Designing a Green Belt for Xalapa City, Veracruz under current Mexican policies

Abstract: Green Belts are often proposed as an alternative for containing urban sprawl, restoring ecological processes and recover connectivity, and maintaining the multi-functionality that cities need. This article analyzes a proposed Green Belt for Xalapa, Veracruz, Mexico. It is spatially examined through GIS analysis and designed on the notion of Garden City as a strip to circumvent the city. Existing conditions are also discussed. Two existing conservation initiatives are compared to the proposed Green Belt strategy. Its establishment requires agreements between Xalapa and surrounding municipalities. The proposed strategy brings local government and citizens together to preserve the remaining vegetation and thus promote the well-being of local inhabitants.

Keywords: conservation, cloud forest, Green Belts, planning, recreation, Xalapa

Resumen: Los cinturones verdes frecuentemente se han propuesto como una alternativa para contener la expansión urbana desordenada, restaurar los procesos ecológicos y recuperar la conectividad, y mantener la multifuncionalidad que las ciudades necesitan. Este artículo analiza un esquema de Cinturón Verde para Xalapa, Veracruz, México. Es espacialmente examinado, diseñado bajo el concepto de Ciudad Jardín, como una franja que rodea a la ciudad, el análisis se elaboró con un SIG. Las condiciones existentes también se discuten. Se comparan dos iniciativas de conservación existentes con la estrategia propuesta de Cinturón

Verde. Su establecimiento requiere acuerdos entre Xalapa y los municipios aledaños. La estrategia propuesta requiere reunir a los gobiernos locales y ciudadanos para preservar la vegetación remanente y así promover el bienestar de los habitantes locales.

Palabras clave: conservación, bosque de niebla, Cinturón Verde, planeación, recreación, Xalapa

Introduction

When uncontrolled, urban development spreads over rural surroundings, often transforming the land from agricultural areas or natural ecosystems to more intense urban use. The demand for urban land is a powerful driver of landcover transformation, putting pressure on the permanence of vegetation (Baycan Levent, Vreeker, & Nijkamp, 2009). Vegetation loss results in a decrease in ecosystem services (i.e. water cycle regulation, air purification and recreational values) provided by those remnants, eventually affecting the quality of life for neighboring inhabitants. Additionally, the fragmentation or disappearance of vegetated areas leads to a reduction in biodiversity. A major challenge for city planners is sustainability, which should integrate economic growth, social welfare and environmental conservation—especially at urban/rural borders—through coherent policies for development (Gopinath & Jackson, 2010; Morrinson, 2010). Urban land is a limited resource because of the constraints imposed by the topography of neighborhoods (ONU-HABITAT, 2012). The scarcity of land available to meet the constant demand for housing and infrastructure pushes marginalized communities—usually low-income populations—to risk-prone conditions and irregular appropriation of land. Despite these challenges, cities must plan for the maintenance of a

minimum plant cover in order to provide the ecosystem services necessary for the wellbeing of all inhabitants (Tang, Wong, & Lee, 2007)

Green Belts are a planning instrument intended to preserve urban green space through the creation of a land classification policy to preserve natural vegetation areas around urban centers (Madureira, Andresen, & Monteiro, 2011). Green Belts restrain urban growth and separate satellite developments from the main downtown. (Amati, 2010; Gamez-Basten, 2002; Gennaio et al., 2009; Rowe, 2012). They also are intended to maintain the remnants of natural forests (Ignatieva, Stewart, & Meurk, 2011).

We intend in this paper to explore the likely implications of implementing a green belt in the outskirts of the city of Xalapa, Veracruz. This Green Belt should help the city conserve the remaining natural vegetation cover. Our work considers existing policies and regulations with the goal of preserving ecosystem services (Reyes-Díaz, 2010; Saunders et al., 1987). In addition to seeking to preserve the vegetation remnants present in the periphery, we also look at ways a Green Belt can contribute to recreational opportunities (Žlender, & Ward Thompson, 2017). The research question asks: is it possible to adopt an urban planning instrument such as a Green Belt to mitigate the disappearance of vegetation attributed to accelerated urban expansion and thus contribute to safeguard vital ecosystem services and also provide recreation opportunities for the inhabitants of Xalapa?

Area of study

Xalapa, Veracruz is a medium-sized city in the center of the State of Veracruz, Mexico. It covers an area of 124.38 km^2, with a population of 480,841 (INEGI, 2015a). In the 1990's, it was one of a group of Mexican cities regarded as targets for development to induce the

redistribution of national income through decentralization (Castillo Palma & Patiño Tovar, 1999). Currently, mid-sized cities are under scrutiny because of their accelerated growth, and the composition of the current national urban system. Xalapa has accelerated population growth and will be under strong demographic pressure in the near future. The forecasts suggest that the population will grow to reach more than 780,000 inhabitants by 2030 (ONU-HABITAT, 2016). This data is frequently used to plan for infrastructure and public services, but rarely is it linked to demands for ecosystem services (Albert & Von Haaren, 2017). Population growth obviously implies increased stress on the environment, including the loss of vegetation cover within the city, as well as increasing pollution and difficulties for water provision. Urban plans must be updated to prevent and protect the remaining natural territory (Bazant, 2010).

The cloud forest is the most widespread vegetation type in Xalapa's periphery. It has great floristic richness and it is one of the most threatened in the country (Rzedowski, 1993). In the municipality of Xalapa, it remains in a small area, totaling 3.33 km^2 in 2013. Despite its small size, it is still home to around 1,300 plant species (Castillo-Campos, 1991). Other types of vegetation found in Xalapa municipality are oak forest, riparian forest, and tropical dry forest. The cloud forest and many of its species have survived because of their role as shade for coffee plantations, which has encouraged some degree of conservation of tree cover. This crop spans 25.15 km^2 (20.18 % of the municipality). However, shade coffee plantations are mainly monocrops in the northeast, with trees of the *Inga* genus which is then described as "shade monocrop" (Ortiz-Ceballos, 2004; Pineda-López, Ortiz-Ceballos, & Sánchez-Velasquez, 2005). But even as a monocrop, they preserve a good proportion of the biodiversity of the surrounding forests. The best-preserved forests are situated in the

southwest of the city and in the northwest, on the borders with Tlalnelhuayocan and Banderilla municipalities.

Methodology

Our analysis was based on the description and study of the vegetation cover, defined as the layer of natural vegetation that covers the terrestrial surface, comprising a wide range of biomasses with different physiognomic characteristics and environmental conditions that go from grasslands to areas covered by natural forests (Ellis, 2007). The Green Belt is a territorial policy offering environmental and social benefits to the city, demanding the application of better-quality land policies and housing in the urban sector. We conducted a review of the national, state, and municipal regulations to explore normative coherence with its implementation and thus to identify suitable instruments to support it.

The delimitation of the Green Belt for the City of Xalapa was carried out on vector data of the polygons representing the urban locations as they were available from the official geostatistical dataset (INEGI, 2015b). To identify and delineate vegetation types in the belt, we defined a buffer area 1000 m wide, centered on the borderline of the polygon of the City of Xalapa and its Metropolitan Zone. The Metropolitan Area of Xalapa (MZX) is a shared urban space that encourages the governments of the municipalities to negotiate and work on agreements on urban development policies, to coordinate urban development and safeguard the environment (Zentella, 2005). This is sometimes difficult because the agreements cannot be implemented easily. The difficulties for its management and implementation involve long and complex processes.

We classified land cover units using the Landsat 8 panchromatic band (15 m of resolution) in this buffer area using ArcGIS (version 10.2.2, 2014). We used Landsat 8 imagery acquired on January 27th, 2015, path 25/row 46, UTM zone 14N. We classify the panchromatic band (band 8), using the Natural Breaks utility, which allows the identification of classes according to the "best group of values" defined by maximizing the differences between classes (ESRI, 2016). This allowed us to discriminate between forested surface, surfaces without trees and urban areas, with higher efficiency compared to other raw bands or vegetation indexes.

The article is organized as follows: following this introduction, a general review of the history of Green Belts is presented in part two. Part three then discusses some normative instruments about Green Belts in Mexico with particular focus on the State of Veracruz. The proposed Green Belt for Xalapa is examined in part four followed by presentation of the article's conclusions in part five.

History of Green Belts

When planning studies recognized the challenges of messy urban growth, Green Belts emerged as a tool intended as "geographic normativity" to establish natural limits to cities. A broad definition of a Green Belt is a land classification policy used in urban planning to conserve areas of natural vegetation and agricultural lands around cities. The Green Belt has also been defined as the reserves of open spaces around urban concentrations, but, of course, these are not the only definitions. The concept of a "continuous Green Belt of rural land, surrounding the cities" has changed (Whittick, 1974, p. 485), because it has become evident that such schemes are virtually impossible to implement. Laruelle & Legenne, (2008) offer

a new alternative notion to the continuous green loop surrounding cities, composed of "patches and a discrete, flexible, Green Belt", like the Green Belt of Paris. Currently, they can be identified by two features: connectivity and multi-functionality (Cormier & Madureira, 2013). The first promotes ecological processes, and the second feature refers to multiple social functions. The idea of connecting open spaces was originally related with aesthetic values and social purposes, such as sports; but now the ecological implications of connectivity are also acknowledged in public policy. These implications including the protection of biodiversity by maintaining habitat, and conservation policies have been reformulated for their integral application in different scales. The multi-functionality concept also argues for an important social function and health benefits associated with recreational and leisure opportunities as well as environmental improvement (Alfie Cohen, 2011: James et al., 2015; Madudeira et al., 2011).

Ebenezer Howards' 1898 proposal of a "Green Belt" for Letchworth, then named Garden City, is considered the first reference to a Green Belt in the modern context (Lucey, 1973). It was designed to limit urban expansion. Its objective was to maintain an agricultural area, reduce urban poverty, and provide a means to improve the health and well-being of the population. In the twentieth century, metropolitan Green Belts in the United Kingdom were an important planning tool, and the concept was extended to other countries (Amati, 2007; Amati, 2012). The Garden City started a movement aiming to build a new urban paradigm and start a movement for regional planning innovation. Regional planning was proposed by Patrick Geddes, mainly aimed to decentralize the location of industrial land. In some cities, Green Belts have influenced urban configurations without necessarily controlling growth (Capel, 2002; Evans, 1997).

In the 21st century Green Belts still are an environmental planning option for vegetation conservation on a macro-urban scale (North, 2012). However, the maintenance of the "untouchable" land, both physically and politically has been practically impossible. For example, in Beijing, China, a second Green Belt was proposed when the first one failed to contain urban sprawl. This failure was attributed to the underestimation of the magnitude of urban growth, and lack of participation of the inhabitants in the planning processes. The predictions for Beijing's second Green Belt are similar (Yanga & Jinxing, 2007). Only England and Korea have strict control of their limits, ensuring that there is no urban growth in them (Bengston & Youn, 2006). Although not always possible, there is strong support for stronger limits and reinforced conservation values within planning systems.

The long-lasting debate about the role of the urban Green Belt has taken on new significance in London where the housing shortage has prompted a discussion about whether to repurpose some of its Green Belt parts that are in quite poor condition to build new homes to alleviate the housing crisis (URBAN-HUB, 2017). The concept and its application remain on the agendas of cities (Amati 2012; Gant, Robinson, & Fazal, 2011; Tang, Wong, & Lee, 2007), linking global agendas to local concerns and policy. There are emblematic programs inspired by this concept, including the Great Green Wall of Africa (http://www.greatgreenwall.org/) and the Green Belt Movement in Kenya initiated by Wangari Maathai (Maathai, 2008), which had such an impact that it received the Nobel Peace Prize in 2004. It is aimed as a belt to protect people from the desert of the Sahel and Sahara. It has prompted women from different locations to plant 30 million trees along the belt, providing food and wood in this way, while reducing soil erosion and desertification.

Some researchers have stressed on this regard that governments find themselves at a crossroads between preserving the environment and having land available for development. Although Green Belts do not always stop urban growth, the potential of the concept has impacted the development policies of some countries (Amati & Taylor, 2010), including Mexico. In Mexico, Miguel Angel de Quevedo created the first National Park "Desierto de los Leones" in the south east of Mexico City in 1917. In what is considered to be the first national Green Belt proposal, Miguel Angel de Quevedo, convinced then Mexican President Carranza to include a text in Article 27 of the Mexican Constitution, for the conservation of vegetation cover, which is now binding (Vargas, 2014). This laid the foundations for policy-making examined in the following section.

Mexican policy instruments for the establishment of Green Belts

In the case of Mexico, the notion of Green Belts has been included in national environmental policies (Gastélum Bajo & Albores Gleason, 2015), mainly with the objective of preserving the vegetation in the periphery of cities. Along with the strategies issued in Mexico's six-year National Development Plan, there is currently a proposal to promote Green Belts as a national policy for Mexican cities on the U3 Perimeter of the national program for agriculture, territory and urban development (SEGOB, 2013). Green Belts are described as adjacent zones to urban areas that act as buffers (peripheral belt to the urban area) defined according to the size of a city. Unfortunately, this proposal has gone almost unnoticed by municipal and state authorities. It was supported by the "Project of Decree" initiative of 2015 (Gastélum Bajo y Albores Gleason, 2015), where there is an addition to Article 2 stipulating the creation of Green Belts.

Amongst the normative instruments in the state of Veracruz that support the creation of the Green Belt, we find the Law of Urban Development, and Territorial and Housing Planning of the State of Veracruz (*Ley de Desarrollo Urbano, Ordenamiento Territorial y Vivienda del Estado de Veracruz*) (GOBVER, 2011), the most relevant aspects of which are emphasized in Article 29 that highlights the restrictive ecological reserves of high environmental value as protected areas for urban centers (GOBVER, 2011). Two other normative instruments decreed for Veracruz state exist. The Archipelago (GOBVER, 2015) is denominated Archipelago of forests and tropical dry forest of the capital region of the state of Veracruz, a total of 7 polygons located in the Restrictive Ecological Reserve. It is a "protected natural area in the category of multifunctional biological corridor". The Land Use Planning, POETX (GOBVER, 2018), is based on the conviction that the sustainability of cities is not viable without considering their regional environment and planning their uses.

Some authorities point out that the limited success of environmental actions could be explained by the lack of an appropriate budget, but researchers have instead shown that limited progress is due to the small influence of the environmental criteria in the policies of economic and social development sectors (Hernández-Huerta, Pérez-Maqueo, & Equihua, 2018). The fact is that production has been prioritized without consideration for the consequences on the natural environment, and therefore the health of ecosystems and the people who inhabit them remain secondary. The great number of laws, regulations and urban environmental policies have not prevented, for instance, irregular urbanization (Schteingart & Salazar, 2003). This is partly because the application of a restrictive or containment policy raises the land value by creating a higher demand for it. Therefore, to avoid market stress, it is necessary to apply instruments for the recovery and creation of accessible housing. The

implementation of this initiative can be achieved through social networks, non-governmental organizations (NGO) and individual citizens with the support of research centers who can generate synergies to improve self-management and allow diversification opportunities.

This Green Belt proposal hopes to generate a territorial and regional planning scheme that is more appropriate to the contemporary needs of metropolitan areas, but its operation can only be implemented trough an integral and coherent approach to sustainability. It calls for innovative urban management and an update of the policies and instruments of territorial planning in Mexico. In addition, it is important to explore the densification of existing underutilized spaces within the city. Although controversial, urban densification seeks to induce the development of cities that are more compact, efficient, equitable and sustainable. Strategies for the inner city include vertical growth, recycling and re-developing abandoned or underutilized intra-urban spaces for their greater and better use, intending to intensify the mixed use of land and increasing urban infrastructure and services to meet the needs of the greater number of inhabitants and users in the same territory (Pollock & López-Silva, 2014).

A Green Belt for Xalapa

As mentioned above, the total area of Xalapa Municipality is 124. 38 km^2. In 1980, the urban area of Xalapa covered a surface of 24.4 km^2. In 2015, it covered an area of 59.91 km^2, 48.07 % of the total area of the Municipality (INEGI, 2015b). The vegetation in the Municipality of Xalapa is very fragmented. Human settlements account for the largest area of land use, replacing crop, grasslands and forested areas. Acosta's results for the period between 1980 and 2015 showed that the biggest land cover replacement took place in the shade coffee

plantations, the area covered by shade coffee plantations decreased 12.9 km^2, and 5.78 km^2 in between primary and secondary cloud forests, mainly due to urbanization (Acosta, 2015).

Green Belt Scheme

The Green Belt suggestion that we explore for the city of Xalapa, and its Metropolitan Zone of Xalapa (GOBVER, 2002), follows some of the guidelines of Garden City: a Green Belt around the city, a circular shape, with mixed uses and with communal ownership, inspired by the ideas of Raymond Unwin (1863-1940), designer of Letchworth Garden City, along with Barry Parker, who defended the existence of Green Belts in cities as a barrier for containment and the separation of the urbanization process. This approach also served as the basis for the Abercrombie London plan (Capel, 2002). Our suggestion of a 1km Green Belt surrounding the urban area of the city of Xalapa is shown in Figure 1. The resulting total area in our scheme for a Green Belt is 38.83 km^2. We found that the proposed area could protect the last remnants of cloud forest, mainly found at the northwest and southwest, and in the shade coffee plantations at the northeast of the city.

<< INSERT FIGURE 1 ABOUT HERE >>

The current urban area of Xalapa Municipality (59.91 km^2) includes 12.63 km^2 of forest land mainly primary and secondary cloud forests and shade coffee plantations (Table 1 and Figure 2). In landscapes with a high degree of fragmentation of the natural ecosystems, development of green infrastructure should be based on the need to improve ecological connectivity to maintain connections among nodes, through buffer zones, and corridors

within the landscape matrix (Capotorti et al., 2015). However, green infrastructure still is not a well-known concept in planning practice (Albert & Von Haaren, 2017). Green infrastructure planning should consider collaborative and participatory approaches to maintain and improve ecosystem services at all scales (Bissonnette et al., 2017).

In areas with currently degraded vegetation, the introduction of complete restoration programs or reforestation practices with native species could be implemented to build corridors that link these areas with the best-preserved forest fragments in order to preserve biodiversity. Restoration practices can reconnect forest fragments even if the vegetation is altered (Williams et al., 2007) with native species (Benítez, Pulido-Salas, & Equihua, 2004, Williams-Linera, Lopez-Barrera, & Bonilla-Moheno, 2015). A program of ecological restoration has also been proposed, with multi-species plantations and suppression of disturbances in a forest to the southwest. Also, other sylvicultural practices can play an important role in the promotion of Green Belts (Konijnendijk, 2010). In addition, species that are tolerant of air pollution should be included in such projects. The plants that can withstand pollutants can serve as tolerant species and may be suggested to act as pollution scavengers (Pathak, Tripathi, & Mishra, 2011; Sharma et al., 2017).

<< INSERT TABLE 1 ABOUT HERE >>

In order to improve the environmental conditions in the Green Belt, municipal administration should also consider the social life of the local community. Of the 38.83 km^2 covered by the Green Belt (Table 2 and Figure 3), 17.02 km^2 (43.82%) is forested area, which should be apt for enrichment with native species which can be established well within the

forest fragments (Alvarez-Aquino, Williams-Linera, & Newton, 2004). The non-forested area (grass, shrubland) which composes 9.57 km^2 (24.64) will require suitable ecological restoration and reforestation programs. Within the developed areas, open space can be used for ornamental species along with the presence of urban infrastructure for recreation and leisure. Tables 2 and Figure 3 show native and exotic species that have potential for restoration, and some can also be established on abandon agricultural sites (Alvarez-Aquino, Williams-Linera, & Newton, 2004; Ortega-Escalona & Castillo-Campos, 1996; Suarez & Equihua 2009). For these types of areas, the inclusion of the rapid growth species such as *Casuarina* spp. may enhance nutrient accumulation on degraded soils, and the results suggest that initial rehabilitation can be achieved by suitable assemblage establishment (Suarez & Equihua, 2009). Moreover, infrastructure for children and youngsters can be installed appropriately along the corridor to support recreation and leisure.

<< INSERT TABLE 2 ABOUT HERE >>

<< INSERT FIGURE 3 ABOUT HERE >>

The opportunity to preserve these spaces, conserve biodiversity and, consequently, provide ecosystem services should be considered in the design of environmental policies (Capotorti et al., 2015). The benefits would include maintaining part of urban agriculture, improving urban resilience and increasing capacity to adapt to climate change. Table 3 and Figure 4 show the areas of the Green Belt to be managed by each municipality involved. Of the 38.83 km^2 area designated for the Green Belt, the Xalapa Municipality contributes 31.1 km^2, and only 7.74 km^2 include the participation of other municipalities. Banderilla is the

smallest municipality by area and it is the one which would contribute the greatest surface (15.75%) to the Green Belt. Banderilla has been identified as the most dynamic conurbation, and it keeps a substantial forested boundary within its limits with Xalapa. The peripheral belt can include remnants of vegetation in the area and create public spaces with tangible social benefits for the inhabitants of Xalapa. Also, the public spaces formed by a belt can serve to create local identity, in addition to recreation, for the people of Xalapa (Boege et al., 2013). It would serve the inhabitants of informal settlements, who are underserved by recreational green areas.

Urban expansion into the periphery with a high degree of densification place the permanency of such green areas at risk. Most inhabitants must go far away to sites where green areas have park furniture. Because of this, the public space provided by the Green Belt with infrastructure could promote social leisure and recreation as a common denominator. Increasingly, green areas have gained importance due to the scarcity of vegetation with leisure infrastructure within settlements and the growing social demand for urban green space even the small ones (Peschardta, Schipperijnb, & Stigsdottera, 2012). It is important to involve the community and decision makers in a dialogue that leads to an understanding of a sustainable and healthy environment, biodiversity and living conditions that foster a sense of belonging (Ignatieva, Stewart, & Meurk, 2008).

<< INSERT TABLE 3 ABOUT HERE >>

<< INSERT FIGURE 4 ABOUT HERE >>

Figure 5 shows the overlap of all the instruments: The Archipelago (GOBVER, 2015), the Land Use Planning (POETX; GOBVER, 2018) and our Green Belt proposal. It is evident

that the notion of a Green Belt for the region has a good match with the two decrees Considering that the instruments decreed were mainly conceived for the conservation of natural resources. The comparison with our Green Belt scheme also makes apparent that they complement each other in terms of the conservation of natural resources and, as is intended, create a kind of ecological corridor between them, joining areas of remaining vegetation. The Green Belt is oriented not only to conservation but also to human use, so it includes recreational spaces with infrastructure that must be located in accessible places and outside the open spaces protected by the two decrees, in which recreation is not included, or at least, it has not been strongly emphasized so far.

Conclusions

Urban green areas are not always accessible or open for public use (ONU-HABITAT, 2012). As stated in goal 11 (UNDP, 2018) of the Sustainable Development Goals, the usage and availability of green urban areas in the 21st Century should be more equitable with suitable access channels for all the inhabitants of the city (Ward Thompson, 2002). The current discourse addresses the need to offer legal, cheap and environmentally suitable urban land that does not compromise other land uses that are important for the local economy. Green Belts support this objective. In response to our original research question of whether it is possible to adopt a Green Belt instrument to mitigate the disappearance of vegetation remnants, we answer that it is possible and that attempts are being implemented because of this threat. With a Green Belt, it should be possible to better guide and organize the growth of the city of Xalapa, while contributing to the conservation of the vegetation remnants that provide important ecosystem services, including the cloud forest in the northwest and

southwest of the city, the shade coffee plantations, and the other productive areas in the northeast. The conservation of the coffee agro-ecosystems will preserve a good proportion of the biodiversity of the surrounding forests (Manson et al., 2008; Perfecto et al., 1996).

The process of spatially overlaying different ecological and social requirements highlights multi-functionality as well as spatial consistency of selected restoration sites. With the forest degradation that has taken place, restoration should be part of the developing conservation policy for the Green Belt area. For these types of areas, the inclusion of the rapid growth species such as *Casuarina* spp. may enhance nutrient accumulation on degraded soils, and the results suggest that initial rehabilitation can be achieved if suitable species assemblages are used (Suarez & Equihua, 2009).

The failure of planning to anticipate the magnitude of urban development in Xalapa has undermined opportunities for vegetation conservation, and it has limited the prospects of the state to secure land for public uses (urban infrastructure, urban facilities, public spaces and green areas) as well as the provision of housing for the poorest families. In authorized settlements, it is necessary to strengthen the enforcement of regulations, to operate with transparency on rights and obligations associated with real estate development. Informal development is currently very active in the northeast of Xalapa, where there are high rates of speculation. The local government must be vigilant to curtail the spread of informal settlements, while providing an adequate supply of land for legal and secure housing and infrastructure for low-income populations. Green Belts can contribute to these objectives when they are properly implemented (Amati, 2008; Keil & Macdonald, 2017).

As it can be seen in the case of Xalapa has shown, however, that even though the implementation of a Green Belt is possible and supported by the constitution, this tool

depends on the establishment of planning instruments that facilitate municipal management. Its establishment requires agreements among cities and surrounding municipalities, where each municipality will keep the specified areas for their own public benefit, in order to predict greater success. The development and application of new land use policy instruments that protect ecosystems and remnant urban vegetation, such as The Archipelago (GOBVER, 2015) and The POETX Land Use Planning, (GOBVER, 2018), could benefit the economic and social sustainability of the entire Metropolitan Zone.

However, political and social costs should be considered as they reduce the probability of successfully executing a Green Belt. Land acquisition is difficult due to the problematic economic situation characterizing the State of Veracruz and its municipalities. Alvarez-Aquino, Williams-Linera, & Newton (2004) point out that there are good chances for such restoration programs, because private landowners within the region are increasingly becoming interested in alternatives to agricultural land use and repairing disturbed forests with selected species based on their high rates of growth and usefulness to wildlife. In this sense, updating the instruments for the territorial planning of Xalapa and its Metropolitan Zone is an urgent step toward benefiting both ecosystems and society. The continued absence of a Green Belt for Xalapa will contribute to the further loss of vegetation and important ecosystem services.

References

Acosta, R.I. (2015). Impacto del cambio de uso del suelo en la regulación de los servicios ambientales del bosque: El caso de la Cd. de Xalapa, Ver. Maestría en Desarrollo

Regional Sustentable. (Tesis de Maestría). El Colegio de Veracruz (COLVER), Xalapa, Veracruz, México.

Albert, C., & Von Haaren, C. (2017). Implications of Applying the Green Infrastructure Concept in Landscape Planning for Ecosystem Services in Peri-Urban Areas: An Expert Survey and Case Study. Planning Practice & Research, 32(3), 227-242. https://doi.org/10.1080/02697459.2014.973683

Alfie Cohen, M. (2011). Planeación urbana y ambiente: los cinturones verdes. Espacialidades. Revista de temas contemporáneos sobre lugares, política y cultura, vol. 1, núm. 1, julio-diciembre, 2011, pp. 73-100 Universidad Autónoma Metropolitana Unidad Cuajimalpa Distrito Federal, México. http://www.redalyc.org/articulo.oa?id=419545116003

Alvarez-Aquino, C., Williams-Linera, G., & Newton, A. (2004). Experimental Native Tree Seedling Establishment for the Restoration of a Mexican Cloud Forest. *Restoration Ecology*, 12, 412–418. https://doi.org/10.1111/j.1061-2971.2004.00398.x

Amati, M. (2007). From a blanket to a patchwork: The practicalities of reforming the London green belt. *Journal of Environmental Planning and Management*. Special Issue: Green Belts, 50, 579-594.

Amati, M. (2008). Green Belts: A Twentieth-centuary Planning experiment. In: Amati M. (ed). Urban Green Belts in the Twenty-first Century. Ashgate Publishing, Ltd. England, pp 1-19.

Amati, M., & Taylor, L. (2010). From Green Belts to Green Infrastructure. *Planning Practice and Research*, 25, 143-155. https://doi.org/10.1080/09640560701475121

Baycan Levent, T., Vreeker, R., & Nijkamp. P. (2009). A Multi-Criteria Evaluation of Green Spaces in European Cities. *European Urban and Regional Studies*, 16, 219-239.

Bazant, J. (2010). Paradigmas de la planeación urbana en la dinámica de transformación del suelo urbano. En: Iracheta Cenecorta, A. y Soto Alva, E. (ed) Impacto de la vivienda en el desarrollo urbano. Una mirada a la política habitacional en México. El Colegio Mexiquense, A.C. pp 59-91.

Bengston, D.N., & Youn, Y.C. (2006). Urban containment policies and the protection of natural areas: the case of Seoul's greenbelt. *Ecology and Society*. *A Journal of Integrative Science for Resilience and Sustainability* 11(1), 3. http://www.ecologyandsociety.org/vol11/iss1/art3/

Benítez, G., Pulido-Salas, Ma.T.P., & Equihua, M. (2004), Árboles nativos de Veracruz potencialmente útiles para reforestación, restauración y plantaciones. SIGOLFO-CONAFOR-Instituto de Ecología, A.C. 288 pp. ISBN 970-709-040-5

Bissonnette, J-F., Dupras, J., Messiera, C., Lechowicz, M. Dagenais, D., Paquette, A. Jaeger, J.A.G., & Gonzalez, A. 2017. Moving forward in implementing green infrastructures: Stakeholder perceptions of opportunities and obstacles in a major North American metropolitan area. Cities, 81, 61-70. https://doi.org/10.1016/j.cities.2018.03.014

Boege, E., Moreno, P., Alatorre, A.l., & Guevara, S. (2013.) Hacia un proyecto para la reserva ecológica de la ciudad de Xalapa y Coatepec Marangola AC Por el rescate del ambiente urbano, pp. 15-18. Available at http://www.lavida.org.mx/sites/g/files/g369226/f/201308/5,6.05%20PROYECTO%20PARA%20LA%20RESERVA%20ECOLO%CC%81GICA%20DE%20XALAPA%20Y%20COATEPEC.pdf

Capel, H. (2002). La morfología de las ciudades. I Sociedad, cultura y paisaje urbano, Barcelona: Ediciones del Serbal. Editorial: Ediciones Del Serbal. 544 pp. EAN: 9788476283912

Capotorti, G., Mollo, B., Zavattero, L., Anzellotti, I., & Celesti-Grapo, L. (2015). Setting Priorities for Urban Forest Planning. A Comprehensive Response to Ecological and Social Needs for the Metropolitan Area of Rome (Italy). *Sustainability*, 7, 3958-3976. https://doi.org/10.3390/su7043958

Castillo Palma, J., & Patiño Tovar, E. (1999). Ciudades Medias. *Elementos*, 34, 29-33 http://www.elementos.buap.mx/num34/pdf/29.pdf

Castillo-Campos, G. (1991). Vegetación y Flora del Municipio de Xalapa, Veracruz. Programa del Hombre y la Biosfera (MAB, UNESCO), Instituto de Ecología A.C., H Ayuntamiento de Xalapa, Veracruz, 148pp.

Cormier, L., & Madurera, H. (2013). Which local approaches for European green infrastructures concept? Case analysis of the Angers and Porto, Actes du 4eme colloque Fábos Conference on Landscape and Greenway Planning, 12-13 avril, Amherst (USA).

Ellis, E. (Lead Author) & Pontius, R. (Topic Editor). 2007. "Land-use and land-cover change." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: environmental Information Coalition, National Council for Science and the Environment). [First published July 17, 2006; Last revised January 31, 2007; Retrieved september 3, 2018]. http://ecotope.org/people/ellis/papers/ellis_eoe_lulcc_2007.pdf

ESRI. (2016). Natural breaks (Jenks). Available in: http://desktop.arcgis.com/es/arcmap/10.3/map/working-with-layers/classifying-numerical-fields-for-graduated-symbols.htm

Gamez Basten, V. (2002). La Idea de Cinturón Verde en el Planeamiento Urbano y Territorial. Universidad Central de Chile Facultad de Arquitectura, Urbanismo y Paisaje, Centro De Estudios C.E.A.U.P. Documento de Trabajo. Santiago, agosto de 2002. 22 p. http://ucentral.cl/fid/pdf/transformacion_paisaje_dt5.pdf

Gant, R.L., Robinson, G.M., & Fazal, S. (2011). Land-use change in the 'edgelands': Policies and pressures in London's rural–urban fringe. *Land Use Policy*, 28, 266-279

Gastélum Bajo, D.H., & Albores Gleason, R. (2015). Iniciativa con Proyecto de Decreto 2015 con la finalidad de incluir el fomento de los cinturones verdes. 11 de septiembre 2015. ,http://sil.gobernacion.gob.mx/Archivos/Documentos/2015/09/asun_3267252_20150911_1441896393.pdf

Gennaio, M.P., Hersperger, A.M., & Bürgi, M. (2009). Containing urban sprawl—Evaluating effectiveness of urban growth boundaries set by the Swiss. *Land Use Policy*, 26, 224–232. https://doi.org/10.1016/j.landusepol.2008.02.010

Gopinath, D., & Jackson, T. (2010). A Pragmatist Lens on Local Planning Practices: The Case of the St. Andrews Community-driven Green Belt. *Planning Practice and Research*, 25, 183-201. https://doi.org/10.1080/02697451003740197

GOBVER, (Gobierno del Estado de Veracruz de Ignacio de la Llave) (2002). Actualización del Programa de Ordenamiento Urbano de la Zona Conurbada de Xalapa, Banderilla, Coatepec, Emiliano Zapata y Tlalnelhuayocan, Xalapa de Enríquez, Veracruz, Primera Edición 2003, Derechos Reservados de Estado de Veracruz−Llave 22

Xalapa−Enríquez Veracruz, 674 pages, available at http://informacion.sedesmaver.gob.mx/transparencia/FraccionVII/Regionales/009_ActualProgOrdUrbXalBanEmZapTlal.pdf.

GOBVER (Gobierno del Estado de Veracruz de Ignacio de la Llave). (2011). Ley número 241 de Desarrollo Urbano, Ordenamiento Territorial y Vivienda para el Estado de Veracruz. Gaceta Oficial 109. Tomo: CLXXXIII. Xalapa, Veracruz. Available at http://www.invivienda.gob.mx/Portals/0/LEY%20DE%20DESARROLLO%20URBANO2011.pdf

GOBVER (Gobierno del Estado de Veracruz de Ignacio de la Llave). (2015). Archipiélago de Bosques y Selvas de la Región Capital del Estado de Veracruz. Decreto por el que se declara área natural protegida en la categoría de corredor biológico multifuncional y se denomina Archipiélago de bosques y selvas de la región capital del estado de Veracruz, un total de 7 polígonos ubicados en la zona establecida como Reserva Ecológica Restrictiva en la Actualización del Programa de Ordenamiento Urbano de la Zona Conurbada Xalapa-Banderilla-Coatepec-Emiliano Zapata-Tlalnelhuayocan. Gaceta Oficial. Órgano de Gobierno del Estado de Veracruz de Ignacio de la Llave. Tomo CXCI, Xalapa de Enríquez, Ver. Lunes 5 de 2015. Núm. Ext. 006. http://www.custodiosanpxalapa.org/ju-download/2-marco-legal/1-decreto-anp-archipielago-gaceta

GOBVER (Gobierno del Estado de Veracruz de Ignacio de la Llave). (2018). Programa de Ordenamiento Ecológico Territorial de la región capital de Xalapa, POETX Xalapa. Gaceta Oficial. Órgano de Gobierno del Estado de Veracruz de Ignacio de la Llave. Tomo CXCVII, Xalapa de Enríquez, Ver. Viernes 27 de abril de 2018. Núm. Ext. 23

170. Corresponde al Tomo I: Gac2018-170 viernes 27 TOMO I Ext.pdf http://www.veracruz.gob.mx/gobiernover/gaceta-oficial/.

Hernández-Huerta, A., Pérez-Maqueo, O., & Equihua, M. (2018). ¿Puede el desarrollo ser sostenible, integral y coherente?. *Regions and Cohesion* 8 (3), forthcoming December 2018.

INEGI. (2015a). Cuéntame. Available at http://cuentame.inegi.org.mx/monografias/informacion/ver/poblacion/

INEGI. (2015b). Polígonos de Localidades Urbanas Geoestadísticas. Marco Geoestadístico 2014. Versión 6.2. Instituto Nacional de Estadística y Geografía. Aguascalientes México.

INEGI. (2016). Población, Hogares y Vivienda. Cuadro Resumen Indicadores de demografía y población. Available at http://www3.inegi.org.mx/sistemas/temas/default.aspx?s=est&c=17484

Ignatieva, M., Stewart, G., & Meurk, C. (2008). Low impact urban design and development (LIUDD): matching urban design and urban ecology. *Landsc Rev*, 12, 60–73. URI https://hdl.handle.net/10182/617

Ignatieva, M., Stewart, G.H., & Meurk, C. (2011). Planning and design of ecological networks in urban areas. Landscape Ecol Eng, 7, 17–25 DOI 10.1007/s11355-010-0143-y

James, P., Banay, R.F., Hart, J.E., & Laden, F. (2015). A Review of the Health Benefits of Greenness. *Curr Epidemiol Rep*, 2, 131–142. DOI 10.1007/s40471-015-0043-7

Keil, R., & Macdonald, S. (2017). Rethinking urban political ecology from the outside in: greenbelts and boundaries in the post-suburban city. Local Environment. The 24

International Journal of Justice and Sustainability 21(12), 1516-1533. https://doi.org/10.1080/13549839.2016.1145642

Konijnendijk, C.C. (2010). The Role of Forestry in the Development and Reform of Green Belts. In: Konijnendijk C (ed) The role of forestry in the development and reform of greenbelts. *Planning Practice and Research*, 25, 241–254.

Laruelle, N., & Legenne, C. (2008). The Paris-Ile-de-France Ceinture Verde. In: Amati, M. (ed) Urban Green Belts in the Twenty-first Century. Ashgate Publishing, Ltd. England pp. 227-241. Available at https://books.google.com.mx/books?id=m4-KJwgaKHQC&pg=PA19&dq=green+belt+city+&lr=&hl=es&source=gbs_toc_r&cad=3#v=onepage&q=green%20belt%20city&f=false

Lucey, N. (1973). "The Effect of Sir Ebenezer Howard and the Garden City Movement on Twentieth Century Town Planning". https://www.rickmansworthherts.com/howard1.htm

Maathai, W. (2008). Movimiento Cinturón Verde. Compartiendo propuestas y experiencia. LA CATARATA, Madrid España. 176 pp. ISBN 10: 8483193515. http://www.greenbeltmovement.org/

Madureira, H., Andresen, T., & Monteiro, A. (2011). Green structure and planning evolution in Porto. *Urban Forestry & Urban Greening*, 10, 141–149 https://doi.org/10.1016/j.ufug.2010.12.004

Morrison, N. (2010). A Green Belt under Pressure: The Case of Cambridge, England. *Planning Practice & Research*, 25, 157-181. https://doi.org/10.1080/02697451003740189North, P. (2012). Preface. In: Amati M

(ed) Urban Green Belts in the Twenty-first Century. Ashgate Publishing, Ltd.UK 268 páginas. 28/11/2012.

North, P. (2012). Prefase. In Amati, M. (Editor) Urban Green Belts in the Twenty-first Century. Ashgate Publishing, Ltd., 268 páginas. 28/11/2012

Ortega-Escalona, F., & Castillo-Campos, G. (1996). El bosque mesófilo de montaña y su importancia forestal. *Ciencias*, 43, 32-39.

Ortiz-Ceballos, G. (2004). El Agroecosistema Café: Crisis de Mercado y Sustentabilidad, Tesis de Doctorado en Ciencias, Programa de Agroecosistemas Tropicales, Colegio de Posgraduados, Campus Veracruz, México.

ONU-HABITAT. (2012). DE AMÉRICA LATINA Y EL CARIBE 2012 ESTADO DE LAS CIUDADES: Rumbo a una nueva transición urbana. HS/053/12S ISBN Serie 978-92-1-133397-8 ISBN Volumen 978-92-1-132469-3 habitat.publications@unhabitat.org

ONU-HABITAT. (2016). 2016 INFORME FINAL MUNICIPAL. XALAPA Veracruz, México. ÍNDICE BÁSICO DE LAS CIUDADES PRÓSPERAS CITY PROSPERITY INDEX, CP. Ciudad de México, México. http://cpi.unhabitat.org/sites/default/files/resources/VER_Xalapa.pdf

Pathak, V., Tripathi, B.D., & Mishra, V.K. (2011). Evaluation of Anticipated Performance Index of some tree species for green belt development to mitigate traffic generated noise. *Urban Forestry & Urban Greening*, 10, 61–66. https://doi.org/10.1016/j.ufug.2010.06.008

Perfecto, I., Rice, R., Greenburg, R., & Van der Voort, M.E. (1996). Shade coffee: a disappearing refuge for biodiversity. *Bioscience*, 46, 598-608.

Peschardta, K., Schipperijnb, J., & Stigsdottera, U. (2012). “Use of Small Public Urban Green Spaces (SPUGS)”, Urban Forestry & Urban Greening, Volume 11(3), 235–244.

Pineda-López, M del R., Ortiz-Ceballos, G., & Sánchez-Velásquez, L.R. (2005). Los cafetales y su papel en la captura de carbono: un servicio ambiental aún no valorado en Veracruz. *Madera y Bosques*, 11, 3−14. https://doi.org/10.21829/myb.2005.1121253

Pollock, J. & López Silva, M. (Coordinadores) (2014). Capítulo II. La densificación urbana en contexto. En México Compacto Las condiciones para la densificación urbana inteligente en México. Cámara de Senadores del H. Congreso de la Unión-Fundación para la Implementación, Diseño, Evaluación y Análisis de Políticas Públicas, A.C.-SIMO Consulting. ONU HABITAT. http://fundacionidea.org.mx/assets/files/MexicoCompacto_Senado_IDEA_SIMO.pdf

Reyes-Díaz, K. de la Paz. (2010). Urge un “cinturón verde” para impedir avance de mancha urbana / MIÉRCOLES, MAYO 19, 2010. La Jornada Veracruz.

Rzedowski, J. (1993). Diversity and origins of the phanerogamic flora of Mexico. In: Ramamoorthy, T.P., Bye. R., Lot, A., & Fa. J. (Ed.) Biological Diversity of Mexico: Origins and Distribution. Oxford University Press, New York. pp. 129–144

Rowe, J.E. (2012). Auckland’s Urban Containment Dilemma: The case for Green Belts. *Urban Policy and Research*, 30, 77-91. https://doi.org/10.1080/08111146.2012.654757

Saunders, D.A., Arnold, G.W., Burbidge, A.A., & Hopkins, A.J.M. (1987). The role of remnants of native vegetation in nature conservation: Future Directions. In: Saunders D.A., Arnold, G.W., Burbidge, A.A., & Hopkins, A.J.M. (eds.) Nature Conservation: The role of remnants of native vegetation. Chapter 52. Surrey Beatty in association with CSIRO and CALM, Chipping Norton, NSW Australia. pp. 387-392.

Schteingart, M., & Salazar, C. (2003). Expansión urbana, protección ambiental y actores sociales en la Ciudad de México. *Estudios Demográficos y Urbanos* 18, 433-460.SEGOB (Secretaria de Gobernación). (2013). Programa Sectorial de Desarrollo Agrario, Territorial y Urbano 2013 – 2018. Diario Oficial de la Federación. México. DOF: 20/05/2013. Available at http://www.dof.gob.mx/nota_detalle.php?codigo=5326473&fecha=16/12/2013

Sharma, B., Sandeep Sharma, S.x., Bhardwaj, S.K., Kaur, L., & Sharma, A. (2017). Evaluation of Air Pollution Tolerance Index (APTI) as a tool to monitor pollution and green belt development: A review. Journal of Applied and Natural Science 9(3), 1637-1643. https://doi.org/10.31018/jans.v9i3.1414

Suárez Guerrero, A.I., & Equihua, M. (2009). Rehabilitación de algunas propiedades químicas de los suelos y del bosque de niebla en Veracruz, México con ensambles experimentales de leñosas nativas y *Casuarina equisetifolia* L, Amoen. *Interciencia*, 34, 471-478.

Tang, B., Wong, S., & Lee, A.K. (2007). Green belt in a compact city: A zone for conservation or transition? *Landscape and Urban Planning* 79, 358-373. https://doi.org/10.1016/j.landurbplan.2006.04.006

UNDP (United Nations Development Programme). (2018). Goal 11: Sustainable cities and communities. http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-11-sustainable-cities-and-communities.html

URBAN-HUB. (2017). Discussing the urban green belt – how much nature does a city need? Published 11-12-2017. http://www.urban-hub.com/urbanization/do-green-belts-make-cities-more-livable-or-costly/

Vargas, R. (2014). Historia de un Árbol: Miguel Ángel de Quevedo. Asociación Mexicana de Arboricultura, México, D.F. 2014, Segunda Época Año 1 No 7. Available at http://www.arboricultura.org.mx/2014/09/historia-de-un-arbol/

Ward-Thompson, C.W. (2002). Urban open space in the 21st century. *Landscape and Urban Planning* 60(2), 59–72. https://doi.org/10.1016/S0169-2046(02)00059-2

Williams-Linera, G, Guillén Servent, A., Gómez García, O., & Lorea Hernández, F. (2007). Conservación en el centro de Veracruz, México. El Bosque de Niebla: ¿Reserva Archipiélago o Corredor Biológico? En: Halffter G, Guevara S, A Melic (eds.). Hacia una cultura de la conservación de la diversidad biológica. *m3m*-Monografías Tercer Milenio, Vol 6. S.E.A. Zaragoza, España. ISBN 978-84-935872-0-8. pp. 303-310.

Williams-Linera, G., Lopez-Barrera, F., & Bonilla-Moheno, M. (2015). Estableciendo la línea de base para la restauración del bosque de niebla en un paisaje periurbano. *Madera y Bosques*, 21, 89-101.

Whittick, A. (1974). Encyclopedia of Urban Planning. New York: McGraw-Hill.

Yanga, J., & Jinxing, X. (2007). The failure and success of greenbelt program in Beijing. *Urban Forestry & Urban Greening*, 6, 287–296. https://doi.org/10.1016/j.ufug.2007.02.001

Zentella-Gómez, J.C. (2005), Intermunicipales y gobernabilidad urbana en zonas metropolitanas en México. El caso de la Zona Metropolitana de Xalapa. *Estudios Demográficos y Urbanos* 20(2), 229−267.

Žlender, V., & Ward Thompson, C. (2017). Accessibility and use of peri-urban green space for inner-city dwellers: A comparative study. *Landscape and Urban Planning*, 165, 193-205. https://doi.org/10.1016/j.landurbplan.2016.06.011