. Wehrle's research/dissertation plan involves the exploration of multiple watersheds in Paraguay, Argentina and Brazil with similar environmental contexts but contrasting land

use trajectories. At this point of the project the watersheds had been identified and their topography and land use has been characterized. We are analyzing flow data after a difficult phase of data quality assessment. This analysis will aid a larger scale analysis of the Paraguay and Parana river flow in collaboration with Dr. Krepper from U of Santa Fe and also Wehrle's co-advisor together with Jobbágy.

Primary productivity in grazing systems

Several groups of our team are tackling the process of primary production in natural and cultivated grazing systems with the aim of understanding its controls and response to climate and the purpose of improving grazing management. Tools involve remote sensing, biomass measurements, and modelling. Systems under study are: Silvopastoral plantations in the humid Pampas (Nordenstahl – Jobbágy), Natural grasslands of Uruguay (Baeza-Altesor), grasslands and C4 pastures in the semiarid Pampas (Martini-Steinaker-Jobbágy-Noellemeyer), dry forests in the southern Chaco, roller chopped systems and pastures (Marchesini-Fernández-Steinaker-Jobbágy)

Ecosystem services

As part of a joint initiative between UBA, UDELAR and INTA; our team organized a workshop and synthesis book on “Agricultural Change and Ecosystem Services”. This initiative follows the format of the Dahlem Conferences in which a subset of participants is invited to write chapters in advance, providing the basis for the development of new synthesis material in the meeting. Editors are Paruelo, Laterra (INTA Balcarce) and Jobbágy. There are more than 20 invited chapters (5 of them by CRN 2031 participants) for the book already in the process of review and edition (see their abstracts in www.bse2009ar.blogspot.com). The workshop was originally planned for July 6-8 2009 in Buenos Aires, but it was suspended due to the national epidemiological alert on swine flu. The event was postponed to November 2009, yet the process of synthesis and discussion is already in progress through online discussions.

The book in progress seeks to provide a Latin American perspective on the relevance, approaches, and challenges of ecosystem services. While in densely populated areas (e.g., in China and India), ecosystems are valued as a source of local food and labour to retain people in rural areas and prevent massive migration to over-crowded cities. This contrasts with the high value that some developed communities in Western Europe give to the scenic and cultural value of ecosystems. A mixed picture that combines economic and natural values arises in some areas of North America and Australia, a mosaic of different perceptions is found Latin America. On the other hand, many attempts have been done in the scientific community to quantify the value of ecosystem services. In general, neoclassical economists developed a human-utility view that was questioned by biologists and environmentalists because the non-economic value of nature was generally set aside. For example, the large disparity between prices paid for ecosystem service provision simply reflects the asymmetry between valuation criteria. Recognizing the need of harmonization between the market and the non-market value of nature, in this special issue we prioritize articles looking at methods and approaches that privilege objective and nature-

driven valuations, assuming that they are a pre-condition to support sound land use policy- and decision-making.

Dry forests: energy flow, fires, and bioelectricity

release ca. 615.673 TJ by combusting between 1.9 and 2.4 % of the global ANPP. Africa and South America, with ca. 20 and 12% of the total land surface area, accounts for 48 and 22% of the total energy released by fires respectively. While this amount represents only the 0.12% of the total energy consumption of the world in 2006, it adds to ca. 7.28% of the global electricity use- assuming a conversion efficiency of 40% -. For 30 countries the amount of energy released in fires could account for more than 10% of their annual electricity consumption (see table 1). A preliminary analysis shows that soybean biodiesel net energy balance in the Chaco region of Argentina (provinces of Chaco, Santiago del Estero and Salta) is positive. Soybean biodiesel provides 162% more energy than is required for its production.

Land use change in the Pampas: The role of farmer decisions and policy

Guillermo Podesta and his group seek to improve understanding of dynamic linkages between agricultural ecosystems, technological innovation, human decision-making, and land use and tenure changes over periods of a few decades, a scale relevant to resource management, and infrastructure and investment planning. Emphasis is being placed on interactions between uncertain decadal climate trajectories, awaited technological developments that decrease vulnerability to climate stresses and enhance efficient water use by agriculture, and individual decision-making, adaptation, and learning. Focus is also on aggregate patterns of land use and land tenure emerging from the intertwined effects of climate, technology, and individual decisions. The work is organized into eight major objectives presented in the special report of the CRN2031 “Addendum” directed by Dr. Podesta.

A small team has initiated activities in late 2007 under the lead of Juan Maceira in SAGPyA (Argentina Government) with the participation of two graduate students and the collaboration of other CoPIs. Focus on the relationship between the agricultural expansion and displacement of extensive cattle raising in the Pampas and public policies between 1970 and 2005, with a view on their effects on rural social and economic development. Search and analysis of information about changes in land use from the 70's to the present, including historical documents and data. Search and analysis of information about public policies which may have had an effect on land use from the 70's to the present. Establish relationships between land use changes and public policies. Study of the impact of LUC and public policies on the social actors and structure of the Argentine Pampa's agrarian sector. Interviews with former policy makers in the agrarian field and actual experts on the subject.

In UDELAR, Diego Piñeiro has established a large team of students dealing with the impacts of forestry expansion on rural societies in Uruguay. Work, employment and migration under the changing conditions of tree plantations in the last three decades is being studied through the analysis of statistics, interviews to local settlers and stakeholders.

3.2. CRN 2031 Events during YEAR 3

During the reported periods we held SEVEN CoPI meetings/workshops. Many of our CoPIs participated in workshops organized or co-organized by IAI.

International Summer School on Land Cover Change and Hydroclimate of the La Plata Basin – Planned for 02-13 November 2009 in Foz do Iguacu, Brazil

TWO students and TWO teacher/speaker from CRN 2031 will participate

Training Institute on Remote Sensing Application to Hydrology in Semi-Arid Regions - XIV Brazilian Remote Sensing Symposium, April 20-30, 2009 in Natal, Brazil

FIVE students and ONE teacher/speaker from CRN 2031

Workshop on Establishing a long-term ecological research program and research collaborations in northwestern Patagonia. January 2009, Bariloche

TWO CoPIs from CRN 2031

Small CoPI meeting "Deep soil and vadose zone responses to land use change"

April 14-15, 2009, San Luis, Argentina

Training workshop "Application of geoelectric tools in ecohydrology" February 19-23, 2009, San Luis, Argentina

SEVEN students and TWO teacher/speaker from CRN 2031

Jornada Nacional sobre Herramientas Satelitales para la detección, seguimiento y prevención de incendios. Buenos Aires, October 22. 2008.

Organized by Di Bella, participation of students and CoPIs

Presentations in scientific meetings by CRN 2031 members included more than 50 talks and posters.

4 Contributions of Co-PIs

Topic	Jobbagy	Paruelo	Oesterheld	Di Bella	Coutinho	Meirelles	Altesor	Panario	Coronel	Piñeiro	Maceira	Viglizzo	Noellemeyer	Schlichter	Podesta	Jackson	Hoffmann	Epstein
characterizations of ecosystem functioning		x		x		x	x											x
Climate mitigation opportunities and costs (biofuel crops)	x				x											x		
Climate mitigation opportunities and costs (tree plantations)	x				x			x		x				x		x		
Ecosystem-Groundwater interactions in the Chaco-Pampa plains	x											x				x		
Fire dynamics				x					x								x	
Deforestation and river flow in Paraguay	x								x									
Primary productivity in grazing systems	x	x	x				x						x	x				
Dry forests, fires and bioelectricity generation	x	x		x												x		
Land use change in the Pampas: The role of farmers decisions and policy	x										x	x		x	x			
Ecosystem Services	x	x					x				x	x						
Tree plantations, rural development, employment, and power relationships										x								

5 Publications

During the first three years of the project our team has published **36 peer reviewed and 6 divulgation papers and chapters** covering a broad range of journals of both national and international scope, in English and Spanish and of both disciplinary and interdisciplinary profiles. In this particular year we produced 32 articles (listed below) counting those in press. Most of these works include authors from two or more collaborating groups within the CRN team and with a couple of exceptions all of them involve students as authors.

5.1. Published

- * Altesor, A. Eguren, G., Mazzeo, N., Panario, D. & Rodríguez C. 2008 La industria de la celulosa y sus efectos: certezas e incertidumbres. **Ecología Austral**, 18: 291-303
- * Cabello J., Alcaraz-Segura D., Altesor, A., Baeza S., Delibes M. & Liras E. 2008. Funcionamiento ecosistémico y evaluación de prioridades geográficas en conservación **Ecosistemas** 17:53-63
- * Di Bella, C.M., Posse, G., Beget, M.E., Fischer, M.A., Mari, N.A., Veron, S. 2008. La teledetección como herramienta para la prevención, seguimiento y evaluación de incendios e inundaciones. **Ecosistemas** 17:39-52.
- * Fernandez, R., A. Quiroga, E. Noellemeyer, D. Funaro, J. Montoya, N. Peinemann. 2008. A study of the effect of the interaction between site-specific conditions, residue

- cover and weed control on water storage during fallow. **Agricultural Water Management** 95: 1028 – 1040.
- * Paruelo, J.M. 2008. La caracterización funcional de ecosistemas mediante sensores remotos. **Ecosistemas** 17:4-22
 - * Baldi G, Nosoetto M, Jobbágy E. 2008. El efecto de las plantaciones forestales sobre el funcionamiento de los ecosistemas sudamericanos. **Ambiência**, 4:23-34
 - * Baldi G, MD Nosoetto, R Aragón, F Aversa, JM Paruelo, EG Jobbágy. 2008. Long-term satellite ndvi data sets: Evaluating their ability to detect ecosystem functional changes in South America. **Sensors**, 8:5397-5425
- Coutinho, H., Noellemeyer, E., Jobbágy, E., Jonathan, M., Paruelo, J. 2008. Impacts of land use change on ecosystems and society in the Rio de La Plata Basin. In: **Applying Ecological knowledge to Landuse Decisions**. H.Tiessen, J.W.B. Stewart.(Ed.). p.56. SCOPE series. ISBN 978-85-99875-04-9.
- * Di Bella CM, IJ Negri, G Posse, FR Jaimes, EG Jobbágy, MF Garbulsky, VA Deregibus. 2009. Forage production of the Argentine Pampa Region based on land use and long-term NDVI data. **Rangeland Ecology & Management**, 62:163-170
 - * Farley KA, G Piñeiro, SM Palmer, EG Jobbágy, RB Jackson. 2008. Stream acidification and base cation losses with grassland afforestation. **Water Resources Research**, 44, W00A03, doi:10.1029/2007WR006659
- Favre, C. and C. Laciana 2009. “Difusión del maíz BT en Argentina: factores ambientales, tecnológicos y sociales en la adopción de la tecnología.” **Revista AACREA**
- Finegan, B., Ojima, D., Lozanoff, J., Menezes, R., Noellemeyer, E., Pinillos, M., Salcedo, I., Sarmiento, G. 2008. Shared functions and constraints of natural and managed systems: implications for human well-being in a changing environment. In: **Applying Ecological knowledge to Landuse Decisions**. H.Tiessen, J.W.B. Stewart.(Ed.). p.14. SCOPE series. ISBN 978-85-99875-04-9.
- * Jackson RB, JT Randerson, JG Canadell, RG Anderson, R Avissar, DD Baldocchi, GB Bonan, K Caldeira, NS Diffenbaugh, CB Field, BA Hungate, EG Jobbágy, LM Kueppers, MD Nosoetto, DE Pataki. 2008. Protecting climate with forests. **Environmental Research Letters**, 3:044006
 - * Jobbágy EG, MD Nosoetto, CS Santoni, G Baldi. 2008. El desafío ecohidrológico de las transiciones entre sistemas leñosos y herbáceos en la llanura Chaco-Pampeana. **Ecología Austral**, 18:305-322
 - * Jobbágy EG y MD Nosoetto. 2008. Pautas y criterios para el monitoreo de niveles freáticos en sistemas de producción agrícola pampeanos. **Revista CREA** Feb 2008:32-38.
 - * Nosoetto MD, EG Jobbágy, GA Sznaider, RB Jackson. 2009. Reciprocal influence between crops and shallow ground water in sandy landscapes of the Inland Pampas. **Field Crops Research**, 113: 138-148
 - * Nosoetto MD, EG Jobbágy, T Toth, RB Jackson. 2008. Regional patterns and controls of ecosystem salinization with grassland afforestation across a rainfall gradient. **Global Biogeochemical Cycles**, 22-10.1029/2007GB003000
 - * Piñeiro G, EG Jobbágy, J Baker, B Murray, RB Jackson. 2009. Set-Asides Can Be Better Climate Investment than Corn-Ethanol. **Ecological Applications**, 19:277-282
 - * Piñeiro G, JM Paruelo, EG Jobbágy, M Oesterheld, RB Jackson. 2009. Effects on belowground C and N stocks along a network of cattle exclosures in temperate and subtropical grasslands of South America. **Global Biogeochemical Cycles**, 23: doi:10.1029/2007GB003168

- * Piñeiro G, S Perelman, J.P. Guerschman y J.M. Paruelo. 2008. Evaluating models: observed vs. predicted or predicted vs. observed? **Ecological Modelling** 216:316-322.
- * Straschnoy J., Mari N., Di Bella C., Rebella C., Caride C., Fischer M. Á., Melchiori A., Verón S. y Oricchio P. 2008. Incendios forestales en America Latina. **CEIBE** 5: 14-17
- * Viglizzo EF, EG Jobbágy, LV Carreño, FC Frank, R Aragón, L de Oro, VS Salvador. 2009. The dynamics of cultivation and floods in arable lands of central Argentina. **Hydrology & Earth System Science** 13, 491-502

* *PDF attached*

5.2. In press

- Baeza, S.; Lezama, F.; Piñeiro, G.; Altesor, A. and Paruelo, J.M. Aboveground Net Primary Production spatial variability of Uruguayan Grasslands: a remote sensing approach. **Applied Vegetation Science**, in press
- Berthrong ST, EG Jobbágy, RB Jackson. A global meta-analysis of soil exchangeable cations, pH, carbon, and nitrogen with afforestation. **Ecological Applications**, in press.
- Irisarri, G., Verón S., Oesterheld, M. and Paruelo J.M. 2009. Grass species differentiation through canopy hyperspectral reflectance. **International Journal of Remote Sensing**, in press
- Jackson RB, EG Jobbágy, MD Noretto MD. Ecohydrology in a Human-Dominated Landscape. **Ecohydrology**, in press
- Leoni, E., Altesor, A. and Paruelo, J.M.. 2009. Explaining patterns of primary production from individual level traits. **Journal of Vegetation Science**, in press

6 Data

We are maintaining the sites <http://platabasin.unsl.edu.ar>
 Collaborative site: <http://lechusa.unsl.edu.ar>
 Collaborative site: <http://stipae.ebd.csic.es>

Databases and data sharing

In collaboration with a private company dedicated to the development of data sharing platforms among farmers, we have introduced a systems for groundwater level/quality data that can be visited in <http://napas.iyda.net>. Our team is providing regular reports on the situation of groundwater an crops in the Pampas that are visited by farmers all over the region.

7 Capacity Building

7.1. Students

During the third year our team hosted 2 postdoctoral students, 4 PhD students, and 11 MSc students using IAI funds. In addition, all groups have other students committed to the project and supported by other sources of funds (49 additional students and collaborators, see Appendix A). Remarkably, IAI funds had helped us to recruit students and have them working and getting trained in the project until they were able to obtain new fellowships from national sources. This strategy proved very flexible and efficient to retain the best people in the team.

A specific goal of our project was to develop scientific capacities in Uruguay and Paraguay. In the case of Uruguay we have two PhD students (Baeza & Lezama, directed by Altesor and Paruelo) working on their dissertation in UBA, and a PhD student doing his degree in Universidad de Cordoba (Carambula, codirected by Piñeiro). Regarding Paraguay the PhD candidate Andres Wehrle started his IAI fellowship in July 2007 to perform doctoral studies in Hydrology in Universidad del Litoral – Argentina, under the codirection of Jobbagy. Students Nosetto, Piñeiro, Aragón and Verón had finished their degrees in the frame of the project and are now postdocs or independent researchers. CoPIs in the CRN work as directors or codirectors of many students working in institutions with strong local influence such as INTA and EMBRAPA. These students participate in CRN-related activities and transmit goals, ideas, and capacities to their home institutions.

7.2. Training activities

Besides the courses and practices associated with the formal programs in which students are enrolled, in the current year CRN 2031 students visited the labs of different CoPIs for discussion of projects and training, acting as a very effective link across groups:

Gervasio Piñeiro (with Jobbágy) visited Jackson and Panario (*)
Marcelo Nosetto & Silvina Ballesteros (with Jobbagy) visited Jackson (**)
John Kim & Dush Jayawickreme (with Jackson) visited Jobbágy and Paruelo (**)
Domingo Alcaraz (with Epstein) visited Paruelo, Jobbágy, Di Bella, Berbery (**)
Andres Wehrle (with Coronel) visited Jobbágy (*)
Juan Martini (with Noellemeyer) is now working based in San Luis with INTA & Jobbágy
Santiago Baeza and Felipe Lezama (with Altesor) visited Paruelo and Oesterheld
Dario Ceballos (with Schlichter) visited Jobbágy (*)

(*) - one week to one month

(**) – more than one month

7.3. Outreach

7.3.1. Afforestation and its impacts

Our team is involved in a series of debates with stakeholders regarding afforestation expansion. We are participating in the online forum “forestación responsable” in which companies, policy makers, researchers and NGOs converge. CoPI Piñeiro has been engaged in discussions on afforestation issues with policy makers of Uruguay. It's important to highlight that the scientific production our team (papers reported here and in years 1 to 3

report) have been playing a central role on the regional debate on forestry impacts and benefits and ways for sustainable forestry development.

7.3.2. Climate, Hydrology and Agriculture

During Year 3 our team has expanded its links and participative research plans with farmers in three locations in the Pampas: Western Pampas in Cordoba (Mackenna), Inner Pampas in Buenos Aires (America and Pehuajo). These programs involve collaborative work with two large farming companies (LIAG SA and Biznaga SA) and a farmer consortium (AACREA & AAPRESID) and the service company “GeoAgris” (<http://www.geagris.com.ar>) and IyDA (<http://www.iyda.net>)

Several stakeholders had active participation in the research process

- Jorge Mercau – Farming consultant / Universidad de Buenos Aires
Crop modelling, development of decision support rules based on groundwater information
- Gustavo Sznaider – Precision agriculture consultant / Universidad de Buenos Aires
Development of groundwater depth and crop yield mapping methods for massive application in farms.
- Gustavo Duarte – Farming consultant & Farmer
Conduction of field measurements in América location
- Guillermo Mangas – Agronomist & Farmer
Conduction of field measurements in Vicuña Mackenna location
- Federico Albina - Agronomist & Farmer
Conduction of field measurements in Pehuajo location
- Santiago Gonzalez Venzano – Consultant
Development of a web-based system for groundwater depth data integration and application in agricultural decision making (<http://napas.iyda.net/>)

We developed to large networks of continuous groundwater monitoring – CRN researchers are in charge of the hydrological monitoring design and farmers take the periodic measurements. In addition, farmers and GeoAgris collect yield maps from the studied plots. In this way we have been able to relate yields to water table depth in a very large number of plot and broad range of environmental situations. We discuss with farmers the mechanisms of yield-groundwater links and outline a decision support scheme to take maximum advantage of groundwater contribution to crops and minimize waterlogging and flooding risks.

7.3.3. Participation in AAPRESID national congress

One of the most important farmer’s association of Argentina, AAPRESID invited Dr. Viglizzo as keynote speakers for its national congress in 2008 and Dr. Jobbágy for its congress in 2009. <http://www.aapresid.org.ar/>

7.3.4. Participation in AAPRESID national congress

Our team has introduced remote sensing tools into the fire monitoring and control programs at the nacional and provincial level in Argentina. Of particular importance was the “Jornada Nacional sobre Herramientas Satelitales para la detección, seguimiento y prevención de incendios” organized by CoPI Carlos Di Bella in Buenos Aires in October 2008. Stakeholders related to fires participated in the meeting.

7.3.5. Assesment of the environmental impact of agriculture

Transference of environmental assessment tools (AgroEcoIndex model) to agricultural investment funds like Los Grobo, El Tejar, AgroNegocios del Plata (Uruguay) and farmers grouped in CREA and AAPRESID were implemented by CoPI Viglizzo

7.3.6. Forage production assessment tools

A system for forage productivity monitoring based on satellite NDVI has been Developed by CoPIs Oesterheld, Paruelo and students. This system is already being implemented by AACREA in several regions of Argentina. Publication: Oyarzabal, M. M. Durante, M. Oesterheld, C. Bagnato, y M.D. Arocena. 2008. Variación espacial y temporal de la productividad de los campos naturales y pasturas de la Depresión del Salado. Gacetilla de la Región Sudeste de AACREA, N° 248, 12-16.

8 Regional Collaboration/Networking

In the current year our team continues its involvement in the following networks/teams

SENSOR: This European Commission funded project, carried out by 33 Institutions from 15 European countries, aims at developing a Sustainability Impact Assessment Tool for policies related to land use changes. It relates to the IAI CRN project since it has components for the identification of land use change drivers, the elaboration of a spatial reference database, integrating thematic data from the La Plata basin, modeling future land use changes considering different scenarios for the state of the drivers, and the involvement of stakeholders, from land owners to policy makers to validate the system that will be developed, specially the impact indicators and their thresholds. The knowledge acquired in the Sensor project, involving UBA, UDELAR, and Embrapa, will be greatly useful for the development of the IAI CRN project. CoPIs Coutinho, Meirelles, Jobbagy, Altesor. (see www.sensor-ip.org).

ENVIAR: Ongoing effort bringing together researchers at Embrapa, UFRJ (Federal University of Rio de Janeiro), UERJ (State University of Rio de Janeiro) and INRIA (Institut National de Recherche en Informatique et en Automatique, France). It is focused on the development of advanced digital image processing technologies for the automatic monitoring of deforestation, land degradation and expansion of no-tillage agriculture through systematic classification of land use and land cover. CoPIs Meirelles & Coutinho

SERENA: (Red Latinoamericana de SEguimiento y Estudio de los REcursos NATurales) is a CYTED founded network composed by 18 research groups from 11 countries involving

48 researchers from 18 institutions. SERENA aims to produce reliable information about biomass burning processes and land use changes in Latin-American and the dissemination of specific products. Major institutions are INPE (Instituto Nacional de Pesquisas Espaciais) from Brazil, CONABIO (Comisión Nacional para el Conocimiento de la Biodiversidad) from México and INTA (Instituto Nacional de Tecnología Agropecuaria) from Argentina, which are in charge of the development and delivery of satellite products. As an associate project of IAI CRN, SERENA will contribute directly in to the generation of annual information of land use changes and burned areas among other related products at the continental level, with special interest on the dissemination to final users and decision makers.

MLURI-INTA: Macaulay Land Use Research Institute and INTA (CoPI Viglizzo) to jointly research a) the underlying drivers and the processes of land use change in Argentina and Scotland, b) the environmental, social and economic consequences of land use changes in Argentina, c) the socio-economic problems related to extensive grazing systems on rangelands. The agreement involves a program of staff exchanges

Pulp Mills & Society Network. CoPI Piñeiro in UDELAR is part of a network involving Lakehead University (Canada) and University of Jyväskylä (Finland). A small grant (Research Development Initiative Grant) based in the existing “Northern Communities in a Changing World: Towards a Better Understanding of Global Competition” is exploring the effects of the withdrawal (Canada and Finland) and the arrival (Uruguay) of pulp plants on social aspects of small towns. Project is funded by the Social Sciences and Humanities Research Council of Canada

Involvement in other IAI projects:

Collaboration with CRN 2094 (PI: Hugo Berbery) is ongoing and a shared postdoctoral student, Domingo Alcaraz, is working as the link between both projects.

Collaboration with members of Luckman’s CRN in IANIGLA-Mendoza, regarding land use effects and their interaction with climate change regulating the hydrology of Andes water in the desert. With this team we obtained matching funds from National Geographic Society. Antonio Lara, from the same CRN project invited Jobbagy for a brief course in Universidad Austral in Valdivia, Chile in November 2008.

Several CRN 2031 members (Podesta, Meirelles, Coutinho, Jobbagy) are involved in the IDRC project together with participants of different CRN and SGPs

We have initiated the collaboration with the CRN directed by Arturo Sanchez and trained one student (Correa from FAUBA-GEA) to start the deployment of phenology towers in our study sites

In collaboration with CoPIs of CRN 2005 (PI: Guillermo Sarmiento) we started measurements in grassland watersheds and afforested pairs

9 Media Coverage and Prizes

- TV Program “Recurso Natural” (Argentina) covered Dr. Piñeiro.
- Newspapers, radio and TV programs (Argentina and Uruguay) on the large fires in the Parana Delta (Di Bella), Droughts in the Pampas (Oesterheld & Paruelo), groundwater & crops (Jobbágy), forestry, water & carbon cycling and climate change (Piñeiro, Jobbágy)
- Duke, University. Press release. Durham, NC. “Study critiques corn-for-ethanol's carbon footprint”, by Monte Basgall. Mayo 2009.
- Several TV channels, Newspapers and Radios covered Drs. Viglizzo and Jobbágy at the national AAPRESID congress, Argentina
- Jobbágy & Viglizzo were part of IPCC AR4 team of authors. The Nobel Prize for IPCC was covered in local media and both contributors were acknowledged
- Jobbágy was distinguished with the National award for young scientists (Age > 40) in the area of Biology (Argentina).

10 Policy Relevance

Policy relevance: some of our results fit directly into the process of land use regulation. So far we have been actively involved in the discussion of two issues: a) dry forest replacement by agriculture and its influence on hydrology/salinity in the context of the San Luis province government, and b) afforestation of grasslands and its impacts on soil and water quality in the context of the national government of Argentina. Our team participated in workshops with policy makers in both cases and some of our proposals are being considered in the development of new regulations.

Public outreach: We implemented several outreach avenues including divulgation (Jobbágy & Nasetto 2008) and teaching publication (Jobbágy et al. 2008) as well as open web sites for land use observation and understanding (<http://lechusa.unsl.edu.ar>) and for groundwater/flooding understanding and monitoring (<http://napas.iyda.net>). In addition we have been contributing to the media (local TV, newspapers, radio) on land use – hydrology issues (http://gea.unsl.edu.ar/gea_medios/Articulo%20Esterban%2005-05-08.php.htm).

Interaction with stakeholders involves not only outreach activities but the knowledge generation process. As it has been pointed out in the previous sections we are collaborating with farmers, agronomist, and consultants in data gathering, analysis, synthesis and application along the line of groundwater-crop interactions. Most of our contacts and collaborations in this cases stemmed from workshop and training events with consortiums of agronomists such as “La Reja, Lincoln-Buenos Aires” and “Labrador, Villegas-Buenos Aires” and farmer associations named CREA and AAPRESID. So far we had five workshop/training events done (July 2008 in Villa Mercedes with AAPRESID, August 2008 in Trenque Lauquen with AACREA, November 2008 in Daireux with AACREA, April 2009 in La Carlota, and the largest annual encounter of AAPRESID in Rosario in August 2009)

Our team has provided input to the strategic planning of INTA in two occasions participating in workshops with presentation on agriculture and water issues. We have initiated together with INTA researchers, farmers and local policy makers from San Luis and La Pampa the “Red de apoyo a la gestión del agua en la región semiárida central”. The idea is to conform a network of diverse affiliations focalized on the science, practice and debate around water resources in the semiarid section of the Plata Basin.

We initiated a very promising research line within Secretaria de Agricultura de la Nación (Argentina) where CoPI Maceira and two students are exploring the history land use influencing policy of the last 30 years. Their work will help gain a better vision of the policy impacts and effects.

Our work with biofuel, bioelectricity and C sequestration option will have a direct influence on the strategies that national governments, companies and NGOs envision for the replacement of fossil fuels. At the time of the first publication we expect to release policy briefs in national and international forums.

11 Main Conclusions

In the third year of the project our team has consolidated three major topics (A) Improving satellite-based characterizations of ecosystem functioning, (B) Land use and climate change mitigation: Opportunities and costs, (C) Ecosystem-groundwater interactions in the Chaco-Pampa plains. In addition other lines have gained importance, namely (D) synthesis of land use effects on soil carbon, (E) Characterization of atmospheric depositions, (F) Deforestation and river flow in Paraguay, (G) Primary productivity in grazing systems, (H) Ecosystem services, (I) Dry forests: energy flow, fires, and bioelectricity.

The project maintains a staff of 2 posdocs and 15 graduate students with IAI funds and involved 41 additional students financed by other sources. These students continue to bridge the labs of different CoPIs. In year 3 we have produced 32 publications and made more than 50 presentation in scientific meetings. Members of the team had been actively involved in workshops and debates with stakeholders such as ag-policy officials, farmer associations and environmental NGOs. Four active web sites maintain their growth and are regularly updated by the team

12 Work Plan for Next Year with Associated Costs

We will continue our work in the TOPICS mentioned above, focused on the following aspects of land use change in the Plata Basin:

- a) improvement of the description, monitoring and spatial modeling of land use changes in their multiple dimensions
- b) synthesis of carbon cycling shifts under dominant land use trajectories
- c) land cover climate interactions
- d) synthesis of groundwater-vegetation
- e) fire patterns and drivers
- f) exploration of sound bioenergy options

- g) understanding land use response to policy and decision making by farmers
- h) synthesis of trade-offs and synergies between ecosystem services and land use changes

Forecasted budget for year 4 is the following

	UBA-CONICET	INTA cautelar	EMBRAPA SOLOS	UDELAR Ciencias	UDELAR Sociales	SAGPyA & UB	UNIV MIAMI	INTA La Pampa	UNIV N. Asuncion	INTA Bariloche	NCSU	Duke	UVA	Univ La Pampa	capacity building in PY	TOTAL
salaries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
fellowships	21300	8520	10396	8520	8520	0	8520	10980	0	0	0	0	0	16200	8520	101476
travel	7075	7390	5854	1688	937	1481	3109	569	569	569	1539	1539	1539	2761	0	36620
equipment	1458	729	889	1458	658	658	0	0	729	0	500	500	500	622	0	8700
expenses	9272	3414	3947	5421	587	587	0	1279	1227	2027	0	0	0	2639	0	30400
communication	1000	250	250	250	250	250	250	250	0	250	0	0	0	0	0	3000
publication	2200	900	0	0	0	0	0	900	0	0	0	0	0	400	0	4400
administration	6740	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6740
overhead	2978	1287	1295	1053	665	181	721	849	153	173	124	124	124	1373	517	11616
TOTAL	52022	22490	22632	18389	11617	3157	12600	14826	2678	3019	2163	2163	2163	23995	9037	202952

A few modifications from the budget presented in the original project were introduced:

- 1:** Fellowship adjustment (salary raise and 1 year extension of one fellowship)
This budget line moved from 79172 to 101476 USD. This 28.2% raise is partially covered by cuts in travel and communication
- 2:** Travel was cut in order to support item 1
This budget line moved from 43120 to 36620 USD, which involves a 15.1% cut
- 3:** Communication was cut in order to support item 1
This budget line moved from 4500 to 3000 USD, which involves a 33.3% cut
- 4.** We request an overall increase of the annual budget of 8.4% (202952 vs. 187250 USD)

Appendix A – List of students enrolled in IAI fellowships in year 1 of CRN 2031 (PD=postdoc, G= grad student, UG=undergrad)

	Name	Affiliation	Nationality	Grade	Area of expertise	Training activity	Student involvement in project	Scholarship duration & amount	Exchange programs	Note
PD	Aboim, Marcela	EMBRAPA Solos	Brazilian	Postdoctoral student	Soil chemical and physical characterization	flexible training	Soil carbon stocks and gas emissions under contrasting land uses	1 year, 1600 USD/month		FINISHED DURING YEAR 3
PD	Contreras, Sergio	GEA-FAUBA	Spanish	Postdoctoral student	Hydrology	flexible training	Land use - Groundwater hydrology feedbacks	1 year, 810 USD/month		FINISHED DURING YEAR 3
PhD	Lezama, Felipe	Fac. Cs. UDELAR	Uruguayan	PhD student	Grassland Ecology	Program EPG FAUBA	Heterogeneity of the Rio de la Plata grasslands	3 years, 300 USD/month	FAUBA	CONT FROM YEAR 1
PhD	Morazzo, Germán	FAUNLPAM	Argentine	PhD student	Soil chemistry	Program EPG FAUBA	Characterization of humic substances under forest species	4 years, 600 USD/month	UNSL	CONT FROM YEAR 1
PhD	Andres, Wehrle	UNA Asuncion and GEA-FAUBA	Paraguayan	PhD student	Hydraulic Engineering	Program U del Litoral	Land use impacts on surface hydrology in Paraguay	610 USD/month	FAUBA & GEA & U Asuncion	RECRUITED IN YEAR 2
PhD	Baeza, Santiago	Fac. Cs. UDELAR	Uruguayan	PhD student	Grassland Ecology	Program EPG FAUBA	environmental and land use controls over ecosystem functioning over Uruguay	3 years, 610 USD/month	FAUBA	CONT FROM YEAR 1
MSc	Tiago Coelho	EMBRAPA Solos	Brazilian	MSc student	Soil physics and biology	CENA	Soil N cycling and land use	2 years, 610 USD/month		
MSc	Deborah, Leite	EMBRAPA Solos	Brazilian	MSc student	Soil Microbiology	UFRJ	land uses & bacterial community structure of groups of Eubacteria	2 years, 610 USD/month		

MSc	Carambula, Matías	Fac. Cs Sociales UDELAR	Uruguayan	PhD student	Rural sociology	PhD Program U of Cordoba	Social impacts of afforestation	3 years, 610 USD/month	FAUBA	CONT FROM YEAR 1
MSc	Ricard, Florencia	INTA La Pampa	Argentine	PhD student	Agronomy	Program U of Mar del Plata	Dynamics of groundwater and land use	3 years, 610 USD/month	GEA	RECRUITED IN YEAR 3
MSc	Pereira, Hernán	INTA La Pampa	Argentine	PhD student		Program U of Mar del Plata	Ecosystem services assessment	3 years, 610 USD/month	GEA	RECRUITED IN YEAR 2
MSc	Ballesteros, Sivina	GEA-FAUBA	Argentine	MSc student	Soil chemical and physical characterization	Program EPG FAUBA	Análisis regional de flujos de carbono en la cuenca del Plata	3 years, 610 USD/month	INTA Clima y Agua	CONT FROM YEAR 1
MSc	Rositano, Florencia	FAUBA	Argentine	MSc student	Agronomy	Program EPG FAUBA	farmer decision making and its influence on soil quality	1 year mo., 400 USD/month	FAUBA - U of Miami	RECRUITED IN YEAR 2
MSc	Martini, Juan Pablo	FAUNLPAM	Argentine	MSc student	Remote sensing and GIS	Program EPG FAUBA	Development of a land capability map	4 years, 600 USD/month	GEA - INTA San Luis	CONT FROM YEAR 1
MSc	Perino, Ivan	GEA-FAUBA		MSc student	Electronic Engineering, Instrument networks	Program U de San Luis	Involvement of farmers on Groundwater monitoring networks	2 years, 610 USD/months	FAUBA-Quantitative Methods Group	RECRUITED IN YEAR 2
MSc	Román Trucco	FAUNLPAM	Argentine	MSc student	Agronomy	Program U of La Pampa	Water table depth effects on crop productivity	4 years, 600 USD/month		RECRUITED IN YEAR 2
MSc	Ana Acosta	GEA-FAUBA	Argentine	Undergraduate student	Biology	U Of San Luis	Vegetation-Groundwater interaction	2 year 400 USD/month		Starting this year

Other students funded by non-IAI fellowships

GEA-Jobbagy

Roxana Aragon - FONCyT

Marcelo Noretto - CONICET

Germán Baldi - FONCyT

Carla Rueda - CONICET

Celina Santoni – CONICET

Victoria Marchesini – CONICET (with Fernandez from FAUBA)

Eva Florio – FONCyT (with Noretto from GEA)

Guillermo Correa (FONCyT with Fernandez from FAUBA)

EMBRAPA-Solos

Rodrigo Ferraz – EMBRAPA staff

Thiago Côrrea de Almeida – no fellowship

Thamyres Lacerda Rocha - EMBRAPA

Guilherme Angelini - CAPES

Rodrigo Mendes Cavalini – PIBIC

Leila Sheila Lisboa - EMBRAPA

Luiz Ivan Ortiz Valencia - EMBRAPA

FAUBA-Piñeiro

Paola Ecclesia – INTA Misiones

Sebastián Massilli – INIA Uruguay

FAUBA-Paruelo

Costanza Caride - CONICET

Mayra Milcovic - FONCYT

Marcos Texeira – CONICET

Hernan Dieguez – IAI-Berbery

Domingo Alcaraz – IAI-Berbery + IDRC

FAUBA-Oesterheld

Irisarri, Gonzalo - Fundación Estenssoro Doctoral Fellow

Durante, Martín - CONICET Doctoral Fellow

Fernando Pacín – AACREA

Gonzalo Grigera – Ag IDEA

INTA Inst Clima y Agua - Dibella

Fischer, María de los Angeles - INTA

Straschnoy, Julieta Verónica - INTA Inst Clima y Agua

Hugo Álvarez - INTA

SAGPyA – Maceira

Alejandra Moreno - SENSORS

María Mercedes Patrouilleau - SENSORS

INTA La Pampa

Lorena Carreño – INTA

Federico Frank - INTA

Univ. Asuncion - Genaro Coronel

Fernando Pio Barrios – UNA Paraguay

María Elena Hume (LIAPA-Inst Clima y Agua INTA, Dibella)

Udelar -Piñeiro

Natalia Vibel UDELAR

Victoria Menéndez UDELAR

Jimena Vázquez UDELAR

Ivana Cúrbelo UDELAR

Udelar – Altesor

Luis López – Pedeciba

Gastón Fernández. UDELAR

Ana Laura Mello UDELAR

Ana Clara Guido UDELAR

Federico Gallego UDELAR

INTA-Schlichter

Darío Ceballos – INTA Delta

Duke - Jackson

Berthrong, Sean - NSF

Kim, John – NSF/DOE

Jayawickreme, Dushmantha - NSF

Univ. of Miami-FAUBA - Podesta

Carolina Favre – CRN 2031 Addendum