How are jobs and ecosystem services linked at the local scale?

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ABSTRACT

With the exception of subsistence economies, employment benefits along a value chain may represent a relevant, but also a generally neglected part of the wealth derived from nature. Our objective is twofold: i) to determine the extent to which ecosystem services (ES) supply at municipality scale relates to local employment in different regions and economic sub-sectors in Argentina; ii) to determine the multiplier effect of employment in the economic activities most dependent on natural capital (tourism, crop production, animal production, and fishery production), on the employment in the rest of the economy sub-sectors. Landscape capacity to supply ES was represented by land use-land cover (LULC) categories and their relationships with a general ES proxy. Employment information at the municipality level came from nation-wide census data (1600 municipalities). Generalized Additive Models of employment and landscape ES supply revealed that: a) relevant portions of local employment are explained by the landscape ES supply, b) the multiplier impact of tourism employment on the rest of employment was between 5 and 1.7 times higher than the impact of employment in crop production and animal production, and c) the overall multiplier impact of employment on these three activities varied between ecoregions, between 0.5 and 2.7.

1. Introduction

Conventional approaches to the assessment of nature contributions to well-being are based on the aggregation of ecosystem services (ES) values of “first-order” beneficiaries, i.e. people who benefit from the use, consumption and/or enjoyment of ES (Jacobs et al., 2016; Martín-López et al., 2014; Pascual et al., 2017), but fail to integrate the importance of ES for indirect beneficiaries or people within “ES value chains” (Rawlins et al., 2018) that benefit through employment or income generation.

With the exception of subsistence economies, income and employment may represent a significant part of the wealth derived from nature and therefore cannot go unaccounted for (Daw et al., 2011; Fisher et al., 2014; MEA, 2005). By ignoring these benefits and the way in which they are influenced by landscape transformations, the consequences of land use an ES policies cannot be properly assessed. Metrics such as employment (number of jobs) can provide stronger arguments for nature conservation than current measures of economic or social values of ES accruing only to first order beneficiaries.

Any attempt to evaluate indirect benefits derived from ES, implies conceptual and methodological challenges which may explain why they have been largely neglected in most ES frameworks and assessments. Some efforts around these lines include the extended version of the input-output (I-O) models in order to incorporate the influence of several types of ES (e.g., Grêt-Regamey and Kytzia, 2007), the characterization of the local circulation of money in forestry operations using network analysis and Markov chains (Kelly et al., 2014a), the estimation of income and employment multiplier effects of the economic activity in different sectors (Briassoulis, 1991; Miller and Blair, 2009), and the application of the ES value chain framework (Rawlins et al., 2018).
The study of the interdependence between the sub-sectors of the economy, as well as the assessment of the influences of one type of economic activity on income and employment on the remaining ones, is usually approached through the calculation of economic multipliers from I-O matrices. The I-O model assumes that the inputs to produce a product are related according to a linear cost function, which depends on the I-O coefficients and the prices of the inputs. An I-O matrix presents, in a matrix form, the sectoral balance between the supply and use of goods and services of an economy. It is a synthetic description of the economy of a country or region.

Notwithstanding, I-O matrices face several limitations. Firstly, they are rarely available at local level and their parametrization costs are prohibitive. Secondly, approaches based on I-O matrices are characterized by the aggregate analysis of sub-sectors of the economic activity, where interactions are assumed to be independent from natural capital. Although I-O matrices are very effective for understanding the interaction between sectors, assuming that the model is independent from natural capital dynamics implies supposing an unlimited supply of primary inputs and, consequently, an infinite productive capacity (Hall et al., 2001). Thirdly, output multipliers of certain economic sub-sectors may not necessarily reflect the ability of these sub-sectors to distribute the benefits of employment across society when inequity and unemployment are high.

In this study we assess the extent to which ES supply at municipality scale influences local employment and the variation of this relation across different geographic regions in Argentina. Therefore, we aimed to determine the multiplier effect of employment in the economic activities most dependent on natural capital (hereafter, ES-based employment, i.e. tourism, crop production, animal production, and fishery production), on the employment in the rest of the economy sub-sectors. Our working hypothesis is that local-scale (municipal) variation in employment is partly explained by ES supply in the neighboring landscape, and by the differential contribution of ES-employment to the overall local employment.

In order to test the hypotheses, we propose a methodology based on: i) the assessment of the relationship between ES and employment in different economic sub-sectors as an estimator of indirect (second-order) benefits by type of economic activity; ii) the use of multiplier factors of employment in the different economic sub-sectors, as estimators of the capacity of ES-based employments to revitalize other economic sectors (high-order benefits). For this purpose, we rely on a large set of municipalities (n = 1600) grouped under the different geographic regions of Argentina. For these municipalities we collected information on employment from different economic sub-sectors and explored the degree to which these employments can be explained by the supply of ES at the local level.

2. Conceptual framework

In this article we provide a first attempt to understand the influence of local ES supply on the indirect benefits obtained from natural capital estimated as the number of jobs along different economic sub-sectors. This objective expands the relationships between natural capital and human well-being usually assumed in ES frameworks (see for example Haines-Young and Potschin, 2010), by considering the relationships between direct and indirect beneficiaries pointed out by Daw et al. (2011) (Fig. 1).

Indirect benefits can be better described as a multidirectional spread of economic inputs and outputs, linking different economic activities and beneficiaries through distinct paths. Just as the economic multipliers of I-O matrices or the length of economic paths within a particular economy are useful descriptors of aggregated economic impacts (Kelly et al., 2014a,b,c), employment multipliers can be considered as a useful proxy of distribution of indirect benefits across sectors of the economy. As the employment level across different economic sectors is determined by the economic structure (patterns of markets segmentation, Reich et al., 1973), employment multipliers reflect the magnitude of the links among economic sub-sectors (Miller and Blair, 2009).

Since “every time a local economy generates a new job by attracting a new business, additional jobs may also potentially be created, via an increase in the demand for local goods and services” (Moretti, 2010, pp. 373), then, employment multipliers may also reflect the distribution of economic benefits through interdependencies among employment levels in different economic sub-sectors. Differences among employment multipliers for specific economic sectors are expected, for example, due to underlying disparities in the average purchasing power of employees (e.g. 700% of variation between the top and the bottom salaries ranking in Argentina) (MTESS (Ministerio de Trabajo, Empleo y Seguridad Social, Argentina), 2017), and probably, due to variation in consumer preferences according to their income.

3. Materials and methods

3.1. Study sites

This study extended across the entire Argentine continental territory. By encompassing large latitudinal (21° 46’ 52” S to 55° 03’ 21” S), climatic (from subtropical to cold), ecological (15 terrestrial ecoregions), and socio-economic ranges, Argentina offers the opportunity to explore our hypothesis under contrasting socio-ecological contexts. At the same time, this geographical complexity represents a difficulty for the attempt to find relationships between employment and ES through simple models (based on the composition of the landscape), since the variables capable of removing the influence of various social, economic
and political factors affecting employment, are not available at the scale of observation of this work. Consequently, all the analytical procedures in this study were separately repeated, with the exception of calculus of employment multipliers, within each of the five major geographic regions of Argentina (Northeast, Northwest, Pampas, and, Patagonia) which clearly differ in their provision of ES, according to the Ecosystem Service Provision Index (ESPI, Paruelo et al., 2016, Fig. 2, see 2.3 Section for details on ESPI construction).

By the time of economic data used in this study (2010), the Pampa region included the most agriculturally productive provinces and municipalities of Argentina, concentrating 93% of the areas sown with cereals and oilseed and 77% of the land devoted to raising cattle (Table 1). This region also included some of the main fishing harbors of the country on the Atlantic Ocean, and consequently, supported 66% of employment in fishery related activities. It is also distinguished by having the largest portion of employees in industrial, gastronomy and employment in fishery related activities. It is also distinguished by having the largest portion of employees in industrial, gastronomy and fishery production) that we assumed were the most related to ES flows at municipality scale, within each geographic context (step B). Employment was selected to represent indirect benefits arising from natural capital because it is one of the most important factors affecting well-being (Bonini, 2008).

The two remaining steps were aimed to understand how employment levels explained by LULC in the four selected economic-subsectors (estimated in the previous step) spread towards higher order beneficiaries, that is, along the employment of the remaining economic sub-sectors. Thus, we first estimated employment multipliers at the local (municipal) level, based on functional relationships among the employment levels in different economic sub-sectors, by applying a novel approach (step C). In the final step (D) we inferred how many jobs are linked to ES supply, by combining the employment multipliers with the portion of employments explained by LULC.

### 3.3. Step A: LULC – ESPI relationships

Rather than using LULC categories as proxies of specific ES supply, we used them as indicators of the landscape capacity to supply ES bundles (landscape ES supply) due to three main reasons: a) the relevance of specific ES types in generating benefits (direct and indirect) varies along a large territory, thus LULC and its relationships with ESPI are a better option than the arbitrary ES proxies; b) landscape composition is the reflection of ES tradeoffs and synergisms, thus it may offer better information about landscape ES than the simple aggregation of specific ES models, based on properties of non-interactive pixels (Laterra et al., 2012; Mastrangelo et al., 2014); and c) specific ES indicators are rarely available for an entire country and detailed specific proxies are usually developed and mapped for local scale studies.

LULC has been widely used as an integrative proxy of different ES types (Burkhard et al., 2011; Costanza et al., 1997; Di Minin et al., 2017; Koschke et al., 2012; Grét-Regamey et al., 2015; Martínez-Harms and Balvanera, 2012). In turn, ESPI, as proposed by Paruelo et al. (2016), combines two attributes of the seasonal dynamics of the Normalized Difference Vegetation Index (NDVI), namely the annual mean NDVI (an indicator of light interception and hence of total C gains) and the intra-annual Coefficient of Variation of the NDVI, a descriptor of vegetation seasonality, as $\text{ESPI} = \text{NDVI}_{\text{mean}} \ast (1 - \text{NDVIVARI})$.

Relationships among ESPI and independent estimations of intermediate ES flows (e.g. groundwater recharge, soil organic carbon changes, evapotranspiration), and biodiversity (avian richness), have been validated for Northwest, Northeast, and Pampean regions of Argentina (Paruelo et al., 2016) (Fig. 2).
### Table 1
Demographic, social, and economic statistics for the main geographic regions of Argentina in 2010. Elaborated from the 2010 census data (INDEC, 2010).

<table>
<thead>
<tr>
<th>Regions</th>
<th>Pampa</th>
<th>Northwest</th>
<th>Northeast</th>
<th>Cuyo</th>
<th>Patagonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of municipalities</td>
<td>918</td>
<td>357</td>
<td>253</td>
<td>72</td>
<td>152</td>
</tr>
<tr>
<td>Total population</td>
<td>23,683,442</td>
<td>4,911,412</td>
<td>3,679,609</td>
<td>2,419,984</td>
<td>2,108,188</td>
</tr>
<tr>
<td>Mean number of inhabitants by municipality</td>
<td>25,575 (3470)</td>
<td>13,124 (2482)</td>
<td>14,213 (2366)</td>
<td>39,195 (7125)</td>
<td>13,026 (2424)</td>
</tr>
<tr>
<td>Rural population (%)</td>
<td>13</td>
<td>21</td>
<td>20</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Unsatisfied Basic Needs (%)</td>
<td>9</td>
<td>19</td>
<td>22</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Indigenous population</td>
<td>359,048</td>
<td>138,622</td>
<td>67,180</td>
<td>47,922</td>
<td>122,853</td>
</tr>
<tr>
<td>Employees in gas and tourism</td>
<td>248,123</td>
<td>42,285</td>
<td>33,750</td>
<td>23,197</td>
<td>23,110</td>
</tr>
<tr>
<td>Employees in animal production</td>
<td>178,308</td>
<td>131,165</td>
<td>158,664</td>
<td>107,547</td>
<td>23,420</td>
</tr>
<tr>
<td>Employees in fishing activities</td>
<td>122,769</td>
<td>28,067</td>
<td>50,803</td>
<td>14,632</td>
<td>8,618</td>
</tr>
<tr>
<td>Employees in agriculture activities</td>
<td>3,085,280</td>
<td>28,770</td>
<td>97,640</td>
<td>40,770</td>
<td>2,551</td>
</tr>
<tr>
<td>Employees in industrial activities</td>
<td>12,885,753</td>
<td>20,288</td>
<td>1,785,705</td>
<td>107,547</td>
<td>5,857,270</td>
</tr>
<tr>
<td>Sown area with cereals and oilseeds (ha)</td>
<td>14,143,362</td>
<td>888,843</td>
<td>125,236</td>
<td>1,232,826</td>
<td>1,056,430</td>
</tr>
<tr>
<td>Cattle livestock (thousands of heads)</td>
<td>19,189</td>
<td>1,011,127</td>
<td>7,183,685</td>
<td>1,232,826</td>
<td>1,056,430</td>
</tr>
<tr>
<td>Sheep and goat livestock (thousands of heads)</td>
<td>1,917,425</td>
<td>960,336</td>
<td>1,094,400</td>
<td>9,509,457</td>
<td>9,509,457</td>
</tr>
</tbody>
</table>

± 95% confidence interval.

2 Unweighed averages among provinces within the region.
3 It includes areas with single and areas with double annual cropping.

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**Fig. 3.** Flow diagram of data analysis. Data sources, methods and results. LULC: Land use/land cover; ESPI: Ecosystem services provision index; TOUR, AGR, ANP, and FISH are the employment levels associated to tourism and gastronomy, crop production, and animal production activities, respectively.

### 3.3.2. Data gathering

LULC and ESPI were calculated within a circular area at the center of the municipal head city, rather than within the entire municipality limits. Several reasons justify this selection: i) It is difficult, if not impossible, to trace the propagation of ES and their benefits over space; depending on the type of service, benefits can accrue far from where they are originated. Thus, in most cases, an assumption needs to be made regarding the propagation pattern (see Fisher et al., 2009). Following Fisher et al. (2009) we assume a local omnidirectional pattern considering that ESPI mostly reflects intermediate supporting services; ii) 20 km represent half of the mean distance from the head city center and the municipality’s edge; we believe this is a conservative approach, considering that the sample comprises very large and urbanized municipalities where employment in the three selected sectors might not be related to remnant natural capital, usually concentrated in small patches; iii) in this way, we intend to minimize possible influences of asymmetric municipality shapes and off-center location of head cities, on the estimations of ES-employment relationships.

### 3.3.3. Data analysis

Relationships between LULC categories and ESPI were explored through Spearman’s rank correlation coefficients (ρ), which were separately calculated within each of the main geographic regions of the country. Because the non-linearity of data, and because we were not interested in describing functional relationships, Spearman correlation was considered a better option than linear regression and Pearson correlation analysis.

### 3.4. Step B: Indirect benefits production models

In this step, relationships between the relative employment (response variable) and LULC (independent variables) at municipal level were explored for each geographic region. The 23 original LULC categories were reduced to the following six: forests (merging all forest types), rangelands (merging all savannas, shrublands and grassland cover map for Latin America and the Caribbean (Bianco et al., 2013), based on daily MODIS-Terra surface reflectance data (MOD09GA of collection 5) for the year 2008. Mean ESPI values, based on MODIS NDVI products for the 2010–2013 period, were provided by LART (Laboratory of Regional Analysis and Teledetection, Faculty of Agronomy, Buenos Aires University).
types), wetlands and other water bodies (excluding marine ecosystems), croplands, ice (merging ice and snow and bare soil covers), and sea.

3.4.1. Data sources and data gathering

Employment levels were calculated based on the last National Population Census of 2010 (INDEC, 2010). The level of aggregation of census data does not allow for the discrimination between the levels of employment in gastronomy and those in the tourism sector, or between nature-based tourism and other types of tourism at the scale of the analysis carried out. This is not an impediment to answer our research questions, as it is not our intention to discriminate between different types of tourism.

Further details about employment data gathering are provided in Appendix A (Supplementary material).

3.4.2. Data analysis

Because of different data violations to multiple regression analysis, relationships between the overall relative employment (response variable) and LULC (independent variables) (step B, Fig. 3) were examined by applying a series of Generalized Additive Models (GAM, Hastie and Tibshirani, 1990), which do not assume any specific shape for the relationships. GAM models were specified using a Poisson error distribution and a log link. In order to avoid overfitting and spuriously high levels of explained variation (adjusted R-squared) the complexity of the fitted curves (the number of effective degrees of freedom) was fixed as 2. Employment was modeled in absolute terms (number of jobs at municipality level), and one of the LULC cover categories (percent of urban areas) was omitted from models in order to avoid collinearity.

While the factors that affect the employment structure in Argentina, go clearly beyond the natural capital available in the vicinity (Fiszbein et al., 2003; Gasparini, 2005; Longhi and Osatinsky, 2017), in this work we focused on elucidating the propagation of ES as indirect benefits into different economic sub-sectors, rather than providing best explanatory capacity of employment levels. Therefore, while geographical influences on employment structure were not explicitly modeled, they were at least partially controlled through the modeling of employment-LULC relationships independently within each geographic region.

3.5. Step C: Employment multipliers

3.5.1. Data sources

This step was based on data from 29 economic sub-sectors, that is the complete set provided by de 2010 National Population Census (INDEC, 2010).

3.5.2. Data analysis

This analysis is aimed at testing an auxiliary hypothesis, which poses that interdependence among different economic activities (usually reflected through I-O matrices), is followed by interdependencies among their corresponding employment levels. Accordingly, we have predicted that benefits distribution from particular economic sub-sectors can be captured from the variation in employment structure among different municipalities within the country or within a region with similar socio-ecological features.

Thus, instead of calculating economic multipliers for inferring employment rates, we directly estimated the employment multipliers from available data at the municipality scale.

Therefore, the number of total employment j (overall multiplier factor, EMF) was estimated through the standardized regression coefficients obtained from a series of multiple lineal regressions analysis. Each analysis was separately performed using j employment levels as independent and dependent variables, respectively, for the complete set of municipalities. The overall multiplier factors for each i-main economic sub-sector was then calculated, as follows:

\[
EMF_i = \sum_{j=0}^{n} f_{ij}
\]

where \(f_{ij}\) is the regression coefficient between the i independent and the j dependent variables, that is the employment levels in the j economic sub-sector per each employed person in the i economic sub-sector (hereafter, partial multiplicative factor). Therefore, EMFi represents the overall number of expected employed persons per each employed person in economic sub-sector i. Only significant regression coefficients (P < 0.05), both positive and negative, were considered for EMF (Eq. (1)) calculation.

3.6. Step D: Propagation of ES benefits

While the overall multiplier factor is expected to reflect the number of total jobs (E) promoted by each job in the i economic sub-sector, clearly it does not reflect by itself the indirect benefits of ES. ES influences on indirect benefits can be approached through the overall multiplier factor corrected by the portion of the employment in the i economic sub-sector (Ei) explained by ES (EMFi), as reflected by the R2 values of the corresponding fitted model. Thus, the second and higher order (indirect) benefits explained by ES through the i economic sub-sector (IBi) can be calculated as the fraction of the employment level in the i economic sub-sector plus the influence of that fraction on the rest of the employment, as follows

\[
IB_i = (E_i \times EMF_i) + (E_i \times EMF_i \times EMF_i)
\]

thus the relative number of indirect benefits (employments) by economic sub-sector due to ES (RIBi), is

\[
RIB_i = IB_i / E_i = EMF_i \times (1 + EMF_i)
\]

Consequently, a EMFi = 1 and R2i = 0.6, and a consequent RIBi = 1.2 implies that for every job in the i economic sub-sector due to ES supply, 1.2 additional jobs are sustained in the rest of economic sub-sectors. Therefore, the sum of RIBi for the n economic sub-sectors assumed as the most related to ES, represents the relative number of indirect benefits due to ES, accumulated by a set of economic sub-sectors (RIBtotal), and is calculated as

\[
RIB_{total} = \sum_{i=1}^{n} RIB_i
\]

Therefore, social distribution of ES benefits increase with RIBtotal and its components, OBi and EMFi. Since RIB is intended for the accounting of local couplings between ES proxies and employment, it leaves aside the consequences of local ES supply on extra-local employment.

4. Results

4.1. LULC – ESPI relationships

Correlation analysis between ESPI and LULC categories revealed that supply of ESPI-related ES was, in general, directly associated to forest cover within the buffer zones around the municipality’s center (Table 2). Moreover, forest cover was the main LULC category contributing to landscape ES, with the exception of the Pampa region, where forests are a minor component.

Not surprisingly, in contrast with the Pampa, Cuyo and Patagonia, rangelands represent a negative contribution to ESPI in the Northwest and Northeast regions, where the native forests are most abundant, and rangeland cover (and also croplands in the Northeast) is associated to the expansion of the agriculture frontier at expenses of deforestation (Gasparri et al., 2008; Vallejos et al., 2015).
among different employment sources and regions (see R2 values in specific sub-sector employments. region-specific models were able to explain more than 20% variation in GAM overfitting, adjusted R-squared values indicate that 13 out of 20 fishery production, was related to landscape ES (as reflected by LULC), of employment in tourism, crop production, animal production and sectors and geographical regions

4.2. Employment levels variation explained by LULC across economic sub-sectors and geographical regions

According to GAM, a significant portion of inter-municipal variation of employment in tourism, crop production, animal production and fishery production, was related to landscape ES (as reflected by LULC), within all the different regions and within the complete data set (Table 3). Although a minimum freedoms degree was adopted to avoid GAM overfitting, adjusted R-squared values indicate that 13 out of 20 region-specific models were able to explain more than 20% variation in specific sub-sector employment.

However, the explicative capacity of models was highly variable among different employment sources and regions (see R2 values in Table 3). For example, employment in tourism was poorly associated to LULC variation in the Pampa and the Northeast, but more related to LULC in Cuyo (43%), where forest cover was positively associated to water bodies and forests, and negatively associated to croplands. Similar portions of employment in tourism were explained by LULC variation within the Northwest and the Patagonia regions (19% and 23%, respectively), but with different contributions from the different LULC categories. While water bodies and forests contributed positively to tourism employment in the Northwest, surprisingly, cropland cover had the most important and positive influence in Patagonia.

According to the above described relationships between LULC and ESPI (Table 1), GAM models suggest that increments in municipal employment levels in the selected economic sub-sectors, rather than resulting from the simple increase in the cover of most ESPI correlated LULC categories, depend on different LULC combinations. For example, although the forest is the coverage with the highest ESPI values in all the regions (Table 2), its contribution to the GAM models was positive and relevant for only 5 out of the 20 models obtained for each employment source and each region (Table 3). That result was expected for the economic activities that do not depend on or are even negatively associated to forest cover (crop production, animal production and fishery production), but it was not the case for the negative contribution of forest cover to tourism suggested by GAM in the Northeast and Patagonia. Therefore, despite of the positive association with ESPI in Patagonia (Table 2), rangelands cover was negatively related to employment in all the four selected sub-sectors.

Inter-municipal variation in tourism employment due to LULC was best captured by GAM in the Cuyo region (43%), where forest cover and rangelands (highly and positively associated with ESPI), as well as water bodies (no associated with ESPI), were the main landscape elements positively explaining the employment levels. Therefore, employment in the tourism sub-sector within the Cuyo region, was negatively explained by cropland, which in turn is negatively associated with ESPI.

Employment in crop production was better explained by LULC in the Northwest, Cuyo and Patagonia than in the rest of the regions. In all cases, croplands did not show a positive link with employment in this sub-sector of the economy as would be expected. On the contrary, croplands showed a negative link to crop production employment in all cases.

Since direct grazing dominates animal production systems in most of the Pampa and Northwest regions, employment in this sector was positively related to rangeland cover and, negatively related to crop land cover in all the regions. It is worth noting that employment in this economy sub-sector is not restricted to livestock production, but also includes beekeeping, which not depends directly on grazing laws but it is an important source of job opportunities in peri-urban areas.

Employment in fisheries was the economic sub-sector most closely related to LULC, since GAM analysis showed good and positive relations with sea cover (except in Patagonia) and continental water bodies in regions where the municipalities were far from the sea (i.e. Northwest region with very important river and wetland systems). Surprisingly, Patagoniás municipalities near the sea do not seem to be good places for employment in fishery production.

In few cases, unimportant or mostly negative contributions from tested LULC categories to employment in selected sub-sectors were shown by GAM (e.g. tourism employment in the Northeast, and crop production employment in Patagonia), suggesting an overriding influence of urban cover within the 20 km buffer, that is the complementary...
and intentionally omitted LULC category. Thus, influence of urban cover may be also implicitly present, although less dramatically, in the rest of the cases.

4.3. Multiplier employment effects vary among economic sub-sectors

The overall multiplier factors suggest great differences among the four selected economic sub-sectors in explaining employment levels in the remaining subsectors. According to that, for each employed person in tourism a total of 2.79 jobs can be expected to be found in the rest of the economic sub-sectors, 140 times more than was obtained for crop production and nearly the double of the value obtained for animal production (Table 4). While the overall multiplicative factor of TOUR was clearly higher than the overall multiplicative factor of fishery production, extractive production, construction, and industrial production, it was six times lower than the overall multiplicative factor for energy production (Table 4).

While LULC-employment GAM analysis revealed that employment in fishery production was the indirect benefit better related to landscape ES among the four examined employment sources, it was the only one showing an overall negative multiplicative effect in the entire employment market (Table 4). It could be explained by negative influences of fishery employment on the employment levels in industrial and craft production, as well as on the employment in education (Table 4).

Composition of the overall multiplicative factor (e.g.: the contribution of partial multiplicative factor values), also varied among economic sub-sectors. Employment in tourism showed strong positive influences over employment in industrial and craft production, education, household and non-household cleaning, as well as in management of small to medium private companies. On the contrary, employment in crop production showed an evenly negligible influence over the employment levels of the rest of the economy, and employment in animal production particularly promoted the employment in agricultural production.

Therefore, the economic activity in tourism, crop production and animal production was differentially affected by other productive economic sub-sectors, as reflected by their respective partial overall multiplier factors. While tourism employment levels were negatively affected by energy production and positively affected by fishery production, employment levels in crop production were highly and positively affected by energy production, and employment levels in animal production were negligibly affected by those in other productive economic sub-sectors (Table 4).

4.4. How many jobs are linked to the natural capital and ecosystem services at local scale?

The relative number of accumulated employment due to ES occupations in tourism (RIBtourism) was higher than the one due to ES employment in crop production (RIBcrop production) and animal production (RIBanimal production), for the overall data set (between 0.4 and 5 times higher, and between 1.7 and 2 times higher, respectively, according to the region) and for each of the regions, except for the Northwest (Fig. 4). Since we are not able to find reasonable explanations for the overall negative employment multiplicative coefficient in the fishery production sub-sector, after further evaluations we have decided not to calculate its RIB value.

The relative number of accumulated employment due to ES calculated for tourism, crop production and animal production offered a marked contrast between the relatively low values of the Northwest and Northeast regions vs. the rest of regions (Fig. 4).

5. Discussion

This work shows the relevant links that exist between employment levels in four selected economic sub-sectors and the natural capital that the surrounding landscapes and seascapes provide to immediate cities and beyond as represented by landscape ES. This demonstration is important because the dominant focus of ES literature on direct

<table>
<thead>
<tr>
<th>Data sets</th>
<th>Dep. var.</th>
<th>N</th>
<th>Adj. R²</th>
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beneficiaries has greatly masked how local economies are coupled to private and public decisions on surrounding landscapes. By taking into account the spreading of ES benefits to indirect beneficiaries, the relations between natural capital and well-being can be more thoroughly represented.

While our approach was unable to explain the landscape ES influences on their indirect (employment) benefits for the aggregated municipalities of the entire country (Table 3, Fig. 4), their disaggregated analysis into the main geographic regions revealed that employment in tourism, crop production, animal production, and fishery production in different regions are favored by different landscape ES (LULC) combinations (Table 3).

Moreover, in contrast with the poor contribution of landscape ES for the complete employment market which could be concluded at the country scale (RIB = 0.51, Fig. 4), disaggregated analysis allowed to find that landscape ES has a variable relevance for the complete employment market according to the geographic region.

Calculation of economic multipliers and their consequences on employment levels are rarely performed at a local scale looking at landscape use and cover contexts. The relationships between landscape composition and local indirect benefits have been mostly restricted to studies on “environmental incomes” based on primary data gathered at household scale (Angelsen et al., 2014; Vedeld et al., 2007). By ignoring or underestimating indirect benefits of ES, ES remain detached from the interest of policy makers, most social actors lack sufficient motivation to commit to ES governance and, thus, opportunities for ES mainstreaming into public policies are reduced or missed (Cáceres et al., 2016; Cowling et al., 2008; Guerry et al., 2015; Monjeau, 2010).

The dominant development paradigm has generally conceived urban and rural areas as separate worlds (Unwin, 1989), while
globalization forces are shown to promote the decoupling between people’s well-being and natural capital and their ES (Liu et al., 2013; Young et al., 2006). Instead, our findings offer clear evidence about significant local couplings between nature and modern societies which go beyond the direct beneficiaries of ES. In a similar way as classic analysis of economic I-O matrices allow for the identification of subsectors of the local economy with potentialities to be transformed into growth-stimulating policies (Miller and Blair, 2009), disaggregated employment-ES models in combination with matrices of employment multiplicative factors represent a promising procedure for informing local conservation and landscape planning.

As expected, employment levels in both tourism and animal production were negatively explained by cropland cover and positively explained by forest and/or rangeland cover, except in Patagonian municipalities (Table 3). Cropland cover may also reduce the average number of employees per farm, as reported by Viglizzo (2008) for a subregion of the Pampa, as a consequence of the greater demand for labor from the animal production systems than from high-tech crop production systems.

The influence of landscape composition on tourism and recreational potential was previously shown for the entire Argentine territory, including the Patagonia region (Weyland and Laterra, 2014). Therefore, rather than reflecting the irrelevance of landscape ES for tourism employment, the Patagonia case may be illustrating the inability of simple models to capture landscape ES influences on employment when municipalities belong to a very heterogeneous geographical context. In Patagonia, the negative weight of forests hides the importance of Patagonian Andean forests for tourism, and can be explained by the weight that municipalities with coastal resorts and urban areas, associated with small cropland cover, have on tourism employment.

Employment in the tourist sector had a much higher multiplicative effect than crop and animal production. While partial contributions of tourism employment exceeded EMF = 0.5 for several economic subsectors (including EMF = 0.99 for employments in industrial production), all partial multiplicative factors due to crop production employment fell below EMF = 0.10.

Also in agreement with our hypothesis, different geographical regions in Argentina illustrate diverse patterns of ES supply to indirect benefits (jobs) at local scales. Three main different patterns of landscape ES propagation into indirect (employment) benefits are illustrated by the analyzed geographic regions (Fig. 4). In the first place, both the Pampas and Northeast regions illustrate a poor opportunity for propagation of landscape ES benefits to the employment market, since less than one additional employment in the non-directly ES-related economic sub-sectors (high-order beneficiaries) is explained by each employment associated to directly ES-related economic-subsectors (second order beneficiaries of landscape ES). Therefore, it is expected that policies aimed to improve employment access in these regions will be poorly payed by only promoting ES supply (e.g. ES conservation) without a greater focus on institutions and instruments capable of improving the capture of that ES supply into direct and indirect benefits. Clearly, this consideration may be more meaningful for the Northeast, where the population ratio with unsatisfied basic needs is more than double than in the Pampa (Table 1).

Fitted models linking local ES proxies and local employment levels are not including the influence of agricultural management practices. Therefore, the pattern of ES and employment first described does not deny the possible increments in the number of job opportunities associated to, for example, the objective of increasing crop yields (e.g. plant breeding and fertilizer companies, machinery design, production and selling, plague control, etc.). Similarly, low contribution of ES proxies to tourism employment, does not deny that tourism employment can be effectively enhanced by managerial and commercial strategies aimed to obtaining a better capture of ES benefits, independently of changes in ES supply.

Poor links between ES supply and employment, may also result from analytical limitations. Since our analysis of geographical regions is masking a heterogeneous mix of different ecoregions within the Northeast, Northwest and Patagonia regions like the Puna, Yungas, Chaco, Paraná Atlántic Forests, Paraná Flooded Savannahs, Semiárid Steppe, Cold and Temperate Forests, which offer contrasting crop and animal production systems (Rivas and Rivas, 2015) as well as different recreation potentials (Weyland and Laterra, 2014).

Second pattern of landscape ES propagation into employments is represented by the Northwest and the Patagonia regions, where between one and two additional employments in the non-directly ES-related economic sub-sectors are explained by each occupation in directly ES-related employments (Fig. 4). Moreover, this landscape ES contribution to overall employments (RIBotal) is better explained by employments in tourism (RIB = 0.70 and RIB 0.88, for Northwest and Patagonia, respectively) than by employments in animal production (RIB = 0.58 and RIB 0.50, for Northwest and Patagonia, respectively) and employments in crop production (RIB = 0.35 and RIB 0.36, for Northwest and Patagonia, respectively) (Fig. 4).

Contributions of different landscape elements to second pattern are not congruent for both regions (Table 3). As commented in the Results section, probably because of the large geographic heterogeneity of Patagonia, it is not clear which LULC categories support tourism employment in this region and further analysis should be done before any recommendation. However, according to the results for the Northwest region, it may be meaningful to improve the supply and capture of landscape ES for eliciting the level of tourism employments in this region, over current dominant policies which are focused on landscape transformation for crop and animal production (Vallejos et al., 2015).

Finally, the Cuyo region illustrates a third ES-employment pattern, where contribution of directly ES-related occupations to the entire employment market at the municipal scale is the highest among all the analyzed regions, since for each ES-directly supported employment, 2.70 employments are supported in the rest the economic sub-sectors (Fig. 4). While Cuyo is the region with lowest native forests cover and water supply is scarce due to its arid climate, it may be striking to note that tourism employment is based precisely on both forest and waterbody cover. This apparent paradox suggests that a high contribution of landscape ES to indirect benefits in a context of relatively low ES supply, may be better explained by adequate institutions and instruments, which are able to favor ES capture into benefits and its propagation into indirect benefits (as suggested by the high number of occupied beds in 2010, as compared to the total number of inhabitants in the region, Table 1).

In other terms, these models suggest that ES supply is more important for the creation and maintenance of local jobs in geographical regions where tourism, crop production and animal production are most severely limited by ES supply. Moreover, because of the general aridity of Cuyo and Patagonia regions, observed relations between ESP and employment levels reflect how the capture of water supply through irrigation infrastructure and the rise of primary productivity, agricultural production and recreation opportunities support a better propagation of indirect benefits from ES into the employment market.

Despite the fact that the static nature of our models limits their interpretation in dynamic terms, they are useful for posing hypothesis which can be addressed with other approaches. For example, human-nature systems in the northern regions of Argentina can represent a side effect of the process of agricultural expansion, intensification and landholding concentration. (“agriculturization” syndrome, Manuel-Navarrete et al., 2009). Landscape agriculturization has been fueled by the rise of the soybean international price since the 1990s which not only affected native forests and traditional farming systems in Argentina but also its neighboring countries, Bolivia, Paraguay and Brazil (Galeano, 2012; Murmis and Murmis, 2012; Urioste, 2012). Technological changes associated to soybean cultivation pose dramatic consequences on labor demand. Nadal and Sbroiavacca (2016) calculated a reduction of labor intensity from three man-hours to 40 minutes per
6. Concluding remarks

The levels of employment in economic activities are secondary sources of information useful to characterize indirect benefits of ES at a local scale, of complementary value to the valuation of ES captured by direct beneficiaries. Calculation of employment multipliers from partial regressions of occupation levels by economic sub-sectors proved to be a feasible alternative to evaluating the sensitivity of employment levels to local ES supply, and to compare the reciprocal influences between sub-sectors of the economy within the same region, as well as between different regions. While these procedures may provide useful information for guiding public policies on land use to guarantee the person’s well-being, they may not fully contribute to the understanding of the multiple array of factors that determine employment levels at a given moment in a given locality. Since our approach is static and assumes equilibrium conditions, it cannot incorporate the influence of social, economic, cultural and/or environmental events moving the socio-ecological system from this equilibrium.

Despite the fact that we encourage the adoption of employment models for understanding the ES indirect benefits, their application and interpretation demands caution and further research. Linear models, as those based on employment multipliers, may not be useful for the understanding and prediction of consequences of landscape ES supply on employment in face of non-linear changes in the supply and demand of inputs. It is the case, for example, of declining employment levels in tourism when ES thresholds are overpassed (e.g. Canavan, 2015; Hamzah and Hampton, 2013). Consequently, it is convenient to restrict the application of our models of ES-employment relationships for marginal changes in ES supply and far from possible thresholds, were linear responses can be reasonably expected.

Therefore, it is worth noting that our approach is restricted to understand local couplings between landscape ES supply and indirect benefits (employment), and cannot be directly used to infer the impact of ES supply on the employment at the country level. For example, RIB due to local cropland ecosystems increases with the number of indirect beneficiaries (e.g. tractor drivers, mechanics, supplies sellers, etc.) living in the corresponding municipality, but it leaves aside indirect beneficiaries living in distant big cities (e.g. tractor manufacturers, employees in food, feed, fertilizer and, pesticide industries, etc.).

We hope that quantitative assessment of indirect benefits will complement the conventional economic valuations of direct benefits for raising public awareness of nature contribution to persons and enhancing the interest of policy makers.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecoser.2018.11.011.


