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REVIEW

Impacts of the deforestation driven by agribusiness on urban population and economic activity in the Dry Chaco of Argentina

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Agriculture expansion oriented to global market has changed the relation between population and deforestation in South America. Actually, the population dynamic in an agricultural frontier turned into a consequence of deforestation (rather than the cause). For Dry Chaco of Argentina during the period 1991–2001, we explore the impacts of deforestation over urban population and employment dynamics in small- and medium-size urban centers. We used deforestation maps from remote sensing data and demographic information from the national census. We found a positive relation between population growth and deforestation. Additionally, urban centers in a context of new and active deforestation stages generate more jobs than in a context of advanced stages. Based on our results, we suggest a *boom and bust* pattern. Agriculture expansion and deforestation generate transient jobs and benefits, but in a long-run perspective, positive impacts are uncertain.

Keywords: Chaco region; deforestation; soybean; urban population; employment; regional development

1. Introduction

In tropical countries, population growth and poverty have been suggested to be one of the main causes of deforestation (Lambin et al., 2001). This association is clear in areas where deforestation is caused by subsistence agriculture and small-scale farming (Lininger, 2011; López-Carr & Burgdorfer, 2013), such as in some regions of Africa (DeFries, Rudel, Uriarte, & Hansen, 2010; Fisher, 2010) or in tropical areas of Central and South America (López-Carr & Burgdorfer, 2013; Van Vliet et al., 2012). However, in the last decades, a new pattern of deforestation has emerged, associated with the increasing global demand of agricultural commodities (Geist & Lambin, 2002; Rudel, DeFries, Asner, & Laurance, 2009). Some remarkable examples of agricultural commodities with high impacts on deforestation are palm oil in South East Asia (Saxon & Roquemore, 2011) and soybeans in South America (Boucher, 2011).

Land changes are increasingly caused by global processes, with a growing division of areas of production and those of consumption (Lambin & Meyfroidt, 2014). Urbanization often brings about demands on rural and distal populations to provide land-based resources, being a strong force to create telecouplings between socioecological systems (Eakin et al., 2014; Liu et al., 2013; Seto et al., 2012). Current deforestation in South

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America is related to a rising soybean production (Aide et al., 2013), mainly oriented toward exports. This situation represents a clear example of land use change, linked to distant processes, such as urbanization in Asia, or biofuel demands from the European Union (Lambin & Meyfroidt, 2011).

Deforestation in South America shifts from occurring mostly in moist tropical forests to deciduous dry forests and savannas (Aide et al., 2013; Hansen et al., 2013). Simultaneously, the main drivers of deforestation also changed from subsistence agriculture and small-scale farming to well-capitalized farms and agribusiness companies oriented toward global markets (Rudel et al., 2009). In this context, traditional links between the population and deforestation have changed. Questions about positive or negative impacts of agribusiness expansion on the local population emerge (e.g., Gras & Hernández, 2013).

Agricultural production is oriented toward the global market; in this context, urban centers have declining links with their surrounding hinterlands (Blanco, 2014), and they are mainly manifested through the consumption of resources from outside the urban area. However, the role of urban centers may be more associated with supplies and services for agriculture activities on their hinterlands, and so articulate the value chain of agricultural production. This situation could lead to an agglomeration economy, as proposed by Krugman's (1991) New Economic Geography model. This concept highlights positive externalities for companies, which operate in geographical proximity (through better access to market, information, technology, or labor pool). This mechanism was used to explain contrasts between soybean frontiers dynamics in Amazonia (Garrett, Lambin, & Naylor, 2013a, 2013b). In the context of agricultural frontier expansion and associated value chain development, urban centers adapt their functions to agribusiness demands (Elias, 2007), and consequently, local socioeconomic dynamics are affected by this land use change.

Understanding relationships between land use change and population dynamics is a main concern to land use science and to local economic development. However, there are few studies exploring these associations in agribusiness frontiers of South America, and they focus mainly in Brazil. These studies suggest that deforestation driven by commodity expansion in Amazonia has a nonlinear temporally relationship in the creation of jobs and well-being, according to the pattern of 'boom and bust' (Celentano, Sills, Sales, & Veríssimo, 2012; Rodrigues et al., 2009). The same general pattern was suggested for other agriculture frontiers of Latin America (Angelsen & Kaimowitz, 2001; Barbier, 2004). The 'boom and bust' pattern suggests that economies based on nonrenewable resources tend to have benefits associated with an initial economic 'boom'. However, in a scenario of non-reinvestment in other productive assets, when the reserve of nonrenewable resources are depleted, economic activity in the area decreases and ensues the 'bust' (Barbier, 2004). By contrast, other authors suggest different patterns with agriculture (the soybean case was particularly studied), which are associated with economic growth, increase in urban population and formal employment (Richards, Pellegrina, VanWey, & Spera, 2014; VanWey, Spera, De Sa, Mahr, & Mustard, 2013). However, in the case of soybean expansion, it could present a correlation with increased income, growth of local GDP, and lower poverty levels, but also, in some cases, with more inequality (Weinhold, Killick, & Reis, 2013).

Currently, one of the most dynamic deforestation frontiers in South America is the Dry Chaco (Gasparri, Grau, & Gutiérrez Angonese, 2013; Hansen et al., 2013), mainly driven by soybean expansion (Gasparri et al., 2013). Since the 1990s, Argentina became one of the larger global soybean producer and exporter (FAOSTAT, 2014), with almost 95% of the total national soybean harvest sold on global markets. Between 15% and 27% of soybean grains are exported and 70% is processed industrially (Instituto Nacional de Tecnología Agropecuaria [INTA], 2011). Almost everything of the soybean industry production is designated for export, turning Argentina into the largest exporter of soy oil, meal, and cake (FAOSTAT, 2014; INTA, 2011).

Export-oriented agribusiness (and in particular soybean production) largely contributes to the global and national economy (Brookes & Barfoot, 2009; Burachik, 2010). In Argentina, revenues generated through export taxes (Guerson, Parks, & Parra Torrado, 2007; Leguizamón, 2014; Newell, 2009) are used for poverty reduction (Grugel & Riggirozzi, 2012; Gudynas, 2010), and improvement of public infrastructure (through the so-called 'Fondo Federal Solidario'; National Decree 243/2009). Additionally, it was estimated that soybean and other crops contribute to generate new sources of employment (Richards et al., 2014; Trigo, 2011), raise local income and improve life conditions (Qaim, 2009; VanWey et al., 2013), and is a strong engine of economic growth (Awokuse & Xie, 2015). Despite the important role that soybean have in Argentinean national economy (Grau & Aide, 2008; Trigo, 2011; Van Dam, Faaij, Hilbert, Petruzzi, & Turkenburg, 2009), the contribution of soybean crop for local economies is under debate in this country (Manuel-Navarrete et al., 2009; Svampa & Viale, 2014). Soybean expansion and deforestation has also been highlighted as a cause for increased hunger, poverty, unemployment, and rural migration, as well as having major impacts on livelihood conditions (e.g., Krapovickas, Sacchi, & Hafner, in press; Paolasso, Krapovickas, & Gasparri, 2012; Paolasso, Krapovickas, & Longhi, 2012; Teubal, 2009). The new model of agricultural export-oriented soybean production has created a powerful force for economic growth, but it is not clear if its benefits are translated into local development and employment (Turzi, 2012). In particular, soybean production is not for local commercialization, and frequently the local value chain is weakly developed and not articulated with local economies. In addition, the profits obtained by soybean crop are not significantly reinvested in deforestation areas of the Dry Chaco (Botta, Tolon-Becerra, Lastra-Bravo, & Tourn, 2011; Leguizamón, 2014; Paolasso et al., 2012).

The aim of this work is to explore the influence of deforestation driven by soybean expansion on urban population growth and urban employment change of small/medium urban centers in the Chaco region. We propose that urban centers can assume different roles in relation to commercial agriculture, evolving into two pathways. On the one hand, they can turn into a place with a growing economy based on agricultural services and supplies, developing agglomeration economies, with positive impacts on local labor and demography. On the other hand, they can turn into a town functioning inside an enclave economy (Cardoso & Faletto, 1979), with poor integration of agribusiness activities in the local economy, leading to scarce positive impacts on urban employment and urban population. We propose that both pathways are not exclusive. Companies may obtain returns and benefits because of their closeness, and at the same time, do not contribute to social and economic returns for local towns.

In this work, we use the case of the Dry Chaco of Argentina during the period of 1991–2001 as an 'experiment' to evaluate the impact of the agribusiness establishment and deforestation over population growth and employment of local urban centers in the context of open economy without major government intervention. As data sources, we use official population census and deforestation data from remote sensing analyses. We applied general and mixed linear regression models to explore relations between deforestation and population growth and employment in local urban centers. We classified urban centers according to 'deforestation stages', which represent the degree of deforestation advancement (new, active, and advance deforestation stage). They are defined by deforestation rate (DR) and cultivated land proportion in its surroundings. After that, we explored differences in population growth and job generation for urban centers in different deforestation stages. In the last sections, we discuss results using selected cases of urban centers from the Dry Chaco.

2. Materials and methods

2.1. Study area

The study area covers an extension of more than 314,000 km^2 of Dry Chaco forest and the transition sector to the moist Yungas forest. In the study area, the natural vegetation is dominated by deciduous and semi-deciduous forest. Most important tree species are *Aspidosperma quebracho-blanco, Schinopsis quebracho-colorado*, and *Caesalpinia paraguariensis* (Cabrera, 1976). The mean annual temperature ranges from 20°C to 22°C. Rainfall decreases from 700 to 1000 mm in the northern sector to 500–800 mm in the southern sector, and there is a strong east–west gradient in rainfall, with higher levels in the west. Eighty percent of all precipitation occurs between November and March (Minetti, 1999). Historically, the main economic activities in the area were extensive cattle ranching and forest logging for carbon and charcoal. Some areas presented periods of intensive logging for industrial wood for construction and tannins industry (Morello, Pengue, & Rodriguez, 2005). Since the late nineteenth century, cultivation of cotton in the eastern sector began and became dominant in the region toward the 1920s and 1930s (Morello et al., 2005). From the 1970s, cultivation of beans, including soybeans, was made possible due to a more humid cycle (Paolasso, Ferrero, Gasparri, & Krapovickas, 2010). From the early 1990s, soybean turned into the dominant crop of the region, and the geographical expansion tended to occur on previous agricultural lands (e.g., that had been used for cotton), and on pastures and natural forest areas (Aizen, Garibaldi, & Dondo, 2009; Gasparri et al., 2013).

Our study area includes five provinces, eastern Salta and Tucumán, western Chaco and Formosa, and northern Santiago del Estero (Figure 1). We defined urban center as towns with more than 2000 inhabitants, in accordance with the official definition of urban towns in the population statistics of Argentina (Instituto Nacional de Estadística y Censos [INDEC], 2001). There were 64 towns with more than 2000 inhabitants for 2001. In order to capture effects of agribusiness and deforestation over demographic variables, we exclude 17 urban centers that have demographic and economics dynamics clearly related with other process and activities: capital provinces (San Miguel de Tucumán and Santiago del Estero) and surrounding towns of metropolitan area of these capitals (e.g., Alderetes, La Banda). Additionally, northern Salta towns were excluded due to their strong influence from oil industry activities (e.g., Tartagal, General Mosconi, Aguaray). The remaining 47 urban centers were included in our analysis (see ST1 and online supplementary material 1 for a complete list of towns, population data, and localization).

2.2. Demographic and employment data

We used official information provided by the INDEC on population. To estimate the change in population in each town, we took the absolute numbers of inhabitants in 1991 (P_{91}) and 2001 (P_{01}) from the INDEC database (INDEC, 2001). Finally, we calculated the annual population growth rate (APGR) per thousand using the following expression:

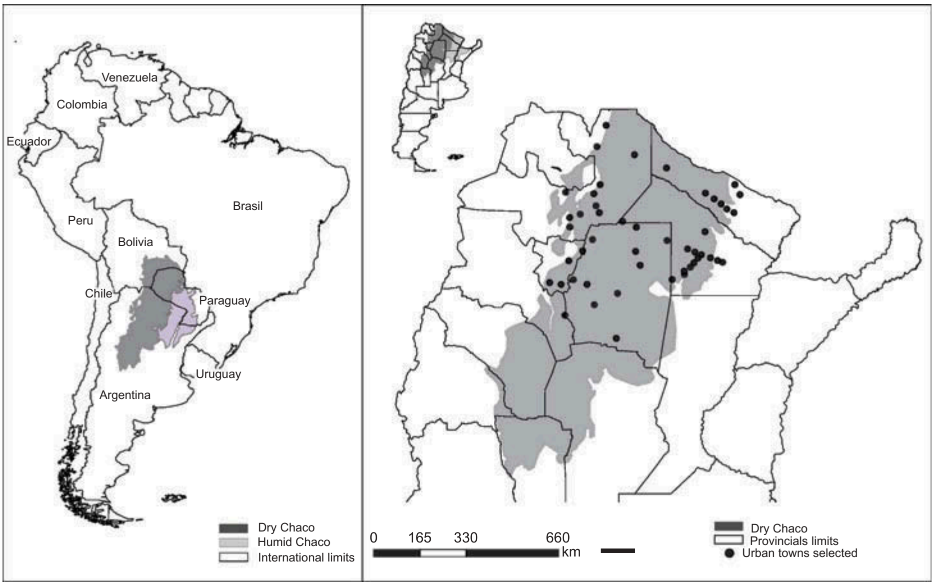

Figure 1. Study area and urban centers included in the analysis for the Argentine Dry Chaco. Left panel: the Chaco region in South America (Dry Chaco = dark grey and Humid Chaco = light grey). Right panel: the Dry Chaco in Argentina and urban centers used in this work.

$$\mathrm{APGR} = \frac{P_{01} - P_{91}}{P_{01} + P_{91}} \times \frac{2}{t} \times 1000$$

We used INDEC data to calculate the unemployment index, defined as the ratio of unemployed people over the total of economically active population[1] (EAP). Change in the unemployment index between 1991 and 2001 is an indicator of development of towns and jobs creation. However, during the 1990s, Argentina experienced a general increase in unemployment from 8.8% in 1991 to 19.7% in 2002 (Grugel & Riggirozzi, 2012). To better assess the particular situation of each town, we calculate the standardized change in unemployment index (ZΔUI).

Finally, to evaluate the capacity of creation and elimination of job positions between years (E_{01} and E_{91}) in each town, we calculated the 'employment generation index' (EGI) defined as changes in number of jobs between each dates expressed in relation to changes in EAP:

$$\mathrm{EGI} = \frac{E_{01} - E_{91}}{\mathrm{EAP}_{01} - \mathrm{EAP}_{91}}$$

EGI has positive values when job creation occurs. A value of 1 indicates that one job position was created for each person incorporated in the EAP. Values < 1 indicate a lower creation of jobs positions in relation to the incorporation of people in the EAP. Finally, a negative value of EGI shows job positions losses in relation to increase of the EAP. In our data set, the EAP increase during the study period in all towns, so the positive or negative sign of EGI in each town depends on the creation or elimination of jobs positions.

2.3. Deforestation and cultivated land data

We used deforestation maps previously prepared by visual interpretation of Landsat images, covering the period of population data (1991–2001) and with an overall precision of 90% (Grau, Gasparri, & Aide, 2005). The complete list and specific dates for each scene are presented in ST2. The procedure to map deforestation was done according to the national forest monitoring system (e.g., Gasparri & Grau, 2009; Gasparri et al., 2013). Based on these maps, we calculated DR (1990–2002) and cultivated land area (CLA) (1991) in a buffer of 50 km of each town. In the Dry Chaco, cultivated land replaced natural vegetation, including mostly dry forests, small portions of natural grasslands and some sectors previously affected by fires (this situation was more common in the early stages and toward the southeast of the study area). For simplicity and considering that only exceptionally cultivated land replaces natural grasslands, we assume that cultivated land expansion is equivalent to deforestation (Gasparri, Grau, & Sacchi, 2015).

2.4. Data analysis

To explore relations between deforestation and population on urban centers of the Argentine Dry Chaco, we used mixed linear models to find relationships between DR (as independent variable) and population and employment data (APGR, ZΔUI and EGI as dependents variables) using all towns included in our study.

To define deforestation stage, we explore towns' relationships in a cluster analysis (average linkage based on Euclidian distance). A decision tree was made to explore limits between classes. We use as explicative variables CLA and DR for each town in the Chaco region.

To explore differences of socioeconomic variables between deforestation stages defined by cluster analysis, we used the Kruskal–Wallis test (i.e., APGR, ZΔUI, and EGI), and Fisher's LSD post hoc test. We prepared descriptive boxplots for each deforestation stage, and scatter plot with absolute numbers of EAP and jobs positions to support interpretations and discussions.

3. Results

The mixed regression model for the APGR shows that DR is positively related with urban growth ($p < 0.0001$). For each 1000 deforested hectares, urban growth rate increases 1.6 times. The analysis shows that deforestation has no significant relation with parameters of employment (i.e., ZΔUI; EGI) (Table 1).

The cluster analysis allows us to define three main groups of towns (Fig. S1) with a cophenetic index of 0.72, that is, slightly below the ideal (0.8; Sokal & Sneath, 1963). The definition of groups is based on CLA and DR. We use these variables in the decision tree analysis to identify the threshold values that define the classes (Fig. S2). We define them as followed: (a) new deforestation stage: this group represents small proportion of CLA in the buffer zone (CLA < 36%) and low DR (DR < 7235 ha/year); (b) active deforestation stage: this group shows a higher DR (DR > 7235 ha/year), independently of the proportion of CLA in the buffer zone; and (c) advanced deforestation stage: this group has a large proportion of CLA in the buffer zone (CLA > 36% in 1991) and a low DR (DR < 7235 ha/year) (Fig. S2). Pampa del Infierno was a particular case, with early divergence, but linked with the group of active deforestation. Within urban centers

Table 1. General linear model for each socioeconomic variable used as dependent variable.

Model	R^2	AIC	p
APGR* = 28.97 + 0.0016 × DR + ε	0.25	416.79	<0.0001
ZΔUI = −0.04 + 0.0000061 × DR + ε	0.0012	162.51	0.8117
EGI = −0.19 + 0.000015 × DR + ε	0.02	111.81	0.3136

Notes: APGR, annual population growth rate; ZΔUI, standardized change in the unemployment index; EGI, employment generation index, in relation to deforestation rate (DR) used as independent variable. Results reported are R^2, Akaike information criteria (AIC) and probability (p). *Shows significant model.

included in this study, there are no cases of inactive deforestation with less than 10% of CLA in the buffer zone and nondeforestation in the area. Towns with this situation show less than 2000 inhabitants in 2001 and were not considered to be urban. The deforestation stages defined above were used to explore differences of socioeconomics variables between them.

The analysis of the annual population growth rate shows significant differences among the deforestation stages (Figure 2a). New and active deforestation do not differ significantly ($p < 0.05$). New deforestation shows intermediate APGR values (average APGR = 39.73‰), active deforestation shows the highest value (average APGR = 50.31‰), and advanced deforestation has the lower average values of APGR = 26.34‰.

The deforestation stages have not significant differences for ZΔUI. However, there are differences between deforestation stages for EGI values (Figure 2b). Towns in the active and new deforestation stages are different from those in the advanced deforestation ($p < 0.05$). Towns in the advanced deforestation stage have fewer levels of EGI.

The combined dynamic of population growth and employment change is summarized by EGI. Results show that towns in advanced deforestation have significantly less

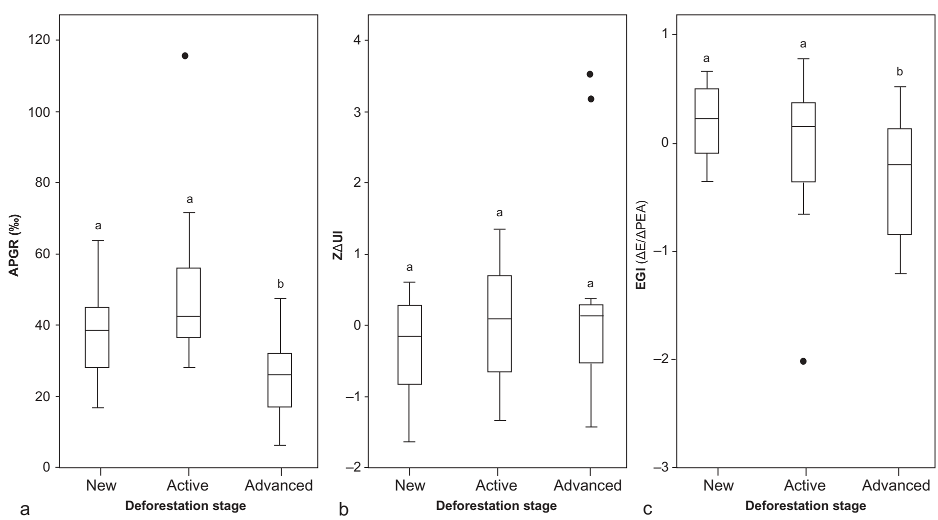

Figure 2. Box plot of socioeconomic variables: (a) annual population growth rate (APGR); (b) standardized change in the unemployment index (ZΔUI); and (c) employment generation index (EGI) for the different deforestation stage. Letter above the box plot indicates differences in mean values. Lowercase letters indicate differences with $p < 0.05$.

capacity to generate jobs positions and integrate new people in condition to work (EAP) into employment (p = 0.0138) than the new and active deforestation stages (Figure 2c). Changes in absolute numbers of job positions and EAP (Figure 3) also show this pattern. They show that new deforestations have been able to generate employment and integrate new people in condition to work (EAP). This is reflected in low values of ZΔUI (instead nonsignificant differences) and in high EGI values.

Based on different combinations of change of EAP and employment, we separate four sectors in Figure 3. Sector (a) shows the combination that is near to generate one job by one new person in EAP. Sector (b) is the combination with job positions creation, but in lower quantity that increase in EAP (e.g., generate one job position for each three new EAP). Sector (c) includes situations that receive a high number of new EAP and lost job positions. Sector (d) is a combination that shows loss of jobs in a context of moderated increase in EAP. The majority of urban centers in a context of

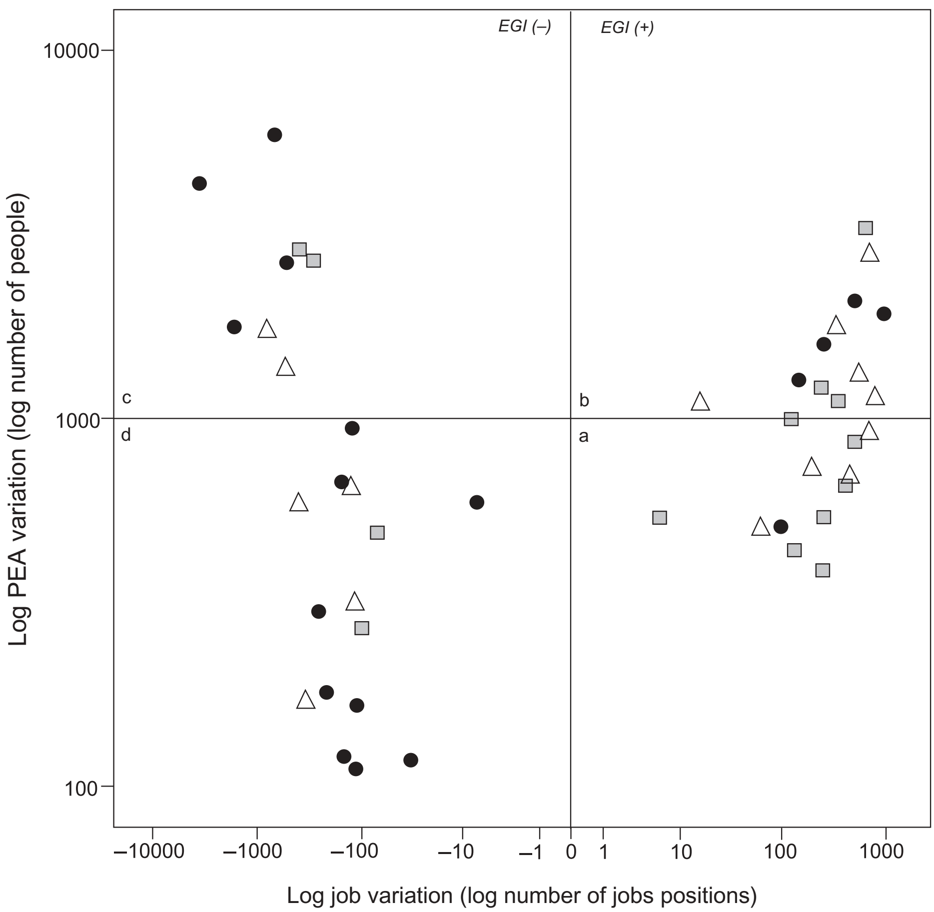

Figure 3. Variation in the population economically active (EAP) and jobs in the period 1991 and 2001 for each urban center. Data are presented in absolute numbers of persons and job positions. Dots represent data for each urban town included in study area (n = 48). Letters a, b, c, and d correspond to sectors. Vertical lines divide positive and negative values of the employment generation index (EGI). Squares represent urban towns in new deforestation stage, triangles in active deforestation stage, and circles in advance deforestation stage.

new deforestation are being located in (a) or (b), the best relative situation, with EGI positive values (Figure 3). The active deforestation stage presents a more variable situation concerning the creation and elimination of jobs in terms of absolute values (reflected also in positive and negative values of EGI) (Figure 3). That is, some towns in active deforestation stages were able to generate job positions in the same rate that receive new EAP. However, others show the opposite situation: They received new EAP, but lost job positions. Finally, advanced deforestation stages show a variable situation in terms of population growth and creation of employments, reflected in positive and negative values of EGI. However, the majority of towns in advanced deforestation are located in (c) and (d). It is remarkable that extreme cases of growth population and loss of employment situation correspond to advanced deforestation (Figure 3).

4. Discussion

Previous studies in Argentina focused on negative consequences of agricultural expansion over rural population (Paolasso et al., 2012, 2012; Rodriguez, 2010; Van Dam, 2003), and on its benefits for the national macroeconomy (Bisang, Anlló, & Campi, 2008; Rodriguez, 2010; Trigo, 2011). In this work, we explore the consequences of soybean expansion over urban employment and urban population growth in the Dry Chaco. These two variables can be considered as related with the economic dynamic of towns.

Our results show a generalized urban population growth for the study period. Urban centers with more dynamic deforestation in its surroundings tend to have higher population growth (Figure 2a). We relate this situation to migration. It is important to point out that for our study region, data to determine if urbanization is caused by natural population growth or migration are only available at a department level, thus, we cannot confirm this hypothesis. However, the pattern found for urban centers in our study is consistent with observations at department level, indicating that those political units (departments) with higher deforestation present greater population growth (Krapovickas, 2009) mainly due to positive migrations (Paolasso et al., 2012). Our results are also in accordance with the situation described in the Brazilian Amazon where deforestation and agriculture have positive association with population increase (Richards et al., 2014; Rodrigues et al., 2009).

Our analysis of employment dynamics shows that new deforestation stage presents less increase of the unemployment than active and advanced deforestation stages (Figure 2b), in spite of nonsignificant statistical differences. This is consistent with the low capacity of job creation of advanced deforestation stages (reflected in EGI values: Figure 2c). As a consequence, towns in the stage of advanced deforestation present the worst employment situation. For the Chaco region, Krapovickas (2009) found that soybean production is positively related with availability of employment only through deforestation (the event of clearing the land) and showed that towns in advanced deforestation have less employment than new ones. Richards et al. (2014) found a positive linear relation between agriculture expansion and population growth and employment in Amazonia. For the Chaco region, we find variations, with modal relations, from this pattern.

Based on our results, we suggest that different deforestation stages are associated with the pattern previously described as 'boom and bust' (Barbier, 2004; Rodrigues et al., 2009) and are related to the 'resource curse hypothesis' (Barbier, 2004; Celentano et al., 2012). For the Chaco region, we propose that the 'boom and bust' pattern is related with labor demand generated by the clearing of land to put it into production. This indicates that the 'boom' observed is based on the availability of forested land to be converted into cultivated land. Available forestland, thus, functions as a nonrenewable resource. Depletion of this area in advanced stage could be associated with the diminution of economic activity, a characteristic of the 'bust' period. Therefore, clearing the forest creates employment opportunities that attract migratory population. The pattern of 'boom and bust' suggested for our study area is consistent with the resource course hypothesis, mainly proposed to 'mining' economies, but with parallels to forest exploitation (Celentano et al., 2012). This pattern is also observed in countries with high natural resource dependence (Barbier, 2004). It is important to point out that the 'boom and bust' pattern shown in our study is exhibited on a short timescale. However, on a long timescale there could be a new wave of deforestation or other activities that require much workforce, and then becomes a new 'boom'. For example, in Brazil, a short period of study showed a 'boom and bust' pattern (Rodrigues et al., 2009), but in the long run it appears to benefit local population (Celentano et al., 2012).

To exemplify the proposed sequence for the Chaco, we selected case studies from the Argentine Dry Chaco (Figure 4 and Table 2) (refer to ST 1 and online supplemental material 1 to see demographic, agriculture, and localization data of all selected urban towns in the Argentine Dry Chaco).

Stage I (new deforestation stage): New deforestation exhibit a low change in population in conditions to work (EAP) because growth is mainly based on natural population growth (low APGR). A low dynamism in productive activities is

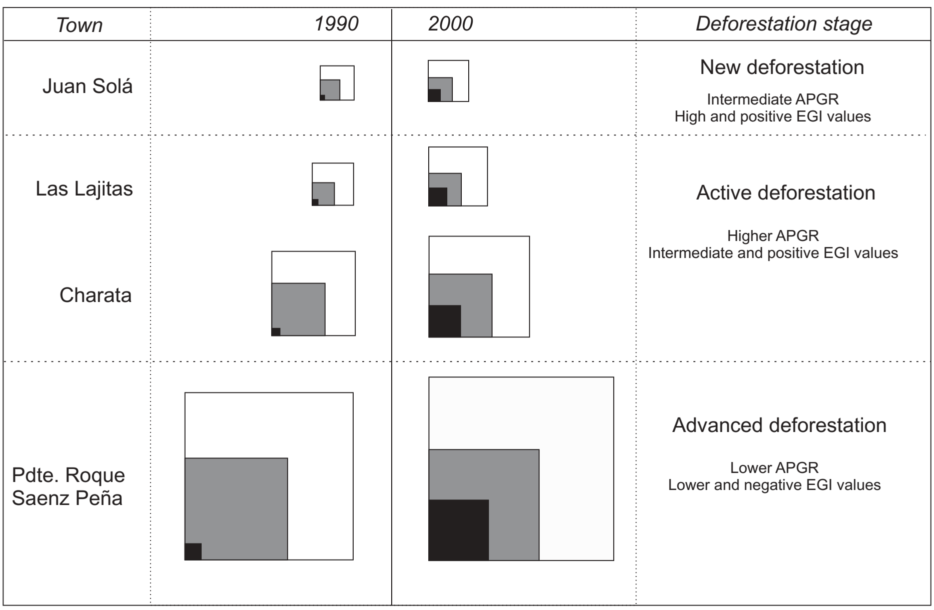

Figure 4. Proposed sequence of boom and bust exemplified with local cases, expressed in a relation of 0.5 cm^2 = 1000 inhabitants. The total area of each box represents the total urban size. Light grey and black areas in the lower-left corner of each box represent EAP, where black areas are the number of unemployed persons. The white area of each box represents the people not included in the EAP.

Table 2. Demographic and deforestation situation (deforestation rate and cultivated land area) of the urban centers used to exemplify the *boom and bust* sequence related with the deforestation stage.

	Juan Solá		Las Lajitas		Charata		Roque Saenz Peña	
	1991	2001	1991	2001	1991	2001	1991	2001
Total population (persons)	2467	3678	3941	7688	15,836	22,573	63,135	76,794
Employee (persons)	831	966	1076	1634	6098	6813	22,968	19,356
Unemployee (persons)	27	307	75	754	144	2062	548	7961
Unemployment rate	3.15	24.12	6.52	31.57	2.31	23.23	2.33	29.14
Urban growth rate (‰)	39.41		64.44		35.08		19.52	
Deforestation rate (ha/year)	3		10,229		15,233		6868	
% CLA in 1991	20.44	20.45	31.06	44.37	44.78	66.71	53.84	62.57
EGI	0.31		0.43		0.26		−0.83	

reflected in a low attractiveness to migrants. Then, new deforestation creates job opportunities for a relatively small population, and in consequence, the employment situation is comparatively better than active and advanced deforestation. This is the case of Coronel Solá (Salta province).

Stage II (active deforestation stage): For active deforestation, agricultural expansion demands more jobs, but, at the same time, promotes the arrival of migrants. The number of new job positions is not enough to integrate the majority of new people in condition to work (EAP) into employment. In consequence, employment (reflected in our indices ZΔUI and EGI) shows a situation with job opportunities but also high population increase. Thus, the active deforestation stage has a high capacity to create new job positions, but due to high population growth, it is not sufficient. To exemplify this situation, we present two cases: (a) Las Lajitas (Salta province) is a small urban center located in one of the most active deforestation stages during the 1990s (Grau et al., 2005), with high population growth and medium unemployment rates. (b) Charata (Chaco province) is a medium-sized urban center with more deforested area than Las Lajitas at the beginning of the 1990s. Although Charata had high DRs, the soybean production not only expanded into forested areas but also replaced previous agricultural land. The Charata case showed less population growth (low values of APGR) but also a lower capacity to create and integrate new EAP into employment (lower EGI).

Stage III (advanced deforestation stage): For urban centers in advanced deforestation, the urban population is large. Deforestation in the surrounding of the urban center is low because most of the deforestation occurred before the study period, and the predominant conversion process is the replacement of crops (e.g., cotton) and pasture by soybean. In this case, the establishment of the soybean economy was done without deforestation, the main activity that requires labor. Employment (ZΔUI and EGI) presents the worst situation, with low creation of employment (ΔE). This is the case of Presidencia Roque Saenz Peña (Chaco province). This urban center presented a low population growth (lower APGR); nevertheless, it showed low capacity for employment creation. Thus, although this town received few migrants, its employment system was not able to integrate them. In addition, the situation was aggravated since cotton was partially replaced by soybean crops, which has much less labor demand (García, 2007), further influencing the loss of employment positions (reflected in negative EGI values) in the area of the Presidencia Roque Saenz Peña.

Certain characteristics of the agricultural system could be determinant to develop a pattern of 'boom and bust' or not. These are, for example, the organization as minifundio vs. latifundio, or the development of a local value chain associated with agribusiness. The profits from agriculture can play a vital role in the rural–urban linkages, promoting higher demands of services and agricultural inputs from the local urban centers, diversifying activities and creating nonfarm jobs (Garrett & Chowdhury, 2004; Richards et al., 2014). Garret et al. (2013b) highlight a positive feedback between agriculture expansion and the agglomeration of producers and companies. Agglomeration and the diversity of local supply chains promote cluster economies that could be articulated around local urban centers. However, when production is oriented toward global markets, there are more possibilities that economic benefits bypass local urban centers (Garrett & Chowdhury, 2004; Tacoli, 1998). Our results suggest that commercial agriculture generates employment principally by clearing forest areas, but has limited capacity to generate the same number of perdurable jobs with agricultural production activities. This situation is concomitant with an enclave economy, where the profits of the activity are not locally reinvested. This situation contrast with these of soybean production in the core area of Argentina. In the Pampas region of Argentina, soybean production promotes economic development of local urban centers, associated with high prices of land rent (Reboratti, 2010) and with an emerging agriculture machinery industry (Moltoni & Gorenstein, 2010) and agriculture services activities.

One main question that emerges from our study is about the mechanisms associated with urban growth. We propose two pathways to explain the association of deforestation and the increase in local urban population: (a) the local rural–urban migration and (b) the creation of job opportunities associated with agriculture expansion and extra regional migration. Understanding which of these two mechanisms are more important to explain the urban population growth is a relevant question, to comprehend deforestation impact over population and employment dynamic of small and medium urban centers. The outcomes that emerge from this study have high relevance since they describe the direct influence of agribusiness on local development. Agricultural expansion during the 1990s has been implemented without major government regulation and with weak restrictions for deforestation (Gasparri et al., 2013). For this reason, studies that reproduce our analysis for the 2000s in Argentina will consider a contrasting situation, where the government plays a more active role over socioeconomic aspects, employment creation, and deforestation regulation.

For the Chaco region, our work describes a pattern already observed in Brazil. This promotes awareness about possible consequences of soybean expansion and deforestation in other regions of South America (e.g., Paraguay and Bolivia), but also worldwide, for example, sectors of the African continent, where the expansion of soybean is highly likely to occur in the future (Gasparri, Kuemmerle, Meyfroidt, Le Polain De Waroux, & Kreft, 2015; Sinclair, Marrou, Soltani, Vadez, & Chandolu, 2014). Finally, this work presents a contribution for the understanding the consequences of deforestation in a high dynamic region, such as the Chaco, with quantitative data about the impact on the local population of the Chaco region.

5. Conclusions

Our results suggest that agriculture expansion and deforestation in the Argentine Dry Chaco have a modal relation with population growth and employment in the small and middle urban centers. We found that urban centers surrounded by agriculture expansion and deforestation generate more job opportunities during the early stage of clearing the land and putting it into first production. We suggest that agricultural expansion in the region follows the 'boom and bust' pattern, with economy expansion and posterior decline, more related with the use of nonrenewable natural resources. In particular, the advanced deforestation stage offers limited job opportunities, especially when soybean expansion replaces other crops with comparative higher labor demand (e.g., cotton).

The impact of deforestation on population dynamics shows a modal trajectory. In the short time, active deforestation could be seen as a positive way for local economy development. At its early stage, it can translate into high demands of labor to prepare the land for cultivation. However, in the long run, it is not clear whether new agricultural activities (especially soybean) can sustain the same number of jobs created in the expansion period associated with deforestation. Taking into account this dynamic, we suggest that it is relevant to generate specific land planning policies and local incentives to promote the creation of jobs associated with new cultivated areas. In particular, local policies to promote the development of agglomeration economies in urban centers could be valuable in order to increase the integration of agricultural economic benefits in socioeconomic dynamics of local urban centers.

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Supplemental data

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Note

1. By INDEC definition, EAP is a people set older than 14 years, who has an occupation, or are looking for employment actively. Is composed by employment and unemployment population.

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