1. TITLE: ***Bridging Ecosystem Services and Territorial Planning (BEST-P): A southern South American initiative***

Proponent –Principal Investigator: ***Dr. José M. Paruelo*****. LART-IFEVA. Facultad de Agronomía and CONICET. Av. San Martín 4453. 1417 Buenos Aires – Argentina.**
E.mail: paruelo@agro.uba.ar/www.agro.uba.ar/users/paruelo

2. EXECUTIVE SUMMARY: Territorial planning of land use is an urgent need in southern South America. The area cultivated with soybean, and *Eucalyptus* and *Pinus*, is expanding at increasing rates in both grasslands and forests of Argentina, Chile, Uruguay, Paraguay, and Bolivia. Territorial disputes motivated by land use changes have affected basic human rights of peasants and aboriginal people. Throughout southern South America, the costs and benefits of these land transformation for the different stakeholders are poorly characterized, and the benefits are not available to the most vulnerable social sectors. **The main goal of our project is to make operational the concept of Ecosystem Services (ES) for land use planning in southern South America** We will focus on landscapes of the Rio de la Plata Grasslands of Argentina and Uruguay, the dry-forests of the Gran Chaco (Argentina, Paraguay and Bolivia), and the Valdivian forests of south-central Chile.

In this project, we will emphasize ecosystem aspects related to: (a) carbon dynamics (e.g. Net Primary Production, C stocks and losses**,** carbon released by fires); (b) water (e.g. evapotranspiration, hydrological yield and quality); (c) climate regulation; (d) trace gas (e.g. NOx) emissions; and (e) type and distribution of habitats (e.g. landscape structure and configuration). For some specific landscapes, we will also analyze the potential for recovery of ES through the restoration of ecosystems and landscapes that have been impaired or degraded.

ES supply will be evaluated in a spatially explicit manner, by describing the ecosystem processes that support ecosystem services with relative (unit-less) ES values, and based on the assessment of ES vulnerability according to ES delivery (social capture and distribution) and ecosystem recovery after agricultural replacement. For the landscapes to be selected in each of the three regions, we will develop specific ES production functions according to the characteristics of the Socio-Ecological Systems. We will characterize the past and current distribution of Land Use and Land Cover (LULC) types for the landscapes to be analyzed and their regional context. An important part of the project will be the analyses of stakeholders and of the governance in each of the landscapes.

A team of 23 researchers from 9 institutions and 5 countries will merge their complementary backgrounds, generating novel insights on ES theory and on the application of the ES framework for territorial planning. The project includes an important component of capacity building through training programs oriented to both the professional sectors and to local stakeholders. The existing partnership with government agencies, NGOs, the private sector, and other stakeholders provide the basis for dissemination and application of the results of the project. At the end of the project we hope to have: a) a better understanding of the effect of functional and structural diversity of landscapes on the provision of ES, b) a comprehension of the effect of social and cultural capital on ES supply and demand in the different landscapes studied, c) impact and production functions for key intermediate and final services for the three regions under study, d) toolboxes that allow an effective integration of the ES paradigm into territorial planning and, e) a greater capacity to influence territorial planning processes through trained agents and stakeholders. Peer review articles on the more basic aspects of our agenda, a synthesis book, regional meetings and workshops, and an established program to train professional agents and stakeholders will be the objective indicators of the level of achievement of our goals.

3. BACKGROUND AND OBJECTIVES

3.1 Land use conflicts in South America: Territorial planning of land use is an urgent need in southern South America. The area cultivated with soybean is expanding at increasing rates in both grasslands and dry forests of Argentina, Uruguay, Paraguay, and Bolivia. *Eucalyptus* and *Pinus*, planted by timber companies, are replacing large areas of native forests in southern Chile and grasslands in Uruguay. The territorial disputes motivated by land use changes have affected basic human rights of peasants and aboriginal people, including violent removal from their traditional territories with unfortunate consequences in terms of marginalization, several deaths, and deep political crisis in the Chaco region (Carruthers and Rodriguez 2009, Meza 2009, Newbold 2004, Stocks 2005, Seghezzo et al. 2011). Livelihoods of local communities, including the supply of relevant ecosystem services (see definition below), are not only being altered by land appropriation associated with large investments in agriculture but also by fast growing tree plantations promoted by REDD+ and similar policies (Borras Jr et al. 2012, Meza 2009). The "Red Agroforestal-Chaco Argentina," a NGO devoted to environmental and social issues identified 153 land tenure and 16 environmental conflicts linked to the expansion of agribusiness in the Argentine portion of the Chaco since 2010 (REDAF, 2010). Based on the cases documented by REDAF, land conflicts affected 97.000 people and more than 1.700.000 ha in the Argentine portion of the Gran Chaco alone. Environmental conflicts affected almost 900.000 people and more than 7.000.000 ha. Throughout southern South America the costs and benefits of these land transformations for the different stakeholders are poorly characterized, and the benefits are not available to the most vulnerable social sectors (Paruelo 2012).

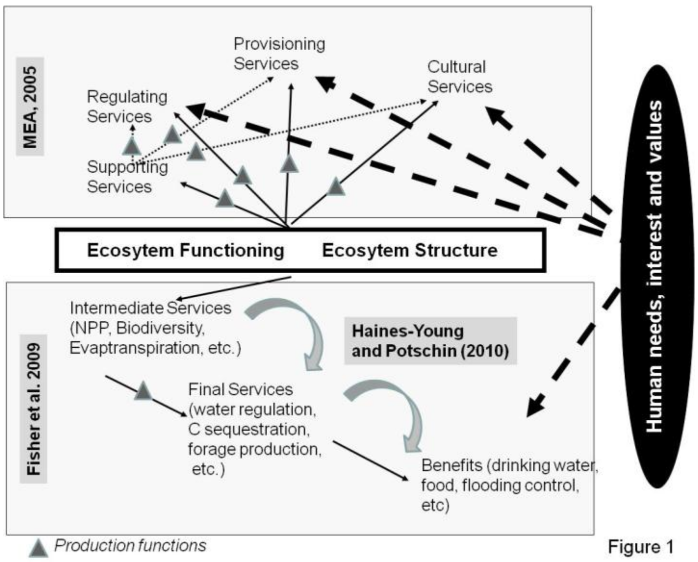

Figure 1

3.2 Ecosystem Services and Land Use / Land Cover Change: Since its introduction more than thirty years ago (Mooney and Ehrlich, 1997) the ecosystem services (ES) concept has gained importance in the analysis of environmental issues. ***Fisher et al. (2009) define ES as the aspects of ecosystems that are utilized or enjoyed actively or passively to generate human well-being (see also Boyd and Banzhaf, 2007; Boyd et al., 2001).*** ES are directly linked to human well-being (MEA, 2005), and they have a direct connection to structural and functional aspects of ecosystems (Costanza et al., 1997), as made clear in Fisher et al.'s definition (Figure 1). Fisher et al. (2009) also introduced the idea of **intermediate and final services** that, in turn, may translate into benefits for society (Figure 1).

Despite increasing recognition of the importance of ES for human well-being, they continue to decline at an unprecedented rate (Chapin et al., 2009). Land use and land cover changes (LULCC) are a major forcing of ES supply at the landscape level (Dirzo and Raven, 2003; MEA, 2005). Tradeoffs between final ES lead to increases in the level of provision of some ES, like food production, and the reduction of others, like soil protection, water regulation, and C sequestration (de Groot et al., 2010). Such changes in ES supply are mediated by structural and functional changes (intermediate services), such as biodiversity losses and changes in C and water dynamics. The "**impact functions**" define the relationship between the level of provision of ES and the main disturbance and stress factors. ***In this project we identify the land use and land cover changes as the main stress/disturbance factors driving changes in ES provision.***

From an operational perspective, the ecosystem aspects to be evaluated (intermediate services) have to be reliable, simple to measure or estimate at different scales, and should be logically connected to final services that are clearly envisioned by stakeholders and decision makers. The sources of data to assess ES supply necessarily include field monitoring systems, but complementary approaches able to cover large areas are needed in monitoring programs. Spectral data are able to characterize structural and configuration aspects of the landscapes (i.e. spatial and temporal distribution of land cover types, and their fragmentation) but also functional aspects of ecosystems like C dynamics, evapotranspiration, watershed water yields, and disturbance regimes (Wessman 1992; Kerr and Ostrovsky 2003; Pettorelli et al. 2005; Paruelo 2008; Cabello et al. 2012; Lara et al., 2009; Little et al., 2009). The specific intermediate services to be monitored vary among landscapes according to the characteristics of the Socio-Ecological Systems, however, some aspects defined as provision services by MEA (2005; Figure 1) have to be considered. This is the case of Net Primary Production (NPP) that has been identified as an integrative descriptor of ecosystem functioning (McNaughton et al. 1989) and is presented as a proxy for the total value of ES (Richmond et al. 2007). ***In this project we will emphasize those ecosystem aspects related to: (a) carbon and energy dynamics (e.g. Net Primary Production, C stocks and losses, energy released by fires); (b) water (e.g. evapotranspiration, hydrological yield, and water quality); (c) climate regulation; (d) trace gas emissions (e.g. NOx); and (e) type and distribution of habitats (e.g. landscape structure and configuration).***

3.3 From ecosystems to societal benefits: Haines-Young and Potschin (2010) showed that there is a cascade from basic ecosystem processes and structures to benefits. As shown in Fig. 1, their connections result from a series of **production functions**. Though ES classifications and typologies are hard to construct, considering the range of values and interests in the society***, in this project we assume the definition proposed by Fisher et al. (2009) and the idea of cascading production functions*** from Haines-Young and Potschin (2010) (Figure 1). This definition and typology allow us to derive, on the one hand, biophysical estimates of intermediate services and production functions of final services and, on the other hand, a characterization of ES demand from stakeholder analyses. The tight link between the biophysical and human components requires framing the study of ES into integrated Socio-Ecological Systems (SES) (Ostrom, 2009, Berkes et al. 2002). ***In such a way our analyses will integrate not only the resource system and units but also stakeholders and the governance system at different spatial scales (Ostrom, 2009***). ***Governance describes the sum of the many ways individuals and institutions, public and private, manage their common affairs. Good governance contains a strong participatory element. .***

Monetary valuation has been the most frequent approach for connecting the ES idea with decision making. This approach, however, has been questioned as a mechanism for making decisions, when information and data are the result of subjective estimations, for example, among different consumer categories (Carpenter et al., 2009). Notwithstanding these considerations, monetary valuation remains as one of the most studied aspects of ES. The lack of a proper monetary valuation is identified as an important driver of decreasing ES provision (MEA, 2005). Despite the effort applied to develop practical and effective methods of ES valuation for policy making, successful examples are relatively rare (Ruffo and Kareiva, 2009); most of them have looked at services associated with water provisioning. An important issue of assigning monetary value to ecosystem services has to do with the ideological choice, not always explicitly assumed, that is made when the ES analysis is based on a market rationale. The power asymmetries of the process of production, exchange, and consumption of ecosystem services may contribute to reproduce, rather than reduce, inequalities in access to environmental benefits (Liverman and Vilas, 2006; Kosoy and Corbera, 2010). ***In this project we have a broad vision of ES valuation that includes***

the biophysical, economic, and social dimensions, and transcends monetary-focused approaches.

3.4 Natural, human, social, and cultural capital as constraints to ES losses: Although the idea of ES is linked to the well-being of the society as a whole, society is not homogeneous (Godking, 1965; Endter –Wada et al, 1998). Groups of stakeholders differ in their interests, values, attitudes, access to resources, and even in their ability to exclude others. In Latin America, such heterogeneity increased in rural areas during the last decades (Van der Ploeg, 1993), associated with the globalization process (Kay, 1995; Escobar, 2000). Adding to this heterogeneity, a given landscape may have different symbolic meanings based on the cultural background of individuals and social groups. (Greider and Garkovic, 1994). All these factors determine diverse and complex **Socio-Ecological Systems (SES)**. The idea of SES highlights the importance of analyzing collectively the ecological, social, and cultural dimensions, their feedbacks and mutual adaptations (Folke et al, 2005). Stakeholders affect ES supply (Chapin et al 2009) through processes that, from a social perspective, are historically located in space and time (Llambí and Correa, 2007). Therefore, stakeholders valuation of ecosystem services is not independent of their place attachment or their socio-cultural bounds to the territory (e.g. García-Llorente et al. 2012). ***For our project this means that historical and regional characteristics are critical to understanding the dynamics of ES supply and, hence, their management.***

Static approaches to studying the association of stakeholder groups and ecosystem properties allow for the generation of descriptive maps but not for providing explanations of the relationships between social and ecological dimensions (Troy and Willson, 2006). However, long term strategies for ES management require the identification of the logic behind the behavior of different stakeholder groups (Tsakoumagkos, 2006). It is important, then, to recognize the collective definition of the social and cultural capital that drives ES management (Pretty and Ward, 2001, Brondizio et al. 2009) since institutions and social relationships at different levels promote the long term protection of ES supply.

The definition of the spatial and temporal scale of the analysis is a critical step in any ecological study (O´Neill et al. 1986, Peterson et al. 1998). Many benefits occur away from the ecosystems providing the services (e.g. downstream) or in particular configurations (Fisher et al. 2009). Depending on human factors (i.e. the population distribution within a watershed), the effect of changing the level of provision may be perceived at local or regional scales. Ecological succession, nutrient redistribution, runoff regulation and filtration, soil erosion and sedimentation, and local extinctions are examples of landscape context-dependent biophysical processes directly linked to ES provision. All these examples highlight the importance of the landscape level to assess ES.

However the biophysical dimension is just one of the components of the Socio-Ecological Systems (SES). The definition of the scales of the analyses must consider the social, institutional, administrative, and cultural dimensions of the SES to design multifunctional landscapes, to analyze tradeoffs, and/or to combine the production of different goods and services (e.g. commodities, and water regulation and supply) ***Though we acknowledge the importance of multilevel controls on SES, this project will focus on scales that result from the intersection of landscape and administrative units (often municipalities). From this level, we will consider the complexity introduced by multilevel influences on governance (Brondizio et al. 2009).***

Introducing the notion of ES into politics and policy requires some revision about the ways in which science connects to society (Pielke 2009). The still-predominant vision of benefit generation by science assumes a unidirectional flux of knowledge from basic science to decision making with an intermediate stop at applied research. An alternative view proposes that benefits are only likely to occur when a "dialog" between research and decision making is developed. The "linear" and "coupled" visions are our first key to the problem. The second clue comes from the way in which societies orchestrate debates, which in simple terms can be seen as bottom-up, when social groups introduce political choices, or top-down, when choices arise from the governmental sphere, stemming from a more technocratic process (Pielke 2009). The interaction of these two dimensions and respective options yields four possible ways for science-policy connections. In very simple terms, scientists that stay in the linear model contribute to decision making processes through what they publish or eventually disseminate in the media (I) or, in a more technocratic society, as arbiters (III) on the request of policy makers, the private sector, or NGOs. By embracing a coupled view of their work, scientists can engage in the role of advocates (II), in which case they restrict decision choices offering evidence to support one and reject others, or they can interact with the decision forums as brokers of options (IV) helping to map conflicts and creating more choices. We suggest that currently the use of ES science by society, especially in Latin-American countries, is still predominantly in the realm of roles I and III, depending on the type of conflict. When a more coupled role is sought, the prevalent path is towards II. ***In this project we will engage in the role of promoting alternatives (role IV in Table I) favoring activities that will connect research with organized debate and development of land use alternatives.***

Table 1. Proposed options for a possible relationship between science view and social context

		Science View	
		Linear	*Coupled*
Social Context	*Bottom-up*	I. Pure Science	II. Issue Advocacy
	Top-down	III. Arbiter Science	IV. Broker of alternatives

3.5 Motivation for the present study: Southern South America is experiencing an accelerated change in land-use and land-cover. Such changes result from the expansion of the area devoted to annual (mainly soybean) and perennial crops (mainly *Pinus* and *Eucalyptus* plantations) and to agriculture intensification. The Gran Chaco in Bolivia, Paraguay, and Argentina is, along with the Brazilian Cerrado and the Chiquitanos Forest, one of the three areas of South America where land clearing has had the greatest impact (Zak et al., 2004; Grau et al., 2005a,b; Boletta et al., 2006, Paruelo et al. 2011, Volante et al. 2012). The Argentine portion of the Gran Chaco ecoregion has been particularly affected with greater deforestation rates than the continental and world averages (0.82% per year in Argentina, 0.51% for South America and 0.2% globally, FAO, 2009; UMSEF, 2007). Deforestation of the Valdivian Forests in south-central and southern Chile has been mainly caused by their conversion to *Pinus* and *Eucalyptus* plantations (68% of the area lost) as well as clearing for agriculture and pasturelands (32%) over the 1993-2008 period (Lara et al., 2011) (a mean loss of 10,000 ha/year). Forest degradation is also significant and affects a large undetermined area for an increasing supply of fuel wood, estimated at 9.2 million m^3 for 2008 (Lara et al., 2011). An important portion of the Rio de la Plata Grasslands has been modified for the expansion of crops and tree plantations (Paruelo et al. 2006; Jobbágy et al. 2006, Baldi y Paruelo 2008, Vega et al. 2009). Tax incentives and other policy instruments drove an increase in the area covered by tree plantations, mainly in Uruguay, from 1.2% in 1990 to 9% at present (Baeza, 2012). The region is experiencing both an expansion of cropped area and an intensification of the agriculture.

3.6 On going initiatives: On the other hand, many initiatives from NGOs, agencies, local and national governments, are trying to develop alternatives to plan land cover transformation. Several of the initiatives incorporate the idea of ES. Ecosystem services research in Latin America has been recently revisited by Balvanera et al. (2012, coauthored by four PIs of this proposal). Important achievements were reached in most of the countries of the region, not only in ES evaluation and mapping, but also for including ES in policy and management design. In Argentina, compensation for ES in the form of subsidies to conservation were incorporated into federal law on land use planning in 2007 (Ley Nacional 26.331). Biophysical evaluation of ES is now part of a mandatory impact assessment for areas under extensive deforestation (Viglizzo et al. 2011, Paruelo et al. 2011), and rural land planning policies are incorporating patterns of ES supply and delivery (Basso et al. 2012), without considering a monetary valuation. A federal law under debate in the Consejo Federal de Planificación (COFEPLAN) is explicitly considering the provision of ES. A novel experience of participatory rural territorial planning (RTP), in which INTA and Universities collaborate with the government sector, was promoted in Balcarce by members of this proposal. This RTP process is strongly based on the provision of ecosystem services associated with land uses in rural areas (Barral et al. 2009, Barral y Maceira 2012)). In Uruguay, ES have been recently incorporated into new norms regarding the potential for carbon sequestration in tree plantations (Decreto 238/009). A current discussion at the *Ministerio de Ganadería* in Uruguay on how to derive sustainable alternatives for managing native grasslands is incorporating explicitly the ES framework. In Paraguay, where deforestation rates have been some of the highest world-wide, intense debate culminated in what is called the "ley de deforestacion cero" (Ley 2524, year 2004), which has targeted only the easternmost third of the country, leaving the Chaco forest unprotected. This law is active until the last day of 2013, when a new legal framework for land use and forest protection should emerge.

In Chile, forest plantations have been promoted by government subsidies since 1974 (Lara et al., 2010a). In 2008 a law on native forests was approved, but its capacity to promote sustainable management and conservation of native forests has been limited. These limitations include the narrow scope of activities that are subsidized, the low amount of these subsidies, and their payment in several installments (Lara et al., 2010b). Members of the team of this proposal have been working on a large-scale experiment to recover water provision as an ecosystem service from the conversion of *Eucalyptus* plantations back to native forests (Little and Lara 2010). This ecological restoration is occuring in Reserva CosteraValdiviana (50,000 ha), through a collaborative agreement between The Nature Conservancy (TNC), Universidad Austral de Chile, and a timber company.

3.7 Our vision

Our ***vision*** for the link between the ES framework and territorial planning includes: A) The need to turn operative the ES framework in both the public and private processes of decision-making, in order to impact the dynamics of land use and land cover change. This will require the development of evaluation tools that allow quantifying ES supply and their delivery to stakeholders in a simple and transparent way. B) The analysis of ES supply and of benefit distribution among stakeholders contributes to solving territorial conflicts, to planning land use and land cover change, and to managing and restoring ecosystems. C) The importance of considering the socio-economic system (SES) in the analysis, quantifying not only ES supply but also the social demand, vulnerability, and resilience for different scenarios. SES framework enables the development of a common language that crosses social and ecological disciplines. D) The role of the ES framework in reducing vulnerability and/or alleviating poverty of local people. We think that identifying the relevant ES, and the factors that control their supply and delivery, will effectively empower local and vulnerable people.

3.8 General objectives and hypotheses: **The main goal of our project is to turn the ES concept operative for land use planning in southern South America (Argentina, Chile, Paraguay, and Uruguay).** Our approach includes investigating the links between the ES framework and South American Socio-Ecological Systems, and to develop toolboxes and training courses for the personnel involved in land use planning.

The project will not only deal with regional issues but also with more general aspects of the ES framework, to identify common patterns that are valid across regions and ecosystems of Latin America. Our approach will consider ES from their supply to their delivery, including their mainstreaming into policy and decision making by linking the ES framework to territorial planning. The ES framework will complement approaches to land use planning based on land suitability by better identifying trade-offs. We will work on understanding the relationship between ecosystem structural and functional attributes and the provision of intermediate ES at a landscape scale, and on defining the main drivers (biophysical and socio-economic) that determine the delivery of the final services and the distribution of their benefits to society, as a basis for making predictions about various land use and climate change scenarios. Therefore, land-use models (e.g. Vega et al. 2009) will be developed in order to facilitate the definition of scenarios by stakeholders and the interactive analysis of their consequences for environmental and social vulnerability. The contributions of the project to the ES framework will be based on the following hypotheses and predictions:

1. The magnitude and interannual variability of ES supply of a given landscape depends on its functional diversity and on its spatial configuration (distribution of filters and barriers).
1.a. Diverse landscapes will have greater and more stable supplies of key intermediate services than simpler landscapes. The intermediate services to be considered will differ among the three regions.
1.b.The rate and timing of the recovery of ES in degraded landscapes depend on the location of the patches that are restored (e.g. Eucalypt plantations removed and planted with native trees or successional grasslands) within the landscapes/watersheds (e.g. distance to streams, lower or higher position in the watershed).
2. Synergism and total supply of relevant ES (including agriculture and timber provision services) peak at intermediate levels of agricultural transformation (AT) of native ecosystems. Land-use heterogeneity (or other configuration descriptors) and optimum levels of agriculture cover depend on the observation scales.
2.a. It is expected that along AT gradients, critical values of land transformation are reached before maximum values for ES supply.
2.b. Optimum heterogeneity levels for current ES supply are poor estimators of optimum heterogeneity levels for reducing environmental and social vulnerability.
2.c. ES supply and ES vulnerability are negatively related along AT gradients.
3. Net Primary Production (NPP) is an integrative attribute of ecosystem functioning (McNaughton et al. 1989) and a key intermediate service. The level of human appropriation of NPP (HANPP) affects the supply of final ES and the distribution of benefits among stakeholders.
3.a. An increase in HANPP will lead to a reduction in the total ES supply of the landscape .
3.b. The HANPP is negatively related to the equity in the distribution of benefits among stakeholders
4. Stakeholders can be defined in terms of their relationships with the supply and use of ES, as affectors and enjoyers (Scheffer et al. 2000). The same stakeholder can play, simultaneously, the role of affector and enjoyer. The supply of ES and the perception of benefits will depend on the territorial bounds of the stakeholders.
4.a. The magnitude of the negative effect of the "affectors" is negatively correlated with their territorial bounds.
5. Social and cultural bounds control human-nature relationships.
5.a. The supply of ES of a given landscape will increase with the social capital.

3.8 ***Specific objectives:*** Based on those hypotheses, and to achieve the overall goal of the project, the following objectives are established:

1. To characterize and map the supply of key Intermediate ES related to carbon, trace gas production, water and climate dynamics, specific final services for each region, and the delivery of benefits (economical, cultural, and social) to the main stakeholders on landscapes of the three study regions (Valdivian and Chaco forest, Rio de la Plata Grasslands) under different land use and land cover scenarios.
2. To evaluate the predictions of the five stated hypotheses in landscapes of the three study regions.
3. To develop toolboxes to incorporate ES flows and benefits, and stakeholder perception into the territorial planning process.
4. To develop alternatives for restoring ES provisions at the plot and landscape/watershed levels in the three study regions.
5. To implement training programs (classes, workshops, and field courses) oriented to the use of the ES framework in the land planning processes at the landscape level. We are planning two types of programs, one oriented to the professional sector and one oriented to empower local stakeholders.
6. To develop outreach activities through a project web site, conferences, press releases, and a strong interaction with NGOs, agencies, local and national governments.

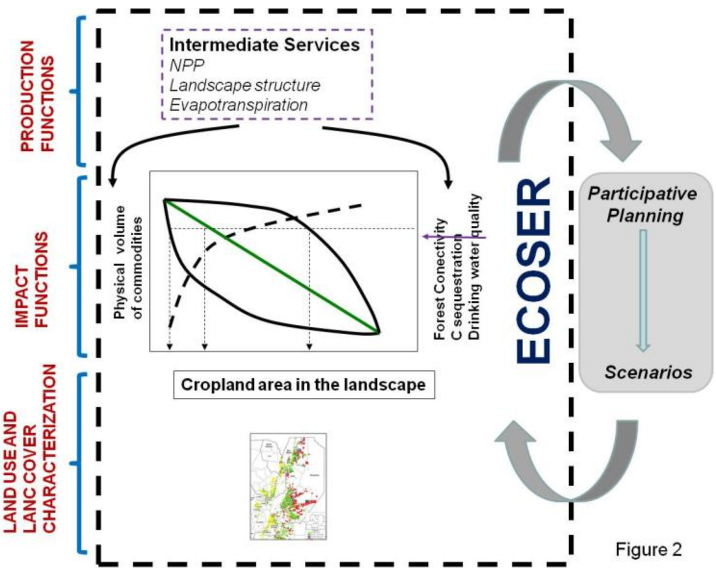

Figure 2

4. METHODOLOGY

We will organize the work on the stated objectives around a number of activities. Each activity will contribute to more than one specific objective.

Activity 4.1: Selection of specific landscapes (Obj. 1 to 3) In the three regions we will select 3 to 6 study areas that combine biophysical (e.g. watershed) and administrative (counties) units. The goal in the selection processes will be to cover most of the heterogeneity of the Socio-Ecological Systems of the region. The heterogeneity will consider biophysical factors (e.g. type of grassland or forest), production systems, governance systems, and the ecological, social, cultural, political, and economic context. Additional points to be considered are the local experience of the different members of the team in particular areas, the availability of data, ongoing projects, among others.

Activity 4.2: Characterization of ES Supply: *ECOSER* (Figure 2), a ES mapping system under development by members of the team (Laterra et al. 2012), will be the basis for the construction of toolboxes (Obj. 3) and for evaluating some of the predictions stated above (Obj. 2) . ECOSER is designed to evaluate ES availability in a spatially explicit manner, based on the integration of models and other proxies, describing ecosystem functions (ecosystem processes or intermediate services supporting final ecosystem service production, de Groot et al., 2002; hereafter, EF) as relative (unit-less) ES values (module 1); and to assess ES vulnerability based on ES delivery (social capture and distribution) and ecosystem recovery after agricultural replacement and abandonment (module 2) (Laterra et al. 2009; 2011; 2012). The module 1 of ECOSER includes three components: final ES production functions, impact functions, and descriptions of the spatial distribution of land-use/land-cover in the territory (actual or scenarios). The current version of ECOSER includes ***production and impact functions*** related to regulation as well as provision services, and was applied for landscapes of the southern part of the Rio de la Plata Grasslands

(Laterra et al. 2012), as well as for landscapes of the Chaco Eco-region (Dagnino et al. 2011). Module 2 still needs to be revised and improved before its application to real cases. Both modules will be developed and implemented for different landscapes of the three regions.

For the landscapes to be selected in each of the three regions, we will develop specific production functions according to the characteristics of the SES (Obj. 1). We will consider as basic intermediate services the landscape structure and configuration, climatic dynamics, and the inter-annual and seasonal dynamics of C gains and stocks, and evapotranspiration***. Boxes 1 to 3*** present the methodological approach to ***characterize the type and distribution of habitats (landscape structure and configuration), evapotranspiration and C dynamics using remote sensing techniques***. ***Box 4*** describes the methodological approaches to derive estimates of particular aspects of ***water dynamics*** from field measurements. ***Long term C gains, trace gas production*** (***Box 5***), ***climate regulation*** (***Box 6***), and ***filtration capacity of riparian environments and wetlands (Box 7)*** will be based on a combination of field data and modeling. The Human Appropriation of Net Primary Production (see hypothesis and Obj. 2) is an aggregated indicator that reflects both the amount of area used by humans and the intensity of land use (Haberl et al., 2007). Prior HANPP analyses characterized this attribute at the regional level; in this project we will characterize HANPP for the different study areas at the farm/ranch level (*Box 8*).

We will combine the characterization of ES supply, the structure and configuration of the landscape, the estimates of HANPP, and the analyses of stakeholders and social and cultural capital to evaluate the predictions of our hypotheses.

Activity4.3: Land use / land cover dynamics: We will characterize the ***past and current distribution of LULC types*** for the landscapes to be analyzed and their regional context (Obj. 1 and 2). The analysis will cover at least the last 10 years. This characterization will be the basis for the analysis of the landscape structure and configuration, and for the defining the level of perturbation in the impact functions. ***Box 9*** presents the protocol to be used to characterize LULC dynamics.

Activity 4.4: Stakeholder analyses and governance systems (Obj. 1 to 3). Here we will investigate the logic of the relationship between stakeholders and ES in the different study regions. The focus will be on the identification of conflicts, interests, strategies, and networks operating within each territory. The characterization of the stakeholders will be based on interviews that will consider the following structural (i.e.: access to land, capital availability, work organization), context (market access, occupation history, conflicts) attitudinal (i.e. perception of ES provisions, changes and the role of the public sector) and social (i.e power and well-being status, links with other social groups, and local organizations) factors. Variables will be recorded from surveys designed to ensure representation of the institutional, social, and cultural heterogeneity of the studied areas. Interviews will be conducted in intended samples for selected cases (See *boxes 10 and 11*).

Activity 4.5: Professional training program (Obj. 5). We will develop and implement a graduate level program on Territorial Planning aimed to train professional personnel of agencies, provincial governments, and NGOs. Courses will incorporate the tools and conceptual frameworks developed during the project, facilitating effective transfer of information to decision makers. The program will be instrumented as a joint activity between UBA, UNMdP, UDELAR and UAustral. The funds provided for IAI will contribute to the design and organization of the program. The implementation will be based on resources provided by other institutions (Ministerios, Provincial Governments, FAO, Universities) and tuitions. At least 70% of the program will be based on video-conferences and e-learning techniques. In situ activities will be offered in each country (Argentina, Uruguay, Chile, and Paraguay) based on local professors. The PIs have extensive experience in developing graduate level courses and programs. JMP has been heading the Master Programs (Natural Resources) and he also developed Professional Programs of GIS and Remote

Sensing at the Escuela para Graduados "Alberto Soriano" of FAUBA. Alice Altesor is the coordinator of the Environmental Science Master Program of UDELAR.

Activity 4.6: Restoration of ES (Obj. 4) Ecosystem services that have been severely reduced by land use conversion and ecosystem degradation can be recovered through ecological restoration (Rey Benayas et al, 2010; Little & Lara 2010). The analyses to be performed will be concentrated in three areas: experimental watersheds at Reserva Costera Valdiviana (which began in 2006) and more spontaneous restorations due to agricultural abandonment in the Chaco forest and Uruguayan grasslands. The set of watersheds in Chile includes a) those in which Eucalypt plantations have been removed (2011 and 2012) and restored through plantation of native trees and natural regeneration (from seeds and sprouts); b) control watersheds where the plantations have not been removed, c) reference watersheds dominated by native forests. Monitoring includes: water yield, sediments, nitrogen and phosphorus exports, as well as the composition and diversity of the plant communities. Another aspect that will continue to be assessed is the effect of the native forest streamside buffer-strip width on nutrient and sediment export in watersheds dominated by Eucalypt plantations. For the Chaco we have already identified 32 patches larger than 30 ha in Salta and Santiago del Estero (Huykman et al. 2012). The sites in grasslands will be identified in the first stages of the project. The results from this monitoring, coupled with water yield records (in Chile), evapotranspiration and NPP estimates from remotely sensed data (in the three areas), and land use/land cover maps from satellite images for different dates employing the methods used by Little et al. (2009), will be used to test the hypotheses proposed for ecological restoration (Boxes 1 to 5). All this information will be used to identify and to model the design of landscapes formed by various land-uses that can synergistically combine two or more ecosystem services (e.g. timber or grain production and water provision and regulation) for landscapes/watersheds of different size (e.g. Laterra et al 2012).

Activity 4.7: Stakeholder training program (Obj. 5 and 6). We are building a strategic alliance with NGOs, foundations, and government agencies that has a direct relationship with stakeholders. In Argentina, this will include participation by the extension services of INTA, REDAF, FVSA, and AACREA. The Instituto del Plan Agropecuario will be the associated institution in Uruguay. U Austral and FORECOS will be coordinating the training activities of stakeholders in Chile, as will the Fundación Moises Bertoni in Paraguay. Alianza del Pastizal is a network of NGOs working on grassland areas of Uruguay, Paraguay and Argentina, and it also will be involved in devising and implementing a stakeholder training program.

Activity 4.8: Outreach activities, networks, meetings and workshops (Obj. 5). Outreach activities will include: 1) an annual cycle of virtual lectures for the dissemination of science to the community, 2) update and implementation of a project website with Web 2.0 tools, as a medium for interaction with the community (the page will be based on www.forecos.net), 3) two international congresses during the period of the project on the development of joint workshops with public, political organizations and users to agree on management strategies and conservation of ecosystems and their services. The congresses will be a follow-up activity of previous initiatives of the PIs of the project (International Congress on Ecosystem Services in the Neotropics, Ist: Valdivia, Chile, 2006, IInd Asunción, Paraguay, 2011), 4) workshops and seminars on land use planning toolboxes with priority groups: decision makers at local, regional, and national levels (see letter of support from Ministries of Argentina and Uruguay), rural organizations such as the Rural Water Supply Committees (CAPR) in Chile or AACREA in Argentina, Peasant and Aboriginal People Associations, NGOs (FVSA, Alianza del Pastizal, REDAF, FMB) and students and teachers of elementary and secondary education, 5) to strengthen the existing bonds with international networks of scientific collaboration on ES issues across Latin America (Latin America Network on Ecosystem Services, http://www.lanes.cl) and the world (The Ecosystem Service Partnership, (http://www.es-partnership.org/esp).

Activity 4.9. Protocols to incorporate the ES framework into territorial planning. The members of team will lead a participatory process to construct protocols to guide the planning process at the municipality/county level in southern South America. The construction of the protocols will be based on Dahlem Conference model (see Box 12) and will bring together the academic sector, government agencies and officers from different levels (national, provincial/regional, municipal), ONGs and selected stakeholders.

5. EXPECTED RESULTS

At the end of the project we hope to have: a) a better understanding of the effect of the functional and structural diversity of the landscapes on the provision of ES, b) a comprehension of the effect of social and cultural capital on ES supply and demand in the different landscapes studied, c) impact and production functions for key intermediate and final services for the three regions under study, d) toolboxes that allow an effective integration of the ES paradigm into territorial planning, and e) a greater capacity to influence land use planning processes through trained agents and stakeholders. Peer review articles on the more basic aspects of our agenda, a friendly version of ECOSER, a synthesis book, regional meetings and workshop, and an established program to train professional agents and stakeholders will be the objective indicators of the level of achievement of our goals.

6. POLICY RELEVANCE

We will work directly with (a) policy makers, i.e., local and national government agencies, and (b) groups of stakeholders, i.e., farmer and rancher associations, aboriginal people organizations, peasant organizations, and NGOs. Several of the alternatives for translating our academic agenda into policy actions are already established. In Argentina P.Laterra, E.G. Jobbágy and J.M.Paruelo are directly involved with the Ministerio de Agricultura, Ganadería, Pesca y Alimentación in a project partially funded by FAO that aims to develop protocols for land planning. Through MinAgri, P.Laterra and J.M. Paruelo are participating in the design of the normative on land planning ("Ley de Presupuesto Mínimos de OT"). P.Laterra and Néstor Maceira were directly involved in developing and implementing the Territorial Plan in the county of Balcarce. To carry out the plan, the creation of a Territorial Environmental Agency was successfully promoted, where different institutions integrated actions to monitor the progress of the plan and propose the necessary technical adjustments to improve the sustainability of development. In Uruguay, Alice Altesor is participating on a Natural Grassland Board organized by the Ministerio de Ganadería that is incorporating the ES concept into the planning processes of the main biome of the country: native grasslands. A. Altesor is also working with the National System of Protected Areas in a project aimed to characterize ecosystem services in protected landscapes that include national parks and commercial ranches. P.Laterra and J.M.Paruelo are also advisors of Alianza del Pastizal, a program sponsored by Bird Life and funded by BID aimed to develop sustainable ranching systems in Argentina, Uruguay, Paraguay, and Brazil. They also participate in a TCP FAO project of the Ministerio de Agricultura aimed to design territorial planning protocols. In Chile, A. Lara has an active collaboration with government agencies including the Ministry of Public Works, CORFO (Corporation for the Promotion of Development), Forest Service, and Environmental Ministry. A.Lara heads a project focused on improving the provision of drinking water in rural areas through watershed management and forest conservation and restoration. This involves working with the above-mentioned agencies, 17 Rural Drinking Water Committees, as well as timber companies and other land owners in order to build and negotiate agreements for the conservation and restoration of watersheds. We plan to expand our influence on the policy arena through two specific actions: (a) A regional, inter-institutional program of professional training on ES and land planning, oriented towards senior-ranking officials at state/local levels (provinces, counties, regions); (b) A book that will compile the conceptual framework, the methodological approaches, and the protocols developed to incorporate the ES design into the land planning process.

7. MULTIDISCIPLINARY AND MULTINATIONAL COLLABORATION

Our team includes a broad and complementary set of expertise and background, including grassland and forest ecology, agronomy, forestry, sociology, hydrology, geography, anthropology, modeling, rural extension, GIS, economics, natural resource management, and remote sensing. Moreover, most of the members of the project have been collaborating for many years, building a joint vision from their different approaches involving the development of ES studies in southern South America. The general framework of our project requires a multidisciplinary perspective. The project will take advantage of the diversity of experiences and backgrounds of the different PIs and collaborators, but we will make a particular effort to avoid a compartmentalization of the research**.** We will avoid both geographic and disciplinary isolation by different means, e.g. periodic meetings and joint direction of graduate students. Some of the planned activities (workshops and the third and fourth version of the Congress on Ecosystem Services in the Neotropics) are particularly designed to promote multinational collaboration.

8. CONTRIBUTION OF EACH CO-PI AND COLLABORATOR.

J.M.Paruelo will coordinate the project, in close collaboration with **A.Lara**, **P.Laterra**, **Laura Nahuelhual, AliceAltesor and Verónica Filardo**. He will be in charge of characterizing landscape structure, land use and land cover changes, evapotranspiration and C dynamics using remote sensing techniques in the different study sites of the three regions. **PL** will be in charge of the development and implementation of ECOSER. **Esteban Jobbágy** and **AL** will focus on the effect of changes in hydrological dynamics on ES supply. **H.Berbery** will lead the effort to identify the LCLUC impacts on climate. **H.E.Epstein** will be leading the analysis related to the C components of the biophysical characterization of intermediate services. **G. Bocco** will provide advice and expertise on land use planning.

Laura Nahuelhual, Verónica Filardo, Ana Murgida and Marcela Román, will coordinate the stakeholder analyses and the characterization of the social capital and the governance systems of the different sites (in Chile, Uruguay and Argentina). **N.Maceira** will devise the general framework for connecting ES assessment and territorial planning. **G.Piñeiro** will be in charge of modeling C dynamics in the different systems, and **S.R.Verón** of characterizing the disturbance regimes. **J.N.Volante and S.Baeza** have worked on the development of the land cover mapping protocols that the project will apply, and on the characterization of Ecosystem Functional Types**. E.Vega** will contribute to the development of land cover change scenarios**. G.Baldi** will be in charge of landscape analyses. **C. Little** will be in charge of the research on water yield (quantity and quality) in the restoration experiments in Chile. **J. Paruelo, P. Laterra, E. Jobbagy and N. Maceira** will organize the process to device territorial planning protocols.

9. CAPACITY BUILDING

The development of a coordinated network of scientists from seven institutions and five countries with complementary expertise in global change and land planning issues will have substantial impact on the academic, educational, agricultural, and political sectors of the MERCOSUR and UNASUR area. The products and tools generated by this team will be available for local governments, federal/ state agencies, NGOs, and the scientific community. In this way we will be bring attention to global environmental change issues and provide scientific tools to deal with them. As has been the tradition for projects headed by this team, undergraduate and graduate level training will be a top priority. New PhD students will be recruited, and current successful PhD students supported by previous IAI grants will be incorporated as post-docs funded with other resources.

As in the past, these students will work with investigators in different countries, working as "nodes" to integrate scientific ideas, approaches, and cultures. A particularly important contribution will be the development of training programs for both professionals and stakeholders. Though some of the proposed research has national level funding, the project will expand and integrate the scope of local studies incorporating novel SES.

10. RELATED WORK

The members of the team have been collaborating both in previous CRN funded projects and in small scale initiatives (workshop networks, co-authored synthesis papers) on which we build a common vision of the role of the ES framework in territorial planning. This project, though original in its objectives and approach, builds upon three previous IAI projects. CRN-2031, (PI Jobbágy), focused on multiple aspects of land use changes over the "La Plata" Basin. By exploring the consequences of dominant land use changes on the carbon and water cycle, this project arrived at the notion of Ecosystem Services being one of the key concepts capable of bridging the biophysical and human aspects of territorial transformations, along with the actual social benefits and costs that they bring. The CRN-2094 was led by E. H. Berbery and is the basis for the proposed experiments to improve our knowledge of the effects of land use changes on climate. CRN-2047, led by Dr. B. Luckman (A. Lara Co-PI), has provided a long-term perspective on streamflows for the last 400 years reconstructed from tree rings, and has supported the research on water provision monitoring at Reserva CosteraValdiviana. Collaboration from this on-going network will be an important contribution to the proposed project. Current projects of the PI and collaborators will leverage the funds provided by IAI. Among already funded projects we highlight the following:

-Floods, Droughts and Farming on the Plains of Argentina and Paraguay: Adapting to Climatic and Hydrological Changes in the Pampas & Chaco Regions – 2011 (PI E. Jobbagy). International Development Research Center (IDRC)- Canada.

- Carta acuerdo FAUBA- TCP-FAO ARG 32. Fortalecimiento de las capacidades que permitan abordar los procesos de Ordenamiento Territorial Rural de forma participativa e iterativa. 2011-2013. (PI J.M. Paruelo).
- Proyecto de Medición y Evaluación de Emisiones de Oxido Nitroso en la Agricultura Resolución N° 710/2012 del MINAGRI. (PI: Gervasio Piñeiro).
- Five members of our team (JMP, LN, AL, GB, and PL as general coordinator) integrate a recently approved multinational collaboration project (11 research groups from 8 Ibero-American countries) funded by CYTED (Vulnerablity, Ecosystem Services and Planning of Rural Territories, VESPLAN, aimed to promote "… the inclusion of the ES approach in Latin America as a basis for the territorial planning and for the improving the well-being of local communities …, which will facilitate the transference of results from this project to stakeholders and decision-makers.

11.WORKPLAN AND TIMETABLE

As we state above, the work will not be compartmentalized thematically or geographically. However to organize the project we will define responsibilities to the different Co-PIs (see above). We list the main events of the project for the first three years:

-First Plenary Workshop September 2013 (two days): identification of the study sites, selection of graduate students and advisors, definition of responsibilities of each team of GS-advisors, plans for data collection on the biophysical, social, and cultural components.
- Field work aimed to characterize stakeholders in the different areas selected coordinated by coPIs with social science background (October 2013 - September 2014)

- Outreach workshop and seminars with government and non-government organizations (October 2013 to the end of the project) with partner institutions (REDAF, IPA, FMB, Alianza del Pastizal, etc.)
- First workshop on ES and territorial planning (two days): (to be defined)
-Data collection on the different study areas: August 2013-August 2017
-Second Plenary Workshop October 2014 (two days): presentation and discussion of preliminary results, reformulation of the operative plans.
-III ES congress of the Neotropics. November 2013.
-IV.ES congress of the Neotropics (November 2015.
-Third Plenary Workshop November 2015 (two days): presentation and discussion of results, reformulation of the operative plans.
-First version of the professional training program. August 2014-July 2015.

BOX 1. *Landscape structure*. Landscape structure characterization will be based on topographic features and land-cover maps of the study areas (see box 9). The maps will provide a high resolution description of land cover of the different study areas. Such maps will be based on segmentation of Landsat images. Segmentation allow us to identify continuous patches of a given land cover. From such maps we will derive metrics related to the relative proportion of natural habitats, size and shape of natural patches, connectivity and fragmentation. We will adapt the protocols developed by members of our team in several recent articles Baldi et al. (2006), Baldi and Paruelo (2009) and Herrera et al. (2013).
BOX 2. *Evapotranspiration estimates*. We will derive estimates of ET from remotely sensed data at two resolutions. We will use the so-called Simplified Method (Jackson et al., 1977) and Landsat TM data (5 ,7 and now 8) to characterize ET at high spatial resolution (30 m) for selected dates (Nosetto et al. 2005). Landsat imagery do not allow for a complete temporal coverage of the growing season. We will also use the MODIS product 16A2 to derive estimates at low spatial resolution (1x1 km) but with a complete temporal coverage. Both estimates will be combined with land cover descriptions and models to analyze the provision of this intermediate service related to water dynamics (ET, runoff, groundwater recharge) but also the effect of landscape structure and configuration on the water balance.
BOX 3. *C gains*. C gains, a key intermediate service will be assess using remotely sensed data provided by MODIS and the Monteith model. We will use the Normalized Difference Vegetation Index (NDVI) and the Enhanced Vegetation Index (EVI) provided by the MODIS products MOD13Q1. Monteith models estimates Net Primary Production (a key functional attribute of the ecosystem) from the total amount of the incoming Photosynthetic Active Radiation (PAR) (derived from global databases), the fraction of PAR absorbed by green tissues (fAPAR) (calculated from NDVI or EVI, see Paruelo et al. 1997) and the Radiation use Efficiency (RUE) (the coefficient that describe the conversion of electromagnetic radiation into biomass). RUE will be estimate from field data (mainly for grasslands and croplands) and from and additional spectral index (the Photochemical Reflectance Index, PRI) (mainly for forests). The PRI will be derived from MODIS data (bands 11 and 12). The group has extensive experience in characterizing C gain dynamics using remotely sensed data and several of the PIs (JMP. EGJ, GP) have led the application of remote sensing for NPP estimation (e.g. Paruelo et al. 1997, Jobbagy et al. 2002, Piñeiro et al. 2006). As part of the project we will fill some methodological gaps related to the application of the Monteith model in forest areas (the actual shape and coefficients of the relationship between NDVI/EVi and fAPAR and the sue of PRI data).
BOX 4. *Water related ES in the plains and the mountains*. In flat regions such as the Pampas and the Chaco, hydrological regulation is likely the most critical service and has as its main gauge, water table levels. Subtle water balance and rooting depth shifts can switch the exchange of water and salts between ecosystems and aquifers from positive (recharge) to negative (dis-

charge). Slow but steady groundwater level shifts in these regions are responsible for floods and salinization that can damage not only water resources but land and infrastructure as well. The combination of field measurements of water table levels and salinity, and remote sensing estimates of water storage, area, and level, (Aragon et al. 2011) with existing well-documented "treatments" of vegetation transformation, will provide the basic dataset to explore how the regulation of floods is affected by different land use/management schemes in the Pampas. In the Chaco region, where water tables are deeper and very salty, increases in salinization, linked to recharge following agricultural expansion, will be documented using high detail imagery showing salt-affected areas, crop yield, and NDVI temporal series, and a scarce yet valuable network of water table level data available for Salta, Santiago del Estero, and Paraguay.

In the mountain areas of the Valdivian Forest, we will monitor six small watersheds (140 – 1,460 ha). In these areas we will record the annual runoff coefficient (quickflow/precipitation, Qq/P) and the planted and native forest cover (Lara et al. 2009). For large watersheds (20,000 and 70,000 ha) we will analyze streamflow records and land use changes from Landsat imagery (since 1975) using the approach presented by Little et al. (2009). This knowledge at different spatial scales provides the basis for the assessment of the recovery of the ES water provision after ecological restoration, and for the design of landscapes for the combined provision of various ES proposed in this study.

BOX 5. *Measuring and modeling greenhouse gases (CO2, CH4, and N2O)*.
Greenhouse gases will be measured and modeled across the study region. Carbon gains and losses and trace gas emissions (CH4 and N2O) will be modeled using DAYCENT (Parton et al., 1998), a daily time-step version of the well-known CENTURY model (Parton et al., 1987). DAYCENT will be used to evaluate and explore mechanisms of trace gas emissions and C cycling, and associated water and N, for biomes under different land uses. Agriculture, tree plantations, and grazing (the main land use changes of the regions) can be simulated with the model (Parton et al., 1998). Carbon cycling estimates will be compared with C gains measured with remote sensing (Box 3), and estimates of trace gas emissions will be compared with field experiments located throughout our study region. Nitrous oxide and methane emissions will be measured monthly with static chambers under different land uses, following the widely used USDA protocol (Parkin and Venterea, 2010). We already set up a network of trace gas emission evaluation in the Pampas and Chaco in a joint project between INTA and UBA funded by the Ministry of Agriculture. We will expand the coverage to the subantartic forests. A paired experimental design will be used to compare emissions from transformed sites with emissions derived from the natural vegetation they replaced. DAYCENT allows the simulation of different events such as fire, fertilization, grazing, plowing, irrigation, etc. Since we have detailed spatial databases (climate, soils, and land use) for the regions, estimates of regional trace gases emissions and carbon fluxes and pools will be assessed.

BOX 6. *Climate regulation services*: Lee and Berbery (2012) have shown through model experiments that an expansion of croplands in the La Plata Basin could lead to changes in the precipitation and surface temperature patterns. The results indicate that the final Ecosystem Services such as regional climate can be affected by land use. We will assess the role of the time-varying land surface states in improving the representation of extremes (droughts, heat waves, wet spells). To this end regional climate model simulations will be carried out with different land surface conditions representing the observed changes in land surface states of recent decades. The numerical component of the proposed research will be based on simulations using the community Weather Research and Forecasting (WRF) system - version Advanced Research WRF (WRF-ARW). WRF is coupled with the Noah Land Surface Model (LSM) to link surface conditions with the atmosphere. Details of this modeling system can be found at http://www.wrf-model.org. We have developed a methodology using time-varying Ecosystem Functional Types (Alcaraz-Segura et al. in press) (Box 8) instead of land cover types, as they represent more realistically the actual conditions at the surface.

BOX 7. *Filtration capacity of riparian environments and wetlands*

Aquifer protection by vegetation cover will be calculated as

APC = I *P *1 / D

where I is the water infiltration factor calculated for a rain event of 100 mm, P is the protection factor of cover type in the pixel (P=0 for annual crops and P=1 for cultivated pastures and native grasslands), and D is the aquifer depth.

Runoff filtration by riparian vegetation (RFRV) will calculated as

RFRV = C * E

where C is the contaminants loading rank, and E is the efficiency of sediment retention rank. The C rank of pixels will be obtained by combining models of export, transport, and accumulation of sediments, nitrogen, and phosphorus. The efficiency of sediment retention rank (E) is estimated from

SRE = 53.35 + 235 * RA

where SRE is the efficiency of sediment retention, and RA, ratio area, is the ratio between the area of the riparian vegetation strip area and source area.

Water filtration by wetlands will determined with the following steps: 1) nutrient runoff modeling in ArcGIS 9.2, 2) wetlands mapping and characterization, and 3) modeling the potential filtration capacity of wetlands. The general decay rates of total nitrogen (TN) and total phosphorous (TP) typically follow first order kinetics (Liu et al., 2006; Rossman, 2004; Skop and Sørensen, 1998). To determine the travel time of nutrients, distance to wetlands as well as speed of transport calculations will be performed considering the topography.

BOX 8. *Human Appropiation of Net Primary Production (HANPP*): We will base the estimate of HANPP on detailed maps of LULC at the farm level and on descriptions of the production systems that dominate each landscape. Vitousek et al. (1986) introduced the concept to describe the fraction of the NPP that is used directly and indirectly by humans. Based on Haberl (1997) we will estimate HANPP as the difference between NPP of an ecosystem not modified by human activities (PPNo) and the remaining NPP in the managed ecosystem that replaced the unmodified (PPNr). The NPPo and the NPP of the modified system (NPPm) will be estimated using the remote sensing techniques described above. NPPr will be derived from the difference between NPPm and the exported NPP. Exported NPP will be estimated at the farm level from the description of actual land covers derived the classification process (see BOX 9) and harvest indices estimated from agricultural statistics and the literature. Our approach has to original features: it is based on actual values of NPPo and NPPm and it will generate estimates at the farm level (not at aggregated levels such as countries or provinces). Based on the characterization of stakeholders (see activity 4.4) and their activities, we will estimate the HANPP of each stakeholder type.

BOX 9. *Land cover classification scheme and Ecosystem Functional Types definition*. For the landscape of the three areas we will use a protocol to map land cover based on MODIS data (Paruelo et al. 2011, Bagnato et al. 2012). This approach is based on a segmentation of the area using high resolution imagery (i.e. Landsat) to define homogenous polygons (objects) and a classification of the objects based on the phenological signature derived from MODIS NDVI or EVI, according to the region. Additionally we will derive, from a combination of MODIS and AVHRR LTDR data, maps of the spatial distribution of Ecosystem Functional Types for the period 1981-present (Paruelo et al. 2001, Baeza et al. 2006, Alcaraz-Segura et al. 2012). This information will allow a direct description of intermediate services (Paruelo et al. 2011, Volante et la. 2012) and will provide basic data for climate simulations.

BOX 10: Stakeholder´s characterization. As a base for the analysis needed to evaluate hypothesis 4 and 5 we will identify individuals, groups and organizations that are affected by or can affect land use and land cover changes (LULCC), following Freeman (1984) definition of stakeholders. We will follow the three steps proposed by Reed et al (2009): 1) identifying stakeholders and their interest; 2) categorizing stakeholders; and 3) investigating relationships among stakeholders.

To identify stakeholders we will work with local partners to define groups that have a particular interests on territorial planning and/or are affected by land use/land cover changes. Agents to be considered will include, a priori, rancher´s and farmer´s associations, local organizations (cooperatives, churches, etc.), governmental agencies, local referents, the academic sector, etc. Each agent will be characterized in terms of power, confidence, competence, conflict and attitude toward the LULCC and the land-use planning processes. We will rank stakeholders according to their impact in territorial planning and the role that plays in their activity, by developing interest-influence matrices, and actor-linkage matrices. Depending on the social and cultural characteristics of the area the definition of categories and the study of the relationships, we will use different tools as Focus Groups, interviews or snowball sampling (Chevalier and Buckles, 2008, Reed et al. 2009, Russel, 2006).

For those agents directly involved on land use decisions (land-owners and managers) we will perform an additional (georeferenced) characterization based on cadastral units. Each cadastral unit (individual farm or ranch) will be characterize in terms of the type of activities performed using the land cover maps to be constructed (see Box 9), size, access to infrastructure and natural habitats. We plan to characterize the activities performed at the ranch/farm level for the period 2000-2015 (the period for which we will have a land cover characterization based on remotely sensed data). Based on these information and ancillary data we will model market-based ES supply, total income and its interannual variability. Cadastral units will be obtained from INDEC in Argentina, MGAP in Uruguay and SAG in Chile. All the information will be integrated into a GIS. A preliminary grouping of agents (based on cluster analysis) will provide the basis for a stratified sampling of the agents. For the sampled agents of each of defined strata we will conduct structured surveys and interviews focusing on features related access to land, land tenure, capital availability, work organization, and labor availability, market access, prices received, occupation history, conflicts, land use, changes and the role of the public sector, power and well-being status, links with other social groups, and local organizations. The items recorded in the interview will partially match the information surveyed by national population and agricultural census (INDEC, DIEA, SAG). We will obtain census information at intermediate scales between the cadastral units and the departments (i.e census radius of INDEC or census sections of DIAE). Based on the structured interviews we will develop protocols to downscale censi data at the cadastral level in a probabilistic way (see i.e. Wood and Skole 2000). Structured interviews will also included a survey of ES perception (Bauer 2003, Martino 2008) by productive agents and ethnographic analyses based on interviews to the main stakeholders. Stakeholders characterization will be coordinated by LN, AM, VF and JMP. Field work will be performed/supported by local partners (i.e people from Redaf in the Chaco Region, agents of the Extension Service of INTA or the Plan Agropecuario in Uruguay). Data analyses will be performed by graduate students under the supervision of LN, AM, VF and JMP. Our project will try to understand the relationship between the biophysical and human component of different SES. Our work with stakeholders will not involve a direct involvement in land use planning processes. We seek to identify their characteristics and perceptions. We will start to work on stakeholders characterization from the very beginning of the project. Additionally our work with stakeholders will include workshops and seminars on land use planning toolboxes with priority groups: decision makers at local, regional, and national levels, rural organizations such as the Rural Water Supply Committees (CAPR) in Chile or AACREA in Argentina, Peasant and Aboriginal People Associations, NGOs (FVSA, Alianza del Pastizal, REDAF, FMB), These activities will start in October of 2013.

BOX 11. Linking ES supply, demand and vulnerability to territorial governance. To address how ES supply and the capture of their benefits relate to territorial governance we will characterize the Socio-Ecological system at the scale of district, department or municipality. At this scale we will build both a spatial index and a typology of ES governance (see our operational definition in the main text) based on the institutional and social capital of the territory. Data to create this index will come from secondary sources available from national/provincial/regional offices of statistics. Variables comprised in this index would include the number of environmental regulation instruments, the number and strength of social organizations, social infrastructure, the local presence of the I&D sector, and presence of protected areas, among others. The relation between ES supply and benefits captured and territorial governance will be tested using a range of multivariate statistic methods. Finally, the territorial bound and governance index will be integrated into the ES vulnerability assessment and mapping, thus contributing to the development of the Module II of ECOSER. Preliminarily, vulnerability of ES will be integrated by three key elements which are the exposure of selected ES (flow and benefits) to land use change scenarios (the stressor), sensibility of the Socio-Ecological system to that stressor (biophysical and social variables are part of this component, e.g. equity), and the capacity of the system to adapt to the potential loss of ES and benefits under adverse land use change scenarios (governance is part of the adaptive capacity of the system). Laura Nahulehual and Verónica Filardo will be in charge of the specific design of the study and analyses.

BOX 12. Protocols to guide territorial planning at the municipality level: We will base the design of these protocols on the Dahlem Conference format (http://www.fu-berlin.de/en/sites/dahlemkonferenzen/modell/index.html). We plan to organize two three-day workshops where 25-30 participants from different sectors (academy, conservation, production, government, etc.) meet in four interdisciplinary discussion groups, in which different aspects of the territorial planning process will be examined from different perspectives. An organizing committee will select special topics to be analyzed and reviewed prior the workshops by keynote participants. These contributors will write background papers on these issues as a basis for the discussions. Papers will be available prior the workshop and they will be reviewed and criticized by the rest of the participants. During the workshops the working groups will define the discussion agenda that will be shared with the other groups. Each group will prepare a report and guidelines for the protocol for the specific topics discussed. The final product of the workshops will be a publication freely available for decision makers and stakeholders involved in territorial planning at the municipality level. The PIs of BEST-P have experience on this workshop dynamics both as participants of previous Dahlem Conference in Berlin and as organizer of similar conferences funded by previous CRN programs (CRN 2031)

Supplementary material and full CVs are available at
https://sites.google.com/a/agro.uba.ar/crn3/

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