

# Current perspectives on forest recovery trends in Guanacaste, Costa Rica

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## SUMMARY

The main goal of this study was to evaluate whether the trends in the recovery of forest cover in Guanacaste continued during the past decade and to evaluate if the socioeconomic drivers of recovery have been altered. Our analysis found that forest cover in Guanacaste province increased marginally from 48.14% in 2005 to 50.74% in 2012. This implies that the forest recovery process during this period has continued but with a much smaller pace, showing signs of stagnation. The province landscape has changed since the 1970s, when it was dominated by livestock ranching and was the most deforested province with only 23.6% of forest cover. Today Guanacaste is a good example of an economic development forest transition region, with a matrix of land use that is dominated by new forests in different successional stages, which has resulted in great benefits to society given the ecosystem services that this landscape provides.

Keywords: tropical deforestation, tropical dry forest, forest transition, land use change, secondary forest

## Perspectives actuelles sur les courants de régénération des forêts au Guanacaste, Costa-Rica

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Le principal but de cette étude a été d'évaluer si les courants de régénération du couvert forestier au Guanacaste s'étaient poursuivis au cours de cette dernière décennie, et d'observer si les conducteurs socio-économiques de cette régénération avaient été altérés. Notre analyse montre que le couvert forestier dans la province du Guanacaste s'est marginalement accru de 48.14% en 2005 à 50.74% en 2012. Ceci implique que le processus de rétablissement de la forêt a continué au cours de la décennie, mais à bien petit pas, révélant des signes de stagnation. Le paysage de la province a changé depuis les années 1970, quand il était dominé par des ranchs de bétail et était la province la plus déboisée, avec seulement 23.6% de couvert forestier. Aujourd'hui, le Guanacaste est un bon exemple d'une région de transition dans le domaine du développement économique de la forêt, avec une matrice d'usage de la terre dominé par les forêts nouvelles à différents stades d'étapes successives, ayant résulté en de grands bénéfices pour la société, étant donné les services d'écosystème que ce paysage offre.

## Perspectivas actuales sobre las tendencias de recuperación forestal en Guanacaste, Costa Rica

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El objetivo principal de este estudio fue evaluar si las tendencias en la recuperación de la cubierta forestal en Guanacaste continuaron durante la última década y evaluar si los impulsores socioeconómicos de la recuperación han sido alterados. Nuestro análisis encontró que la cobertura forestal en la provincia de Guanacaste aumentó marginalmente de 48.14% en 2005 a 50.74% en 2012. Esto implica que el proceso de recuperación forestal durante este período ha continuado pero a un ritmo mucho menor, mostrando signos de estancamiento. El paisaje de la provincia ha cambiado desde la década de 1970, cuando estaba dominado por la ganadería y era la provincia más deforestada con solo el 23.6% de la cubierta forestal. Hoy, Guanacaste es un buen ejemplo de una región de transición forestal de desarrollo económico, con una matriz de uso de la tierra que está dominada por nuevos bosques en diferentes etapas sucesionales, lo que ha resultado en grandes beneficios para la sociedad dados los servicios ecosistémicos que brinda este paisaje.

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## INTRODUCTION

Due to a severe economic crisis, population growth and agrarian policies, during the 1970s and 1980s, Costa Rica (51,100 km<sup>2</sup>) reported alarming annual deforestation trends nationwide (Calvo, 1990, Sader and Joyce, 1988, Myers, 1981). Later, more accurate studies found that the estimated annual deforestation rates were 0.68% for 1960–1979 and 0.89% for 1979–1986. After this period, Costa Rica began a process of forest recovery that allowed it to achieve an annual recovery rate of 0.39% for 1986–2005 (Sánchez-Azofeifa *et al.* 2006, 2002, Quesada *et al.* 1998). More remarkable were the forest cover changes reported for the Guanacaste province during the same periods. According to a detailed analysis of changes in forest cover for this province (Calvo-Alvarado *et al.* 2009), three main findings must be highlighted, first, forest cover decreased from 37.8% to 23.6% for the period 1960–1979, with an annual deforestation rate of 0.74%, higher than the national figure of 0.68%; secondly, a deforestation rate of 0.1% during the period of 1979–1986, extremely low when compared to the national figure of 0.89% for the period 1979–1986 and last; forest cover increased from 23.6% to 47.0% for the period 1986–2005, corresponding to an outstanding annual recovery rate of + 1.26%; more than three times the national annual recovery rate of only 0.39%.

The changes between the trends in deforestation and recovery in Guanacaste and in Costa Rica in general, were in part the result of a combination of factors associated with socioeconomic structural changes and the impacts of novel conservation and environmental management policies that were launched at the end of the 1970s. Among the most important policies were the massive establishment of national parks and protected areas since the 1970's, the approval of environmental legislation including the Forestry Law 7575 in 1997, in which changes in forest cover were prohibited, and the establishment of the Program of Payment for Environmental Services, among other innovative measures. Many authors considered that these public conservation policies were reinforced by concurrent changes in the socioeconomic structure that took place in the country, such as the increase use of irrigation and mechanization for agriculture, the decline of cattle ranching due to low international beef prices and the exponential growth of tourism industry (Garvin *et al.* 2015, Calvo-Alvarado *et al.* 2009, Castillo *et al.* 2013, Jadin *et al.* 2016).

This extraordinary forest recovery is a good example of the land-use transition concept (Lambin *et al.* 2003, Wilson *et al.* 2017), defined as a period of intensified land use change caused by dramatic and interrelated changes in the structure of a society. These changes alters the economic opportunities and restrictions that exist for landholders by considering the relative costs and benefits of alternative land uses. According to Calvo-Alvarado *et al.* (2009) and Garvin *et al.* (2015), during the last decades Guanacaste became more populated but more urbanized, the standard of living increased and tourism industry created more employment opportunities for workers. This context encouraged the

intensification of agriculture and cattle ranching in the best land units and the abandoning of less productive land units for natural forest regrowth.

Nevertheless, according to Lambin *et al.* (2003), there is no reason to believe deforestation will not occur in the next decades, if further structural changes occur to create new opportunities for regressive land use change. Hence, there are always reasons to doubt over the sustainability of current conservation policies to protect the existing secondary and late forest cover extend. By having understood the socioeconomic factors that helped triggered forest cover recovery in Guanacaste, Calvo-Alvarado *et al.* (2009) urged to monitor two drivers that have the potential to promote forest conversion in Guanacaste. The first driver is the increase of international beef price that could make again profitable the cattle farming on marginal land units and the second one is the potential expansion of agribusinesses by introducing of new crops adapted to hilly terrains and dry conditions.

In this context, the goal of this study was to evaluate whether the trend in the recovery of forest cover has been maintained during the past decade and if the drivers of forest recovery have altered to endanger the sustainability of forest recovery.

## MATERIALS AND METHODS

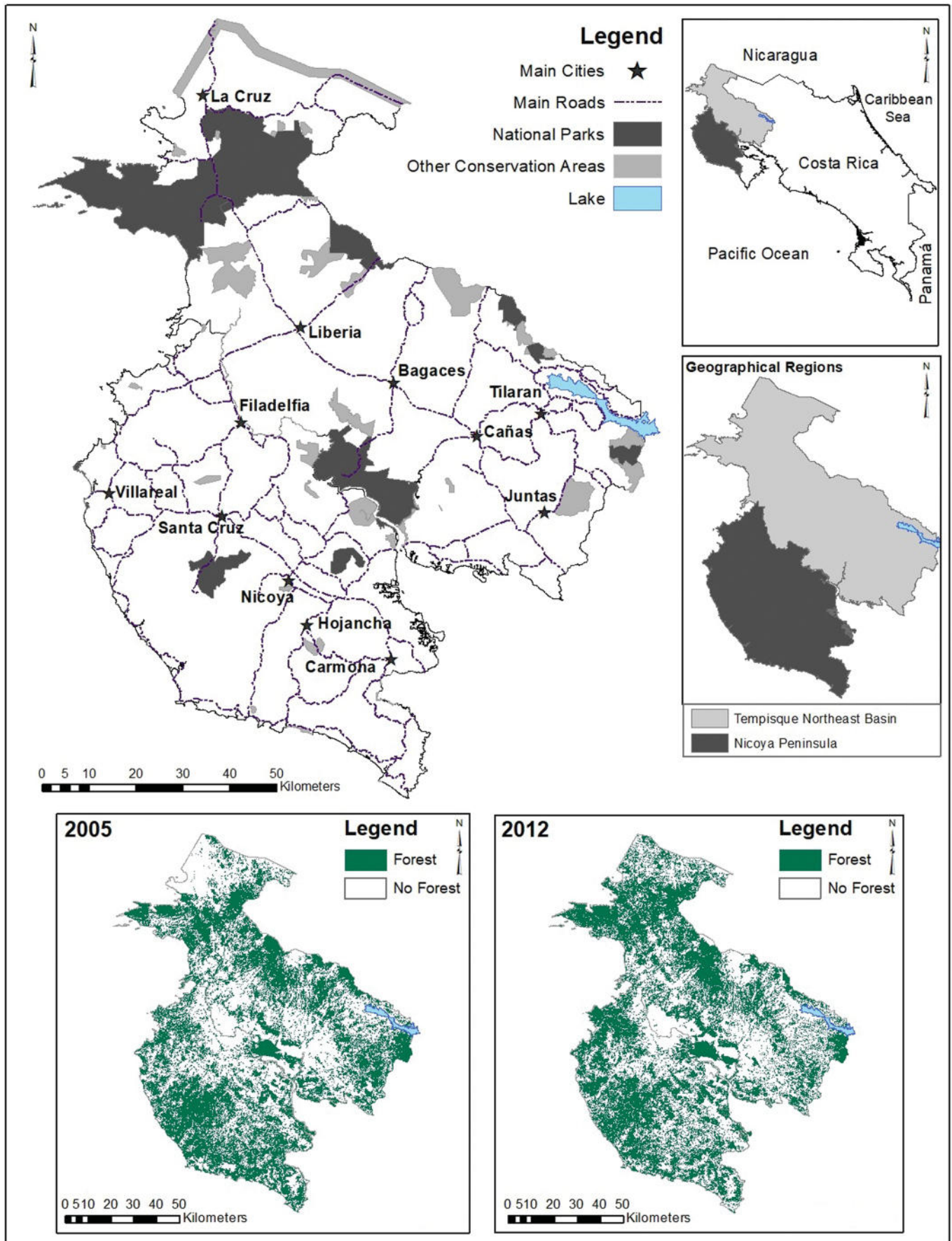
### Study area

The province of Guanacaste is located in the northwest of Costa Rica (Fig. 1). It includes 10,140 km<sup>2</sup>, and for this study it is divided into two geographic regions: the Nicoya Peninsula (3,935 km<sup>2</sup>) and the Northeast Tempisque Basin (6,206 km<sup>2</sup>). The Nicoya Peninsula is characterized by a mixture of Dry and Humid Tropical Life Zones (Holdridge 1967, Bolaños and Watson 1993). The Nicoya Peninsula has steep terrain dominated by soils that are not suitable for mechanized and irrigated agriculture and, as a result, this region is dominated mainly by medium and small farms (Jiménez and González, 2001). On the contrary, the Northeast Basin of Tempisque is a flat area of alluvial lowlands that ascend to the Guanacaste Volcanic Mountain Range. It is predominantly a tropical dry zone and has more fertile fluvial and volcanic soils than the Nicoya Peninsula. The Northeast Basin of Tempisque contains most of the protected land (Fig. 1) and is dominated by large farms or agribusiness companies in the floodplains or by medium-sized dairy or double purpose cattle farms along the most humid slopes of the Volcanic Mountain Range of Guanacaste.

### Methodology

To evaluate the trend in the recovery of forest cover in Guanacaste a GIS analysis was conducted using the forest cover layer from 2005 and the last official layer for 2012. This analysis generated data on the forest cover change at the level of province, region, national parks, and private lands. The

FIGURE 1 Map of Guanacaste Province, geographical regions, protected areas, and generalized forest cover maps for 2005 and 2012



last step was to update the information on the main socio-economic factors that were associated with the dynamics of changes in forest cover in Guanacaste during the last decades.

### GIS analysis

The forest cover layers from 2005 and 2012 were obtained from the website of the National Information Centre for Forest Resources of the Ministry of the Environment (SINAC, 2015). These two layers are considered official maps and are used for legal purposes by the government. The 2005 layer was developed by a study of Sanchez-Azofeifa *et al.* (2006), which continued a sequence of analysis carried out between 1986 and 2002 using the same methodology (Quesada *et al.* 1998 and Sanchez *et al.* 2002). In general, these studies were based on the analysis of seven LandSat T.M images with a mapping resolution of 3 ha.

The 2012 forest cover layer was developed by the National Forest Inventory (SINAC, 2014) with a mapping resolution of 1 ha. Given the fact that the 2005 layer had a resolution of 3 ha and that the 2012 layer had a resolution of 1 ha and three forest cover classes, we normalized the GIS analysis by grouping the three forest classes into one forest class and by removing all forest polygons smaller than 3 ha from the 2012 layer. It is also important to underline that because the two used forest cover layers (2005 and 2012) were based on different remote sensing satellites (LandSat vs. RapidEye) and different resolution levels (3 ha compared to 1 ha), this study only focussed to analyse global net changes in percentage of forest cover area. Therefore, our study was not intended to determine the loss or gain of forest cover at the pixel level.

### Socioeconomic data

The socioeconomic information was collected from the General Direction of Immigration and Foreigners (DGME), National Institute of Statistics and Census (INEC), MAG (Ministry of Agriculture and Animal breeding), MEIC (Ministry of Economy, Industry and Commerce), Costa Rica Foreign Trade Corporation (PROCOMER), Information System of Forest Resources (SIREFOR), National Cattle Census (CORFOGA), the National System of Conservation Areas (SINAC), and the International Commodity Prices data base from the World Bank.

## RESULTS AND DISCUSSION

### Land cover in Guanacaste province for 2012

In 2012, the province attained 50.74% forest cover; the Nicoya Peninsula and the Tempisque Northeastern Basin had 54.03% and 48.54% forest cover, respectively (Table 1). These figures are marginally higher than the figures reported for 2005, which indicates that forest recovery trend has reach stability during the last years at the provincial and regional levels.

### Forest cover in protected areas and private lands for 2012

Guanacaste has 16% (1 631.22 km<sup>2</sup>) of its provincial territory under forest protection; this includes nine national parks (1 106 km<sup>2</sup>) and other protected units (524 km<sup>2</sup>). The most extensive national parks are the Guanacaste National Park and the Santa Rosa National Park, totalling 725 km<sup>2</sup>, which represent 7% of the provincial territory and 66% of the entire protected area of the province. This demonstrates the outstanding conservation efforts that were made since the 1970s to reduce the degradation of dry tropical forests. For 2012, protected areas reached 71% of forest cover, which is significantly larger than the forest cover detected of 62.6% for 2005 (Table 1). On the other hand, private lands represent 84% of the Guanacaste area. As expected, private lands led to very small changes in the percentage of forest recovery, 45.4% (2005) vs 46.6% (2012), reflecting a stagnation in the trend of forest cover recovery in private lands.

### Socio-economic context of forest cover recovery in Guanacaste

Following is an update of the most relevant factors discussed previously by Calvo-Alvarado *et al.* (2009 b).

According to INEC (2018), the size of the labour force in Guanacaste in the agricultural sector continued to fall from 28% of employment in 2000 to 17.8% in 2011. This decrease in the work force in the agricultural sector leads to the conclusion that the economy of the province continued to shift to other economic sectors more related to trade, tourism, and

TABLE 1 Forest cover as a percentage of land area and annual recovery rates by province, regions, conservation areas and private lands in Guanacaste, Costa Rica

Categories	Total Land Area Km <sup>2</sup>	% Forest Cover 2005	% Forest Cover 2012
Guanacaste Province	1 0157.50	48.14	50.74
Nicoya Peninsula	4 061.60	53.33	54.03
Tempisque Northeast Basin	6 095.90	44.69	48.54
Conservation Areas	1 631.22	62.63	71.02
Private Lands	8 526.59	45.4	46.6
Nicoya Peninsula	3 896.41	52.8	53.3
Tempisque Northeast Basin	4 630.17	39.1	40.9

services. Proof of this is that these last sectors (trade, tourism, and services) increased from 22% of the labour force in 2000 to 27.2% in 2011.

Moreover, the population of Guanacaste increased dramatically (24%), from 264 238 people in 2000 to 326 953 in 2011 (INEC, 2018). In 2000, the labour force in the province constituted 27% of the population, but in 2011 this figure increased to 34% (INEC, 2018). Regardless of this recent demographic explosion and the economic development, there was no not major negative impacts on the conservation of forest cover.

Data from the General Direction of Migration and Foreign (DGME, 2018 a, b) indicates that Costa Rica reported 1 679.051 international visitors (air, land, sea) in 2005, a figure that increased to 2 343 213 in 2012, which equals almost to a 40% increment during this short period (8 yrs.). Just in the case of Guanacaste 158 366 people visited this province through the Daniel Oduber Airport at Liberia (Capital City of Guanacaste), in 2005. Eight years later (2012) the number of arrivals doubled (333 472 visits). In addition, two major infrastructure projects have also boosted tourism in Guanacaste since 2005; these projects include the construction of La Amistad Bridge over the Tempisque River in 2003 and the San José – Caldera highway in 2010.

Finally the Program for Payment for Environmental Services (PES), continue with its mission to encourage forest conservation with good results. By 2015, this program covered a total of 55 464 ha in the province under its different modalities: 31 000 ha under natural forest protection, 9 000 ha under forest plantations, and more than 5 000 ha under recovery of secondary forests (FONAFIFO 2018). As stated previously, PES was only one factor behind the recovery of forest cover in Guanacaste (Calvo-Alvarado *et al.* 2009, Garvin *et al.* 2015).

### Treats of sustainability of forest recovery

Next, we analyse the evolution of two socioeconomic factors mentioned in the introduction as possible threats to the sustainability of forest recovery in Guanacaste.

#### *a) Reactivation of livestock farming because of an increase in international beef prices.*

Given the notable decrease in livestock activity, due to the fall in international beef prices after 1975, a significant increase

in international prices could reactivate the livestock industry in Guanacaste, which would cause deforestation of the marginal lands already recovered by natural succession. The forecast of an increase in international meat prices was confirmed when the average price of US \$ 2.55 / kg between 1997–2005 drastically changed to an accelerated price increase trend between US \$ 2.83 / kg in 2006 to US \$ 4.14. / kg in 2012 (World Bank, 2018). Regardless of this increase in the price of beef, there was a notable decrease in livestock indicators at the national level, such as the size of the herd, the number of farms and the pasture area (Table 2).

Therefore, despite the fact that there was a very significant increment in international beef prices, livestock raising did not increase in Guanacaste and forest conversion into pasture land did not materialize as expected. That is, farmers have preferred to stabilize the landscape by obeying the forestry law, by leaving the less productive land units for forest recovery and by intensifying best management practices on existing cattle land instead.

#### *b) Expansion of agribusiness and the introduction of new crops for production of biofuels.*

According to the USA Energy Information Administration (2018), in 1980 there was a peak in the international price (real price) of oil (US \$ 120 / barrel), then there was a sustained decrease until 1986 (US \$ 35 / barrel) followed by a price fluctuation of  $\pm$  US \$ 5 until reaching the lowest value (US \$ 21 / barrel) in October 1998. After 1998, the international price of oil showed a sustained increase until it attained the highest value in the history of US \$ 160 / barrel in June 2008, which caused a severe global energy crisis. During 2008–2014, oil prices maintained an average above US \$ 100 / barrel but after 2014, the average price decreased and since then remained between US \$ 40–\$60 /barrel until 2012.

The high international price of oil after 2008, triggered a great interest by the government and the private sectors, to promote the production of biofuels in Costa Rica. Among the discussed alternatives were to increase the cultivation of sugarcane (*Saccharum officinarum* L.) for gasohol production and to introduce new crops, such as *Ricinus communis* L. (Castorbean) and *Jatropha curcas* L. (Physic Nut), for the production of biodiesel. The potential expansion of these crops, which included sugarcane in the flat lands of the Tempisque Northeast Region and oil producing plants in the

TABLE 2 Comparative data for cattle raising for Costa Rica for years 1984, 2000 and 2014 (CORFORGA 2015, INEC 2015)

Variable	1984	2000	2014
Total Heard (heads)	2 046 372	1 358 209	1 278 817
Number of farms	51 745	38 365	37 171
Total area (has)	1 651 560	1 349 628	1 044 909
<b>Herd distribution by production system</b>			
Meat	1 236 009	882 836	537 103
Meat+Milk	359 957	298 806	409 221
Milk	383 285	176 567	319 704

hillside lands of Nicoya Peninsula, represented a serious threat to the sustainability of forest cover. As indicated previously, the decrease in international oil prices during the last decade discouraged any interest in developing those proposals and, therefore, those threats have not materialized as yet as forest conversion drivers.

#### THE FOREST TRANSITION PERSPECTIVE FOR GUANACASTE PROVINCE

Costa Rica is a world example where net rates of recovery of forest cover exceed those of deforestation, resulting in a clear example of the forest transition concept. Recently Wilson *et al.* (2017) proposed a framework to analyse the social drivers and potential ecological outcomes of three pathways of forest transitions: tree plantation, spontaneous regeneration, and agroforestry. They concluded that, countries or regions, where economic growth creates new opportunities for work and education have as end results an increase in urbanization, agriculture intensification on most suitable lands and the abandonment of marginal lands for spontaneously forests recovery. They also concluded that all spontaneously regenerating forests enhance soil and watershed conservation, have higher biodiversity and biomass, but provide fewer provisioning and economically valuable services as the other two forest transitions pathways (forest plantations and agroforestry). These conclusions corresponds to the case of Costa Rica and more particularly to Guanacaste due to the remarkable magnitude of forest recovery and to the associated socioeconomic drivers. Consequently and according to the forest transitions typology proposed by Wilson *et al.* (2017), Guanacaste followed the path of a classical economic development forest transition case.

In the case of the Province of Guanacaste, three additional socioeconomic drivers must be recognized such as the establishment of a large network of protected areas early 1970's, the emergence of a strong tourism industry and the decrease in the international beef prices after 1980. These factors undoubtedly have been the most important drivers in the forest recovery of Guanacaste. However, to explain how and why the so positive and accelerated recovery of Costa Rica's forests, particularly for the most deforested province in the country, is not an easy task. Garvin *et al.* (2015) developed a more elaborate study to understand the forest transition pathways that occurred, this included a historical analysis of the evolution of the economic and social development, the legal and political framework of conservation/forestry sector and the promotion of scientific research. In summary, the case of Costa Rica, must be treated as exceptional, due to the complex alignment of many factors and circumstances, which have taken place well in advance to create favourable conditions for an outstanding forest recovery.

#### CONCLUSIONS

The main goal of this study was to evaluate whether the trends in the recovery of forest cover in Guanacaste continued

during the past decade and to evaluate if the socioeconomic drivers of recovery have been altered. Our analysis found that forest cover in Guanacaste province increased marginally from 48.14% in 2005 to 50.74% in 2012. This implies that the forest cover recovery process during the period 2005–2012 has continued but with a much smaller pace when compared to previous period, showing signs of forest cover recovery stagnation.

The province landscape has change significantly since the 1970s, when it was dominated by livestock ranching and was the most deforested province in Costa Rica with only 23.6% of forest cover. Today Guanacaste is a good example of an economic development forest transition region, with a matrix of land use that is dominated by new forests in different successional stages, which has resulted in great benefits to society given the ecosystem services that this landscape provides.

A myriad of factors have promoted the recovery of forests in Guanacaste. Among the most important factors since the 1980s were the establishment of conservation areas, the fall in international beef prices, the intensification of agriculture, the introduction of best management practices in livestock farming, the boost of the tourism industry, the approval and implementation of novel laws and environmental policies. All of these driving forces of forest recovery remained in effect during the last decade, except for the international beef prices that have had increased substantially in recent years, but they did not trigger the reactivation of livestock raising in Guanacaste or in Costa Rica generally. This remarkable result demonstrated that farmers have mostly respected the forestry law, and that they value the benefits of stabilizing the landscape by leaving the less productive land units for forest recovery and intensifying best management practices on suitable land for agriculture or cattle raising. In summary, the case of Costa Rica, must be treated as exceptional, due to the complex alignment of many factors and circumstances, which have taken place well in advance to create favourable conditions for an outstanding forest recovery.

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