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 4 of the project the team has received 118000 USD from CNPq (Brazil) and MINCyT (Argentina).Funds obtained during year one (900 K), two (500 K), three (180 K), and four (120 K) add up to 1700 K USD and represent a 170% counterpart on the five year budget of CRN 2031.

Table 1. Additional funding obtained by CRN 2031 CoPIs in year 4 (2009-2001)

Granting Institutions	Grant type	Grant code	Starting date	Ending date	CRN members involved	Role	Amount (USD)(*)
Ministerio de Ciencia y Tecnologia ARGETINA	Proyectos interanuales tipo A (PICT)	PICT-2008-2199	Jun-09	Jun-11	Paruelo -	PI	88000
CNPq and CAPES	Biennial proyect	Not available	Feb-10	Feb-12	Heitor Coutinho	PI	30000
TOTAL							**118000**

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: Agriculture and hydrology in the Pampas

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.

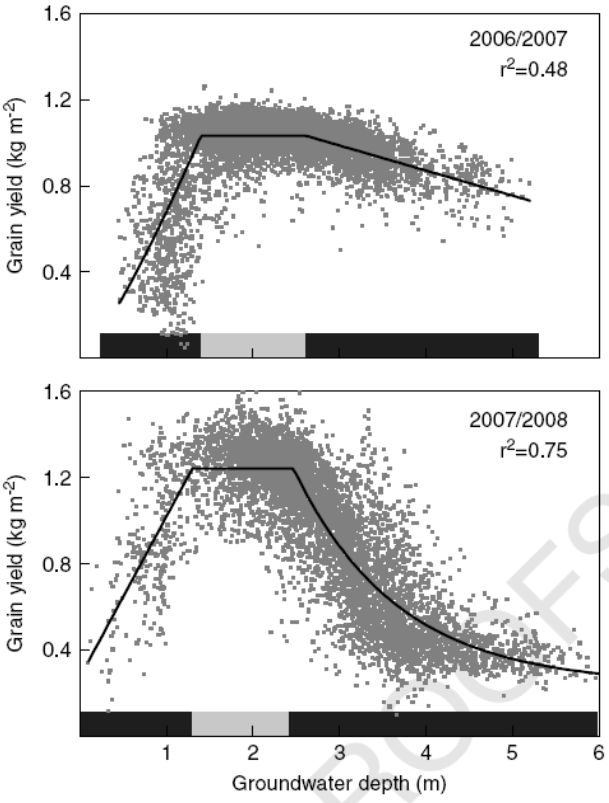


Figure 1. Relationships of corn yields and groundwater depth in the inland Pampas of Argentina for the relatively wet 2006–2007 (upper panel) and dry 2007–2008 (lower panel) growing seasons. Lower horizontal gray bars show the optimum yield zone.

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 (Nosetto 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.

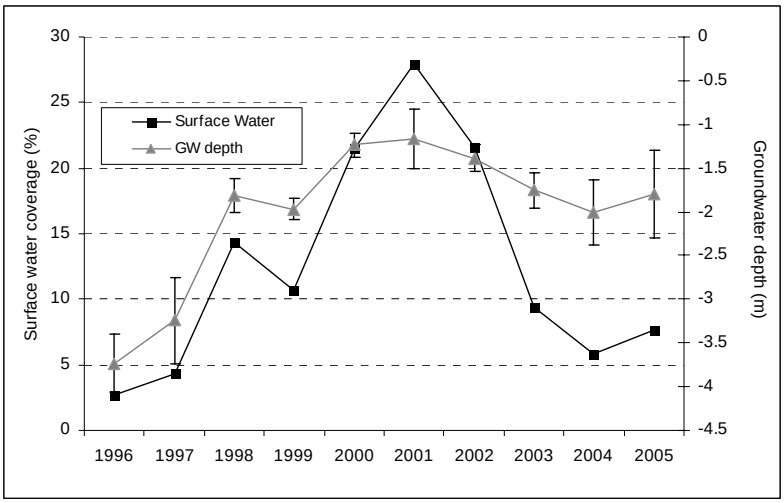


Figure 2. Surface and ground water storage changes throughout the last flooding cycle of the Pampas. Surface water coverage obtained through remote sensing, groundwater level data obtained from a compilation of records by farmers and local agencies (Aragón & Jobbágy in preparation)

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), helps us to transform this information into useful tools. Results from this line have been presented in the most important farmers event of Argentina, (**Congreso AAPRESID**, November 2009, Rosario) by Jobbágy in a plenary session with more than 800 attendees and coverage in the media.

From a hydrological perspective, our work in agricultural systems highlights not only their relevance in terms of groundwater dynamics regulation, but also their value as simplified system in which several challenging ecohydrological questions can be more approached (Jackson et al. 2009, **Ecohydrology**).

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. 2010, **Ecohydrology**).

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. 2009 – **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. This model has as a key rule, the functions shown in figure 3 dictating how transpiration responds to water table level. While deep groundwater levels favour a negative (stabilizing) feedback in which raising water facilitates evaporative evacuation, shallow groundwater favours a positive (destabilizing) feedback in which raising water tables cut evaporative evacuation facilitating a faster progress of flooding. The model captured this dynamic showing a bimodal behaviour under annual crops, in which lower

water consumption, shallower rooting depths, and higher waterlogging sensitivity, created a more flooding prone situation. Modeling efforts are currently being improved and validated with field data and the VEGNAP routine is being included into standard crop models like DSSAT. 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.

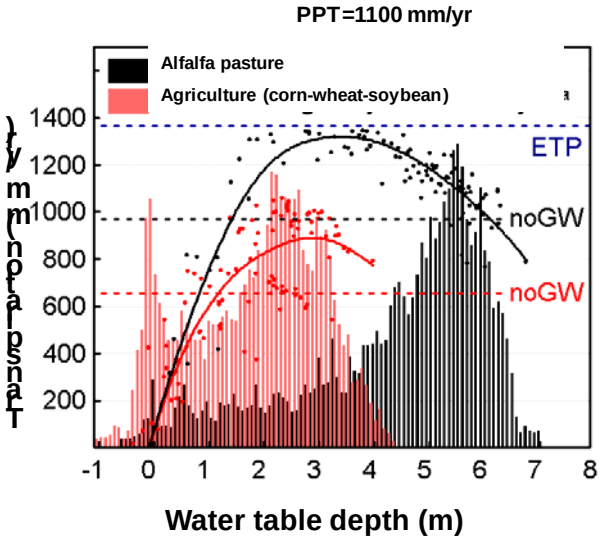


Figure 3. Modeling results showing how water table depth shifts with land use. Bars show the frequency distribution of water table depths measured as the number of days in 100 years in which the water table is located at a given depth. Agriculture (red bars), compared to Alfalfa pastures (black bars) created a shift towards shallower depths, favouring a bimodal distribution with a large frequency of floods (days with water table depth < 0.3 m). Horizontal dotted lines show Potential evapotranspiration and actual transpiration assuming no access to groundwater. Curve lines show the mean response of actual transpiration to groundwater depth.

Location	Host	Date
Buenos Aires	AACREA	jun-07
Buenos Aires	AACREA	jul-07
Pehuajo	AACREA	ago-07
Villegas	INTA	ago-07
Villegas	Local group of farmers	sep-07
San Luis	AACS	may-08
25 de Mayo	Local group of farmers	ago-08
Daireaux	AACREA	ago-08
Lincoln	AACS	nov-08
America	Local group of farmers	feb-09
La Carlota	INTA	may-09
Buenos Aires	AACREA	jul-09
Rosario	AAPRESID	ago-09
Bell Ville	Local agricultural colleg	ago-09
Mackenna	AAPRESID	sep-09
Tandil	AACREA	nov-09
Rio IV	AAPRESID	abr-10
Villegas	AACREA	may-10
Mackenna	AACREA	may-10
Santa Rosa	INTA	may-10
Cordoba	Catholic University of C	may-10
Venado Tuerto	Local group of farmers	jun-10
Manfredi	INTA	jul-10

Table 1 and picture. List of presentations, workshops and events with farmers in which groundwater-crop interactions were discussed. Most of this events involve hands-on field work measuring water table depths and their imprint on crops. From the ideas and discussions that emerged from these workshops we have developed protocols of groundwater monitoring and decision, networks of groundwater monitoring in different zones, and more recently, valuable material to investigate how decision making could affect groundwater and hydrology in the Pampas.

A key new direction that our research on this line has been taking in the last year is the explicit inclusion of farming decision rules as a control of hydrology. Different farming attitudes towards raising water table levels and their associated waterlogging risks may lead to contrasting hydrologic and economic outcomes. For instance, farmers that typically grow summer crops year after year (soybean-corn) may face this risky situation (i.e. water table < 1 m deep) by sowing a low-cost waterlogging-tolerant cover crop like ryegrass, or just skip sowing and leave the land idle for that year. A 100-year simulation with VEGNAP using suggests that the "cover crop scheme", compared to the "idle land scheme", cuts the frequency of waterlogging events, creating 40% more suitable farming years (water-table depth > 1 m, corn or soybean can be sown). These results have been presented in an invited talk on Ecohydrology session in AGU-fall 2009 in San Francisco and a publication is in preparation

TOPIC 2: Hydrological shifts in the dry forests (Espinal and Chaco)

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 (Santoni et al. 2010 - **WRR**). 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.

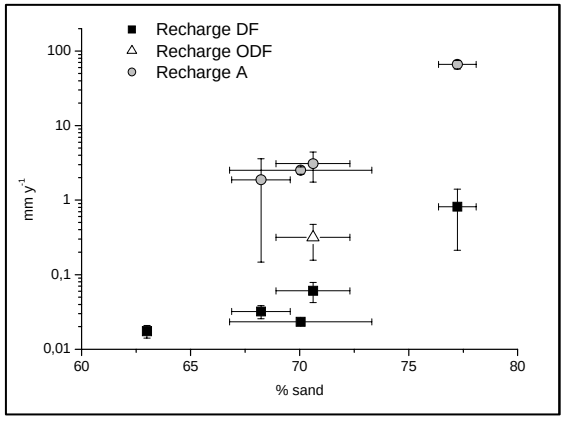


Figure 4. Groundwater recharge estimates based on chloride mass balances for Dry forests (DF), overgrazed dry forests (ODF) and agricultural land (A) in the Espinal of San Luis. Sites are plotted according to their average texture. Recharge analyses were based on 3 or more > 7 m deep soil profiles at each stand.

With the aid of geoelectrical tools, stream monitoring equipment such as continuous level and salinity meters, and satellite information for the last two decades, we are currently characterizing the development of new streams in a region that lacked any surface water manifestation until the seventies but was intensely cleared a century ago in San Luis (Figure 5).

Figure 5. “New river” in San Luis. These type of streams are formed by the sudden liquefaction of sediments in the sloped plains close to the foothills of San Luis. As opposed to gullies created by surface erosion, these streams are generated by raising groundwater flowing at increasingly faster rates. Salty waters and highly dynamic and unpredictable transport of sediments, make this processes very damaging for agriculture and infrastructure. Our team is linking it to land use and climate changes in the area. In the picture, student Celina Santoni is standing on the edge of a stream (red arrow) that emerged in 2007 and deepened by 3 m (white line) in 2010.

We believe that this region can be something like the “canary in the mine” of an incipient dryland salinity syndrome developing in the dry forests of the Plata Basin and since it already attracted a strong attention from farmers and the general public, it can help us illustrate the connection between land use and hydrological regulation (Santoni et al. 2009, presentation in **AGU meeting**, also local media reports).

Geoelectric profiling, long terms groundwater level records being reconstructed by our team, together with the existing collection of deep soil profiles sampled during the last 3 years provide a new perspective on the ecohydrological consequences of agriculture in the semiarid woodlands of the plains (Espinal and Chaco). We are currently in the process of publishing these results and at the same time discussing them with local farmers and policy makers.

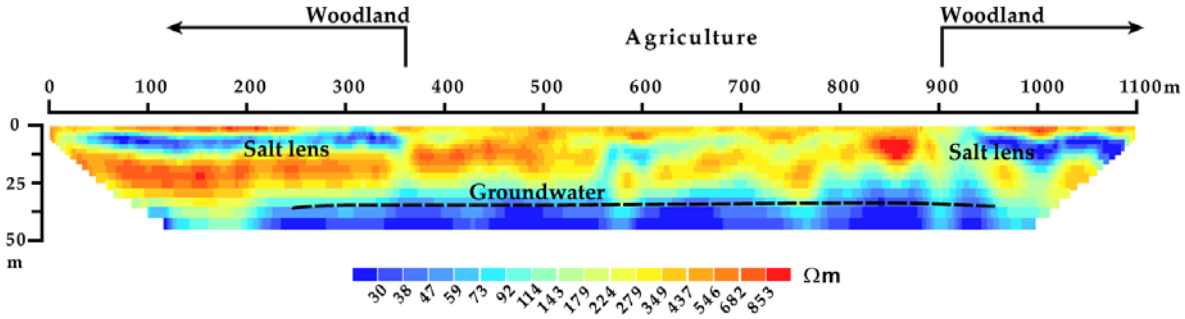


Figure 6. Geoelectrical profile across a woodland-agriculture-woodland transect of 1.1 km. The variable being captured, ground resistivity, integrates moisture and salt content at different depths down to 50 m. The process of soil wetting and salt leaching following 30 years of cultivation in the center of the transect becomes clear with this approach. Groundwater levels are shallower in the cultivated field as suggested by the position of the low resistivity zone at the bottom of the profile.

TOPIC 3: Biomass burning in the dry forests (Espinal and Chaco)

Biomass burning plays a central role in dry forest ecosystems of the Plata Basin. During the last two years several members of our team have explored (a) patterns of fire occurrence, (b) fire risk, and (c) fire energy release. Part of this work has given place to a new perspective on the potential of fire-prone ecosystems, and particularly fire-prone biomass as a source of energy generation.

At the regional scale, in the Southern Chaco and Espinal ecosystems we explored the environmental factors that influence the spatial and temporal distribution of fire events, considering their extension and duration. We identified fire events (FE) using MODIS-hotspots data (2003-2006) and analyzed their association with climate, land cover and land use. The spatial and temporal patterns of FE were associated to agricultural vs. non-agricultural type of use, water deficit, and the presence of shrublands. We observed a spatial delay of FE dates in northeast-southwest sense, related to the spatial variation of the spring beginning and temperature increases. We also detected that the mean FE size and duration varied among vegetation covers, indicating that shrublands concentrate bigger fires while woodlands concentrate durable fires. These results could be useful to agencies responsible for fire prevention/control to preserve natural resources and infrastructure

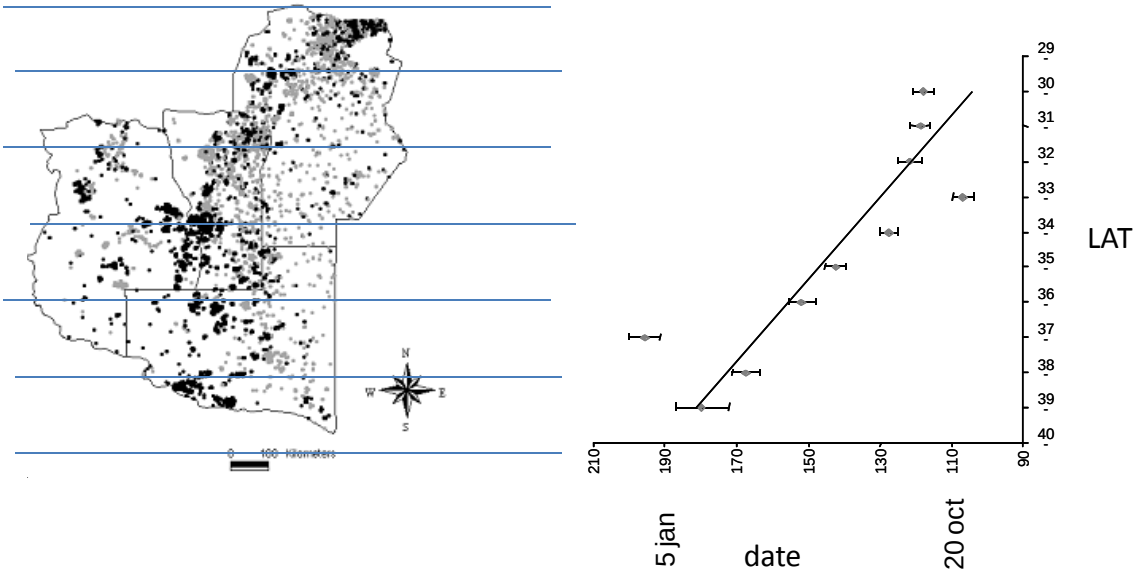
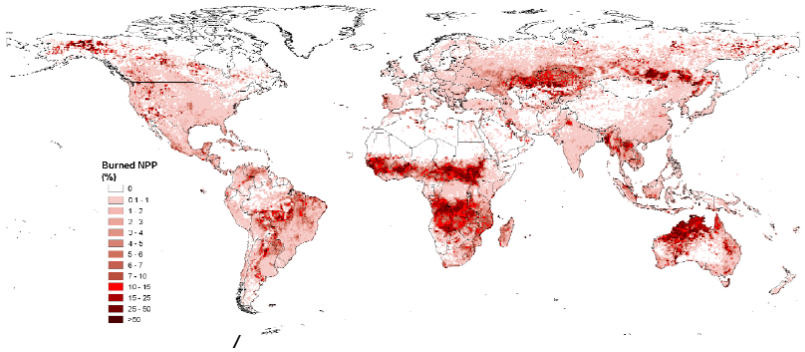


Figure 7. Fire events in central Argentina (Mendoza, San Luis, Cordoba and La Pampa). Note the clear N-S belt of high fire frequency associated with dry forests. The panel on the right illustrated the mean date of fire occurrence along the latitudinal gradient showing how fires shift towards the summer as we move south

Figure 8. Global fires. Energy release shown as a percentage of the net primary productivity of ecosystems. Areas with more intense red tones yield to fires a large fraction of their biomass production.



We identified a unique opportunity to progress on the issue of energy production in (agro)ecosystems, often conflictive due to the possible trade-offs between energy generation, food production, and ecosystem service provision (e.g. hydrological regulation as shown in the previous section). We explored whether fire-prone dry forests can become a sustained energy source capable of replacing fossil fuels for electricity generation with little competition over food production and synergies with forest preservation. This possibility has several justifications including (a) the extent of fire-prone ecosystems is expanding due to climate change (ecosystems that never burned before are starting to burn frequently) (b) the fraction of ecosystem NPP that is proposed to be used to generate energy would otherwise be dissipated by fire, (c) the reduction of this fires through fuel removal and processing in nearby bioenergy plants will eliminate a negative threat to ecosystems and societies, (d) a win-win radiative forcing solution may be achieved by simultaneously replacing fossil fuels, eliminating the emission of gases with high greenhouse power which are generated in the field fire but not in the plants and by skipping the low albedo situations generated after fires leave a charred surface.

Based on our new global analysis of the energy generation and spatial distribution of fires, we estimate that biomass energy could be harvested economically in specific emerging economies, such as Argentina and Brazil, while preserving native habitats. Between 2003 and 2006, global fires consumed ~8500 ± 460 PJ y-1 of energy, equivalent to ~39% of global electricity consumption and exceeding consumption in 55 countries. In Argentina, where forest fires release more energy than the 360 PJ of national electricity consumption, Chaco forests alone could provide a sustained output of 9 GJ ha-1 yr-1, reducing habitat loss to soybean agriculture and maintaining ecosystem services. Bioenergy can help preserve native ecosystems while reconciling their use for energy supply.

Energy yields from biomass harvesting in the Chaco and other dry forests compare favorably with biodiesel production from soybeans in the region. Based on our analysis, for the first 30 years after deforestation soybean biodiesel would result in a net emission of ~580 g CO2e MJ-1 in excess of the petroleum diesel produced (91 kg CO2e GJ-1), with 614 kg CO2e GJ-1 coming from land use change (a loss of ~230 Mg CO2 ha-1). This strong effect of deforestation would take ~550 years to repay (12, Table S2). In contrast, bioelectricity would offset GHG emissions from electricity generated from fossil fuels by 170 to 345 kg CO2e GJ-1. Energy yield per hectare is higher for soybean biodiesel than for bioelectricity,12.5 vs. 9 GJ ha-1 y-1, respectively, but it involves a much higher appropriation of NPP as a result of a higher harvesting intensity (36 vs 11%) and, indirectly, through the decreased NPP of crops vs. forests (5.6 vs. 13.5 Mg. ha-1 y-1). These results are presented in a publication that is currently in review **Global Biogeochemical Cycles** (Verón et al. 2010)

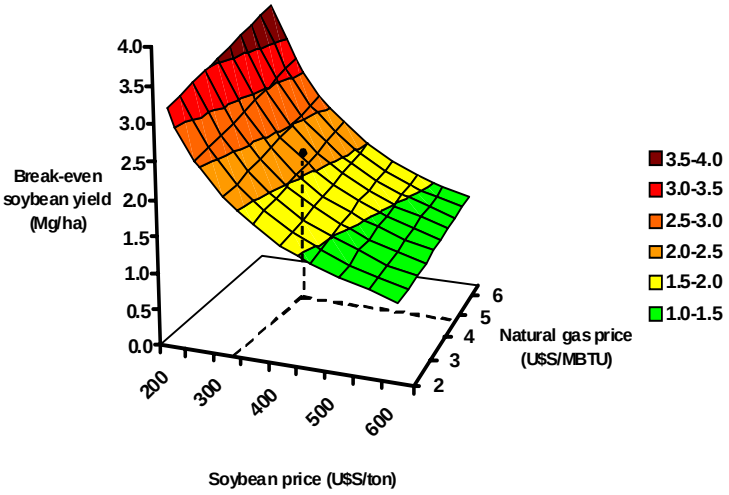


Figure 7. Break-even soybean yield (i.e. the minimum yield required to match the gross margin of wood production) as a function of soybean and natural gas international prices. Wood prices were allowed to vary according to the price of natural gas (the energy source potentially replaced by wood at thermo-electrical plants). Broken lines indicate actual soybean (U$S 330) and natural gas (U$S 4.65/MBTU) prices and the break even soybean yield (2.2 Mg/ha). Average 2003-2008 soybean yield was 1.9 Mg/ha. Local taxes (35%) were discounted to international soybeans prices.

Making a zoom in the driest portion of the Chaco region, our team is now exploring how the primary productivity of native ecosystems is being funnelled to forest and animal products (charcoal, firewood, meat, milk) and dissipated energy (livestock respiration and fires) under contrasting types of land users, such as small goat herders, large extensive calving units, and newer intensified cattle ranches that include C4 pastures. Some of the emerging results of this study are that (a) fires are the dominant energy consumer, (b) charcoal is the dominant productive energy output, second only to fires, (c) extensive livestock systems have a very high respiratory energy dissipation that could be reduced through improved management. Efforts to accurately estimate charcoal production, when official statistics are highly unreliable, involve the use of remote sensing tools including those used for fire energy release quantification combined with the detection of charcoal ovens with Google Earth. This line is part of the dissertation work of Carla Rueda, a PhD student from Santiago del Estero that will reinsert in her home institution within the dry Chaco after finishing her graduate studies.

Figure 8. Charcoal ovens in the dry Chaco of Argentina. Poorly quantified and studied, these facilities and the whole charcoal production chain, represents the main productive energy output of the region, suggesting that these dry forest are already focused on “bioenergy” production. Our team is developing new tools to quantify their energy and charcoal output with the aid of remote sensors. We are also exploring the diversity of actors and contexts in which charcoal production takes place, including large multifamily systems associated with forest clearance operations (agricultural expansion) and small traditional single-oven systems run by one family, usually in association with livestock production.

Due to the important area burned annually we analyzed a fire risk index (FR) currently available for an important area of South America created by the National Institute for Space

Research (INPE). We associated FR values (very low, low, medium, high, and critical) with the frequency and characteristics of fire events (FE) detected in the period 2008-2009 in different land covers. We observed that FE of large extension (more than 180 hectares) and long duration (more than 7 days) presented high/critical fire risk values. However an important proportion of FE had no associated risk. Knowing the level of certainty of FR is essential to anticipate the frequency of fires of different magnitudes and to applied appropriate management practices for fire prevention.

In addition, we developed a new Fire Danger Index (FD) that evaluated not only the probability of fire occurrence but also the fire propagation, duration and severity. This index was created initially for a pilot area in Argentina for further implementation in South America. We used information of: frequency, size and duration of fire events (FE), status and evolution of vegetation before fire occurrence, land cover/use, human influence and distance to protected areas. From the study of these variables, we assigned them six values of severity (very high, high, moderate, low, very low, null). Subsequently, we identified the weights of each variable over FD by applying regression analysis. Finally we generated fire danger cartography for the pilot area, in order to repeat the process at continental scale.

We worked in the Central Region of Argentina in the fuel moisture content (FMC) estimation, since it is related to ignition and fire propagation. FMC is defined as the proportion of water over dry mass and it is widely used for fire danger evaluation. FMC can be retrieved from the inversion of radiative transfer models (PROSPECT + SAILH). These models, both leaf and canopy levels, compute the reflectance of land covers from a set of canopy, leaves and geometric configuration variables. In the indirect mode, models allow to retrieve input variables from satellite reflectance data (e.g. FMC). Since these models need to be parameterized we conducted a series of field campaigns over the study region. We collected vegetation data from 11 sites in Monte shrublands and grasslands (7 dates) and from 5 sites in Pampa grasslands (5 dates). Preliminary results allow us to estimate FMC from MODIS data accurately. This complex model parameterization is an essential step to apply the methodology in future for the generation of FMC cartographies periodically.

TOPIC 4. Ecosystem Services

Our team realized that the notion of ecosystem services was a very valuable tool to discuss our results in particular and the broader issue of agricultural expansion, both in the scientific and the public arenas. However, different visions and definitions of ecosystem services made the debate difficult. Motivated by this challenge/opportunity we jointly organized a workshop on Ecosystem Services with INTA that took place in November of 2009. The workshop had as its main goal the production of a book on Ecosystem Services & Agricultural Expansion/Intensification that will bridge science and decision making in the context of increasing conflicts and trade-offs associated with land use. Inspired on the Dahlem Conferences, we commissioned several participants with the task of writing book chapters before the meeting. The first full drafts of these chapters served as the background for the 3 days discussion that took place later. Four task groups focused on (1) Justification, (2) Dimensions, (3) Methodologies, (4) Action regarding Ecosystem Services generated a synthetic chapter for the book, whose first drafts are now under review. Participants

included social and natural scientists (Ecologists, Agronomist, Economists, Lawyers, Sociologists) as well as representatives from the Academic, Governmental, Productive and NGO "Spheres". Although focused on the Argentinean case, the workshop included participants from Uruguay (Altesor, Piñeiro), Mexico (Balvanera), and Chile (Lara, Urrutia) and the material, written in Spanish, will be of value for the broad Latinamerican public. IDRC funds were used to cover one third of the workshop costs with the rest being covered by INTA. The final version of the book includes 26 chapters and is edited by Jobbágy (PI), Paruelo (CoPI), and Laterra (INTA partner). Its publication is expected for October 2010 with printing being sponsored by INTA and IAI through CRN 2031.

CRN 2031 members have produced chapters on the following aspects: carbon sequestration and agricultural uses in the Pampas, Water services and agricultural expansion and intensification, Theory of ecosystem services, Valuation and pricing of ecosystem services, among others.

All these chapters are in Spanish and target a broad but instructed audience seeking to spread the concept of ecosystem services across professional policy making communities.

In addition to this initiatives our team is leading a special issue of the journal **Agriculture, Ecosystems and Environment** on Ecosystem services and Land use Policy, that has a focus on Latin American cases and issues and will include seven papers, 4 by CRN 2031 members. All these papers are now under evaluation.

OTHER WORK LINES

Agricultural policy history

We found that research in the political dimension was somewhat overlooked in the context of the recent land use changes of the Pampas. For this reason explored the major policies that influenced the agricultural sector of Argenitna during the last 40 years. With the development of these analysis between policy, the State and the agricultural sector in recent decades in Argentina, hope to contribute to the understanding and discussion of recent conflicts and the current difficulties for public intervention in the field of agricultural policy that allow the rational use of soil and its sustainability. Research activities along this line involved so far: (a) Search and analysis of information about changes in land use from the 70's to the present, including historical documents and data, (b) Search and analysis of information about public policies which may have had an effect on land use from the 70's to the present (c) Establishment of relationships between land use changes and public

policies (d) Study of the impact of LUC and public policies on the social actors and structure of the Argentine Pampa's agrarian sector, (e) Interviews with former policy makers in the agrarian field and actual experts on the subject, (f) Recopilation of data in a database containing production, area, land prices, exchange rate evolution and others relevant variables for the study about the Pampas from 1970 to the present.

Atmospheric deposition

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. We have continued measuring atmospheric deposition over a network of sites across the region established previously. 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. Preliminary results are being presented in AGU-Iguassu.

Land use and carbon

We are continuing our work on evaluating afforestation effects on water and biogeochemical cycles in the Plata basin. We have designed a novel experiment to test the effect of afforestation of grasslands on ecosystem biogeochemistry. We have selected 5 triplets that include adjacent stands of *Eucalyptus*, *Pinus* and natural grasslands. All ecosystem compartments (roots, soil, leafs, fruits, bark, stems, litter, etc.) were sampled and analyzed for ions concentration. Soil samples have been analyzed for cation exchange capacity and total bases.

We explored carbon sequestration under afforestations in a soil and climate sequence in the semiarid Pampa. Five forestry nurseries in La Pampa, representing a climatic gradient from 700 to 450 mm and with different soil textures were selected that had at least two forest species planted more than 35 years ago. All sites have been sampled, and laboratory analyses are concluded. Further studies are being carried out, aiming at the chemical characterization of humus under these forests and more detailed studies on physical properties of these soils. Preliminary results show that afforestation with Eucalypt and Pine brings about acidification of soils and loss of calcium and other basic cations. Carbon sequestration under these species is mainly in POM form and very little stabilized OM is bound in the soil matrix

Two large field experiments associated with carbon dynamis are being closed in this year (publications still in process). The first involves the reciprocal replacement of grasslands and forest in the province of Misiones. There, rain forests being converted to pine plantations and C4 pastures, and on the other hand, natural grasslands being transformed to C4 pastures and pine plantations, is allowing us to explore with the power of 13C methods, changes in the input/output C dynamics in woody-herbaceous transitions. This work, led by

Gervasio Piñeiro and students is in the stage of manuscript preparation. The other experimental line has been developed in the Parana Delta, were Tomas Schlichter, Dario Ceballos, and E Jobbagy have explored the combined effects of wetland drainage and tree planting on soil carbon and nutrients. Extremely large volumetric soil changes have made this study unique and challenging and after 2 years of data analysis and additional samplings, the first of two expected manuscripts is under preparation.

We have finished pending analyses on carbon stocks and fluxes in the Rio de la Plata grasslands; a paper was published in Global Biogeochemical Cycles this year. Additionally, two more papers where published recently in Rangeland Ecology and Management which analyzes C cycling in the Río de la Plata basin and propose a generalized model of the effects of grazing on carbon stocks. Another paper was also recently published in Applied vegetation science that analyzes the carbon uptake of different vegetations in Uruguay.

We performed a review work we are analyzing soil C turnover in agricultural lands. The review involves the use of the CENTURY model and stable isotopes data. This work has given theoretical insights on potential carbon sequestration in crop lands via root carbon allocation, and Gervasio Piñeiro has spent 3 months in UC Berkeley developing mathematical models to include multiple isotopic constraints to soil carbon dynamics using both 13C and 14C data.

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.

Particular progress has been achieved in the Cerrado. The land use map of the study area was obtained from processing Landsat 5 satellite images. Four land use classes were considered: natural vegetation, silviculture, pasture and agriculture. The results show that land use stimulated degradation of both old and recently fixed soil C, suggesting that agricultural practices in use in the Southwest of Goiás need to be improved, in order to reduce C emissions and stabilize the C sequestered. For natural vegetation (NV), soil C stocks (0-40 cm) ranged from 11.75 to 83.28 Mg ha^{-1}, with the average (± *SE*) value about 48.36 ± 5.31 Mg ha^{-1}. The average soil C stocks under silviculture, pasture and agriculture were 42.22 ± 3.74, 37.8 ± 2.67 and 36.04 ± 6.32 Mg ha^{-1}, respectively. On average, agriculture use provided the greatest loss 25.5 ± 13.1%, while pasture and natural vegetation, 14.3 ± 5.52 and 12,7 ± 6.3%, respectively. Most of the soil carbon is stored under the native vegetation.

3.2. CRN 2031 Events during YEAR 4

During the reported period we held FOUR CoPI meetings/workshops/events.

International Summer School on Land Cover Change and Hydroclimate of the La Plata Basin – 2-13 November 2009, Foz do Iguassu, Brazil
TWO teacher/speaker (Nosetto – Alcaraz) participated

Workshop on Ecosystem Services and Land Use. Co Sponsored by IAI and INTA. Closing event for the synthesis process of book writing. (see details above)
5-7 November 2009, Buenos Aires, Argentina
SEVEN students+CoPIs participated

Workshop on wireless sensor networks and Phenology towers. Visit of team from Alberta/Morelia (CRN 2021 - PI, SANCHEZ-AZOFEIFA, CoPI QUESADA) to CoPIs of CRN 2031. 22-26 February, San Luis, Argentina
TWELVE students+CoPIs participated

Workshop on climate-vegetaiton feedbacks. Visit of 18 CoPIs and Students from CRN 2034. 28-30 April, San Luis, Argentina
SIXTEEN students+CoPIs participated

Small CoPI meetings

Paruelo-Jobbagy-DiBella-Jackson, July 2009
Bert-Jobbagy-Nosetto, San Luis, October 2009
G Piñeiro-DiBella-Jobbagy-Jackson, San Luis December 2009
Maceira-Jobbagy and students, December 2009
Di Bella – Berbery – Alcaraz, Maryland, July 2010
Viglizzo-Jobbagy-DiBella, Santa Rosa, July 2010
Panario-Altesor-G Piñeiro, Several meetings 2009-2010

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
Hydrology & Agriculture	X	X		X								X	X		X	X		
Dry forests ecology	X			X	X				X					X		X	X	
Fire dynamics	X			X					X								X	
Ecosystem Services	X	X	X	X	X		X			X	X	X		X				
Agricultural Policy History										X	X							
Deforestation and river flow in Paraguay	X								X									
C flow in grazing systems	X	X	X	X	X		X						X	X				
C flow in agricultural systems	X	X										X	X			X		
Land use characterization and mapping																		X
Afforestation and biogeochemical cycles	X					X		X		X				X		X		

5 Publications

During the last four years of the project our team has published (including in press status) **55 peer reviewed articles and 6 divulgation papers, 3 books, and 14 book 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 25 articles, 3 books and 11 book chapters (listed below) counting those published and in press. 18 more articles were submitted this year. Most of these work includes 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

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Fernández,R, Noellemeyer, E, Funaro, D, Quiroga, A, Peinemann, N. 2009. Disponibilidad de agua, nitrógeno y azufre en barbechos con y sin control de malezas en distintos niveles de residuos. Ciencia del Suelo. 27. 57-66.

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Jackson RB, EG Jobbágy, MD Nosetto MD. 2009. Ecohydrology in a Human-Dominated Landscape. Ecohydrology. 2. 383-389.

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5.2. In press

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Jobbágy EG, MD Nosetto, PE Villagra, RB Jackson. Water subsidies from mountains to deserts: Their role sustaining groundwater-fed oases in a sandy landscape. Ecological Applications.

5.3. Submitted

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Laterra P, EG Jobbágy y JM Paruelo. El Valor Ecológico, Social y Económico de los Servicios Ecosistémicos. Conceptos, Herramientas y Estudio de Casos. INTA. XXX pages. Buenos Aires. Argentina

5.5. Book chapters - Published

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Viglizzo, EF, Carreño, LV, Volante, J, Mosciaro, JM. Valuación de bienes y servicios ecosistémicos: ¿verdad objetiva o cuento de la buena pipa?. El Valor Ecológico, Social y Económico de los Servicios Ecosistémicos. Conceptos, Herramientas y Estudio de Casos. Pedro Laterra.

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Lezama F, Altesor A, Pereira M, Paruelo JM. Descripción de la heterogeneidad florística de las principales regiones geomorfológicas de Uruguay. Bases ecológicas y tecnológicas para el manejo de pastizales. Altesor, A., W. Ayala y J.M. Paruelo editores. Serie FPTA, INIA. Uruguay

Pezzani, F, Baeza, S y Paruelo, JM. Efecto de los arbustos sobre el estrato herbáceo de pastizales. Bases ecológicas y tecnológicas para el manejo de pastizales. Altesor, A., W. Ayala y J.M. Paruelo editores. Serie FPTA, INIA. Uruguay

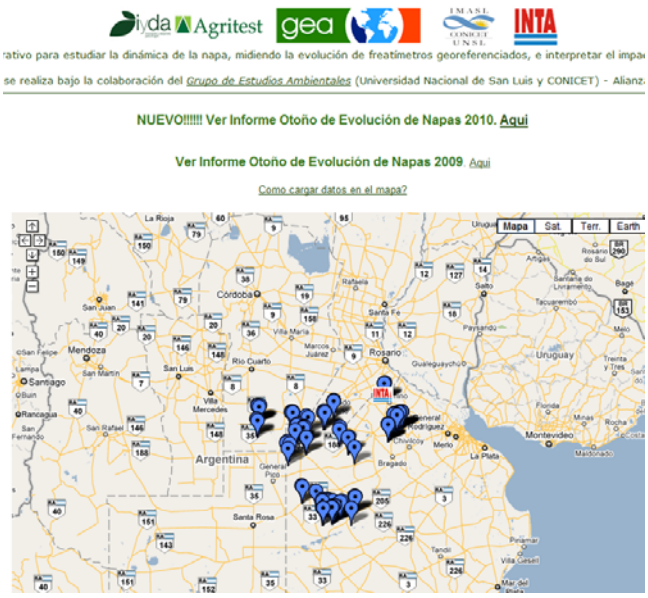
6 Data

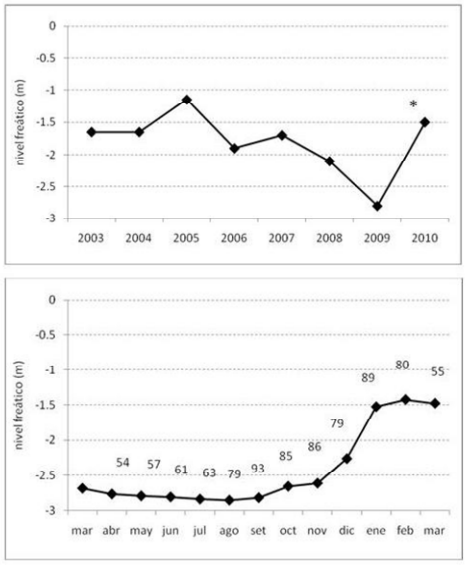
We are maintaining the sites http://platabasin.unsl.edu.ar
Collaborative site: http://lechusa.unsl.edu.ar
Collaborative site: http://stipae.ebd.csic.es

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. **IMPORTANT:** this site has being growing exponentially in terms of contributing collaborators. One of the consequences of this fast growth is that now we count with a much better census of groundwater levels in the region

Figure 9. View of the groundwater monitoring web sites with the location of collaborating farms and wells. The plots on the right show mean water table depth in the month of March for the 2003-2010 period and the monthly levels for 2009-10 with numbers on top of markers active wells in the database





7 Capacity Building

7.1. Students

During the fourth year our team hosted 1 postdoctoral student, 8 PhD students, 7 MSc students and 4 Undegraduate students using IAI funds. In addition, all groups have other students committed to the project and supported by other sources of funds (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 postodcs 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.

Students participated in one shool

International Summer School on Land Cover Change and Hydroclimate of the La Plata Basin – 2-13 November 2009, Foz do Iguassu, Brazil

In this year students have been actively involved in workshops

Workshop on Ecosystem Services and Land Use. Co Sponsored by IAI and INTA. Closing event for the synthesis process of book writing.

Workshop on wireless sensor networks and Phenology towers. Visit of team from Alberta/Morelia

Workshop on climate-vegetaiton feedbacks. Visit of 18 CoPIs and Students from CRN 2034. 28-30 April, San Luis, Argentina

7.3. Outreach

7.3.1. Afforestation and its impacts

The synthesis of four years of research on this theme has been presented in the WORLD FOREST CONGRESS in Buenos Aires in November 2009 by Jobbagy in a plenary session with 1100 participants. In a smaller meeting organized by IIASA results on carbon and afforestation were presented to an international audience discussing CDM and REDD mechanisms and the role of forests. Our team is permanently being consulted by policy makers on the forestry sector in Uruguay and Argentina.

Jobbágy, EG. 2009. Las plantaciones forestales y el ciclo del agua en Sudamérica: Desafíos y oportunidades emergentes. Congreso Forestal Mundial. Buenos Aires, Argentina. CONFERENCIA INVITADA (asistencia estimada: 1100 personas)

Jobbágy, EG, G Piñeiro, RB Jackson, S Berthrong, P Eclesia, MD Nosetto. 2009. Carbon cycling in tree plantations of temperate and subtropical South America. Congreso Forestal Mundial – Evento Paralelo organizado por IIASA. Buenos Aires, Argentina. CONFERENCIA INVITADA

7.3.2. Climate, Hydrology and Agriculture

During Year 4 our team has sustained 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 famer consortium (AACREA & AAPRESID) and the service company "GeoAgris" (http://www.geagris.com.ar) and IyDA (http://www.iyda.net). See details about the regional network and its results in point 6 and TOPIC 1 detailed report.

7.3.3. Participation in AAPRESID national congress

One of the most important farmer´s association of Argentina, AAPRESID invited Dr. Dr. Jobbágy for its congress in 2009. More than 600 attendees participated in his presentation on groundwater/crop interactions http://www.aapresid.org.ar/

8. 1. Regional Collaboration/Networking

To the existing networks in which our team members are enrolled, we added this year the following

FIREGLOBE (PI: Emilio Chuvieco): This project aims to generate a wildland fire risk system that could be applicable at national and global scales using satellite remote sensing and geographic information system tools. The project includes the creation of the main risk factors, their integration into synthetic risk indices, the validation of the results and the analysis of fire risk trends, considering potential changes in socio-economic factors (land use/cover or fire suppression policy, demographic trends) as well as the foreseen impacts of global climate change.

8.2. 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. We held a workshop in San Luis in April 2010 and the collaboration has already yielded 4 presentation in congresses and 1 manuscript in preparation

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.

Our ongoing collaboration with the CRN directed by Arturo Sanchez has yielded TWO functional sites added to the Tropi-Dry Network with fully active phenology towers in the dry forests of San Luis. Canada-funded fellowships for two Argentine students that will visit U of Alberta are under evaluation.

In collaboration with CoPIs of CRN 2005 (PI: Guillermo Sarmiento) we started measurements in grassland watersheds and afforested pairs. Ana Acosta, formerly an

undergraduate student of our team will do her PhD under the advise of Dr. Cingolani, from Sarmiento's team, in Cordoba. She will transfer some of the hydrological expertise developed by CRN 2031 to that team and will maintain fluent contact with our group.

9. Media Coverage and Prizes

AUG 2009, Presentation on GROUNDWATER-CROP interactions in AAPRESID annual event featured in local and national news papers
http://gea.unsl.edu.ar/gea_medios/clarin_aapresid_29_08_09.pdf

SEP 2009, La FAUBA analiza el desmonte en Salta. Agronomía Informa. 2009. http://agro.fauba.info/node/294, also Agencia Nacional de Noticias y Opinión. http://www.auno.org.ar/leer.php/5457

NOV 2009, Presentation in the WORLD FOREST CONGRESS featured in many newspapers and in Nature – NEWS:
http://gea.unsl.edu.ar/gea_medios/nature_20091107.pdf
See also

MAR 2010, Interview to Alice Altesor in "Producción Nacional" (Dirige Alejandro Landoni) AM radio, Program on Medio Ambiente y Cambio climático

10 Policy Relevance

Policy relevance: some of our results fit directly into the process of land use regulation. CoPIs Paruelo, Jobbagy, and Viglizzo have assisted the Ministry of Agriculture of Argentina in the development of a Federal Initiative for Land Use regulation and Policy. Still in its very initial steps, this initiative will likely culminate in the development of new laws for land use regulations to be implemented at the provincial level.

Public outreach: We implemented several outreach avenues including divulgation and teaching publication 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

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 and farmers such as "La Reja, Lincoln-Buenos Aires" and "Labrador, Villegas-Buenos Aires" and farmer associations named CREA and AAPRESID.

11 Main Conclusions

In the fourth year of the project our team has consolidated all the work lines accomplishing to a great extent the long term goal of **"humanizing"** to greatest possible extent our science. This year showed the first clear results on this aspect with explicit human mechanisms being integrated to the **ecohydrological study of floods** in the Pampas, or the human perception of ecosystem processes in the form of **"ecosystem services"** being considered in the projection of our results (see book on ecosystem services). Top quality science has allowed us to increase our publication rate accessing some of the best journals in different disciplines. The project maintains a staff of 1 posdoc, 15 graduate and 4 undergraduate students with IAI funds and involved many additional students financed by other sources. These students continue to bridge the labs of different CoPIs. In year 4 we have produced **25 articles, 3 books and 11 book chapters (counting those published and in press and 18 more articles were submitted**. We made more than 35 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 synthesis and integration activities as well as on warranting the continuation of some long-term initiatives that proved very successful (e.g. long term water table level monitoring, flood warning sytems, afforestation expansion documentation, atmospheric deposition network, etc.)

This last year will involve more modeling efforts

a) HYDRUS-MODFLOW-VEGNAP integration
b) CENTURY integration of land use – soil C research

Development of alternative production models for dry forests

c) Continuation of the "fire to energy diversion" plan exploring both ecological and engineering aspects
d) Analysis of the Espinal-Chaco-Cerrado production and land use trends and results in the context of other dry forests of the World (specifically India-Pakistan, Southern Africa, Mesquite and NE Australia)

Outreach and collaborative avenues

e) Shift LECHUSA from current ´pilot stage to fully operational mode

Forecasted budget for year 5 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	8260	0	3450	0	0	0	0	3060	0	0	0	0	0	12150	8155	35075
Travel	15267	3966	2366	2056	1335	1080	1039	569	569	569	1039	1039	1039	1991	0	33925
Equipment	1310	655	741	1310	584	584	0	0	655	0	0	0	0	563	0	6400
Expenses	8033	2743	5123	4517	252	252	0	252	892	1692	0	0	0	2445	0	26200
communication	1000	250	500	500	250	250	250	250	250	250	250	250	250	0	0	4500
Publication	4400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4400
administration	6740	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6740
Overhead	2733	462	739	509	147	131	78	251	144	152	78	78	78	1041	495	7118
TOTAL	47742	8076	12919	8892	2567	2296	1368	4381	2509	2663	1368	1368	1368	18190	8650	124358

A single modifications from the budget presented in the original project was introduced, 8155 USD were transferred FROM travel TO fellowships

Appendix A – List of students enrolled in IAI fellowships in year 4 of CRN 2031 (PD=postdoc, G= grad student, UG=undergrad)

T	Name	Affiliation	Nationality	Grade	Area of expertise	Training activity	Student involvement in project	Scholarship duration & amount	Exchange programs	Note
G	Damien Arvor	EMBRAPA Solos/ Costel Rennes University	French	PhD student	Land Use Change	EMBRAPA				Joint grant: France/CRN
G	Sandro Pereira	EMBRAPA Universidade do Estado do R de Janeiro	Brazilian	MSc student	Sugar Cane Zoning	UFRJ				Joint grant CAPES/CRN
G	Deborah, Leite	EMBRAPA/ Universidade Federal do Rio Janeiro	Brazilian	MSc student	Soil Microbiology	UFRJ	land uses & bacterial community structure of groups of Eubacteria	2 years, 610 USD/month		Joint grant CAPES/ CRN/IDRC
G	Morazzo, Germán	FAUNLPAM	Argentine	PhD student	Soil chemistry	Program EPG FAUBA	Carbon sequestration in forest soils	4 years, 600 USD/month	UNSL	CONT FROM YEAR 1
G	Andres, Wehrle	UNA Asuncion and GEA-FAUBA	Paraguaian	PhD student	Hydraulic Engeneering	Program U del Litoral	Land use impacts on surface hydrology in Paraguay	610 USD/month	FAUBA & GEA & U Asuncion	RECRUITED IN YEAR 2
G	Baeza, Santiago	Fac. Cs. UDELAR	Uruguaian	PhD student	Grassland Ecology	Program EPG FAUBA	environmental and land use controls over ecosystem functioning over Uruguay	3 years, 610 USD/month	FAUBA	RECRUITED IN YEAR 2

G	Carambula, Matías	Fac. Cs Sociales UDELAR	Uruguaian	PhD student	Rural sociology	PhD Program U of Cordoba	Social impacts of afforestation	3 years, 610 USD/month	FAUBA	RECRUITED IN YEAR 1
G	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
G	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, then 16 months 810 USD/month	INTA Clima y Agua	FINISHED IN YEAR 4
G	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	FINISHED IN YEAR 4
G	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	RECRUITED IN YEAR 2
G	Perino, Ivan	GEA-FAUBA		MSc student	Electronic Engeneering, Instrument networks	Program U de San Luis	Involvment of farmers on Groundwater monitoring networks	2 years, 610 USD/month - 1 year 810 USD/month	FAUBA-Quantitative Methods Group	FINISHED IN YEAR 4
G	Hugo Alvarez	INTA Inst Clima y Agua	Argentine	PhD student				6 months, 710 USD/month		FINISHED IN YEAR 4
G	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

G	Germán Baldi	GEA-FAUBA	Argentine	PhD student	Remote sensing and GIS	Program EPG FAUBA		3 months, 810 USD/month		FINISHED IN YEAR 4
PD	Cristiane Filgueiras	EMBRAPA	Brazilian	PostDoc	Carbon dynamics					
UG	Marconi Betta	EMBRAPA/ Universidade de Rio Verde	Brazilian	Biology student	Carbon dynamics					
UG	Ricardo Paez	GEA-FAUBA	Argentine	Biology student		U of San Luis	Root – groundwater interactions	1 year, USD 405/month		RECRUITED IN YEAR 4
UG	Santiago Cotroneo	INTA Inst Clima y Agua	Argentine	Agronomy student	Agronomy		Rangeland productivity	6 months, 405 USD/month		RECRUITED IN YEAR 4
UG & G	Ana Acosta	GEA-FAUBA	Argentine	Biology student and PhD student	Biology	U of San Luis / U of Cordoba	Vegetation-Groundwater interaction	14 months 405 USD/month		SWITCH TO GRADUATE IN YEAR 4

Other students funded by non-IAI fellowships

GEA-Jobbagy
Roxana Aragon - FONCyT
Marcelo Nosetto - CONICET
Germán Baldi - FONCyT
Carla Rueda - CONICET
Celina Santoni – CONICET
Victoria Marchesini – CONICET (with Fernandez from FAUBA)
Eva Florio – FONCyT (with Nosetto from GEA)
Guillermo Correa (FONCyT with Fernandez from FAUBA)

EMBRAPA-Solos
Thamyres Lacerda Rocha - CNPq
Luiz Ivan Ortiz Valencia – CAPES
Guillherme Angelini - CNPq
Fernanda Teixeira – CAPES
Caio Rachid – CAPES

–FAUBA-Piñeiro
Paola Eclesia – INTA Misiones
Sebastián Mazzilli – INIA Uruguay
Camilo Bagnato - FAUBA
Gonzalo Garcia Azzinelli – FAUBA/CONICET

FAUBA-Paruelo
Costanza Caride – CONICET

Mayra Milcovic - FONCYT
Marcos Texeira – CONICET
Hernan Dieguez – IAI-Berbery
José Volante – FAUBA, INTA
Lisandro Blanco – FAUBA- INTA
Gabriela Cordon - Conicet

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 Ángeles - INTA
Straschnoy, Julieta Verónica - INTA Inst Clima y Agua

SAGPyA – Maceira
Alejandra Moreno - SENSORS
Maria Mercedes Patrouilleau – SENSORS
Carla Seain - SENSORS

INTA La Pampa
Lorena Carreño – INTA
Federico Frank – INTA
Federico Cony – PETROBRAS
Florencia Ricard - Conicet
Jonathan Clatt - El Tejar Fellowship

Univ. Asuncion - Genaro Coronel
Fernando Pio Barrios – UNA Paraguay
Maria Elena Hume (LIAPA-Inst Clima y Agua INTA, Dibella)

Udelar -Piñeiro
Antonio Graziano, UDELAR
Emilio Fernández, UDELAR
Victoria Menendez, UDELAR
Natalia Vibel, UDELAR

Udelar – Altesor
Luis López – Pedeciba

Gastón Fernández. UDELAR
Ana Laura Mello UDELAR
Federico Gallego UDELAR
Andrés Rossado, UDELAR
Gerardo Parodi, UDELAR
Daniella Bresciano , UDELAR
Lezama, Felipe - ANII e INIA

INTA-Schlichter
Darío Ceballos – INTA Delta

Duke - Jackson
Kim, John – NSF/DOE
Jayawickreme, Dushmantha - NSF

Univ. of Miami-FAUBA - Podesta
Carolina Favre – CRN 2031 Addendum
Federico Bert
Florencia Rositano – Conicet (no longer will receive IAI funding)
Santiago Rovere
Ramiro Carretero

Univ La Pampa-Noellemeyer
Diego Riestra - CONICET
Mauricio Perez – ANPCYT
Iván Jorge - FAUNLPam;
Carolina Gaggioli – FAUNLPam
Brian Belcher -, FAUNLPam
Martín Ariztimuño - FAUNLPam
Ramiro Bagnato - FAUNLPam,
Andrea Pía Salvadori – FAUNLPam