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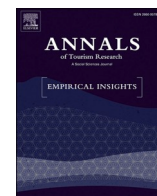
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Anthropization in buffer zones of protected areas

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1. Introduction

Worldwide, protected areas represent one of the main attractions for national and international visitors (Bushell, 2003). Since the end of the 20th century, tourism growth has created different pressures on natural spaces, mainly caused by changes in land use (Boavida-Portugal, Rocha, & Ferreira, 2016). The modification of an ecosystem through anthropogenic effects is known as anthropization (Martínez, 2010). One of the factors that enhances this problem is the attraction of the coastal territories for the sun and beach tourism (García-Ayllón, 2018). Through the increase in urbanized areas, greater traffic flow, consumption of natural resources, increased pollution, and pressure on natural spaces, beach and coastal tourism pose severe threats to the ecosystem (Kim, Lee, & Kim, 2019). Despite this well-known direct impact of tourism on the environment, when it is not clear what is driving the forces (pressures) or the interconnections between factors, anthropization is categorized as diffuse and is generally examined from a global or general perspective (Rova, Pranovi, & Müller, 2015).

In Costa Rica, the creation of Manuel Antonio National Park in 1972, combined with access facilities and the expansion of tourism investment in the buffer zone, has made this region one of the most visited in the country (Broadbent et al., 2012). In the case of famous tourist destinations, the literature coincides that excess visitation impact the environmental and social level (Burbano, Valdivieso, Izurieta, Meredith, &

Ferri, 2022).

There is a paradox because the national park was created to protect nature, but at the same time, it became a popular tourist attraction, which stimulated an unplanned tourism growth in the buffer zone, generating impacts through the negative land cover change on the biophysical environment (Koenig, Dieperink, & Miranda, 2009).

There is a research gap in examining the influence of popular protected areas on the anthropization of the surrounding landscape. This study aims to determine the changes in the landscape in the buffer zone of Manuel Antonio National Park through an anthropization index. The results are analyzed by considering visitors statistics to the protected area, location of the tourist infrastructure, and literature review.

2. Methodology

The study area comprises the North sector of the Manuel Antonio National Park buffer zone. The analysis covered thirty years period (by decade 1990, 2000, 2010, and 2020 to observe more notable changes in the anthropization dynamics). The decade of 1990 is considered the “boom” of tourism in Costa Rica and was considered as a good starting point. The impact on a landscape scale was conducted by determining the degree of anthropization using the Relative Integrated Anthropization Index. This conceptual and technical method was proposed by Martínez (2010) to study in a systematic way the anthropogenic

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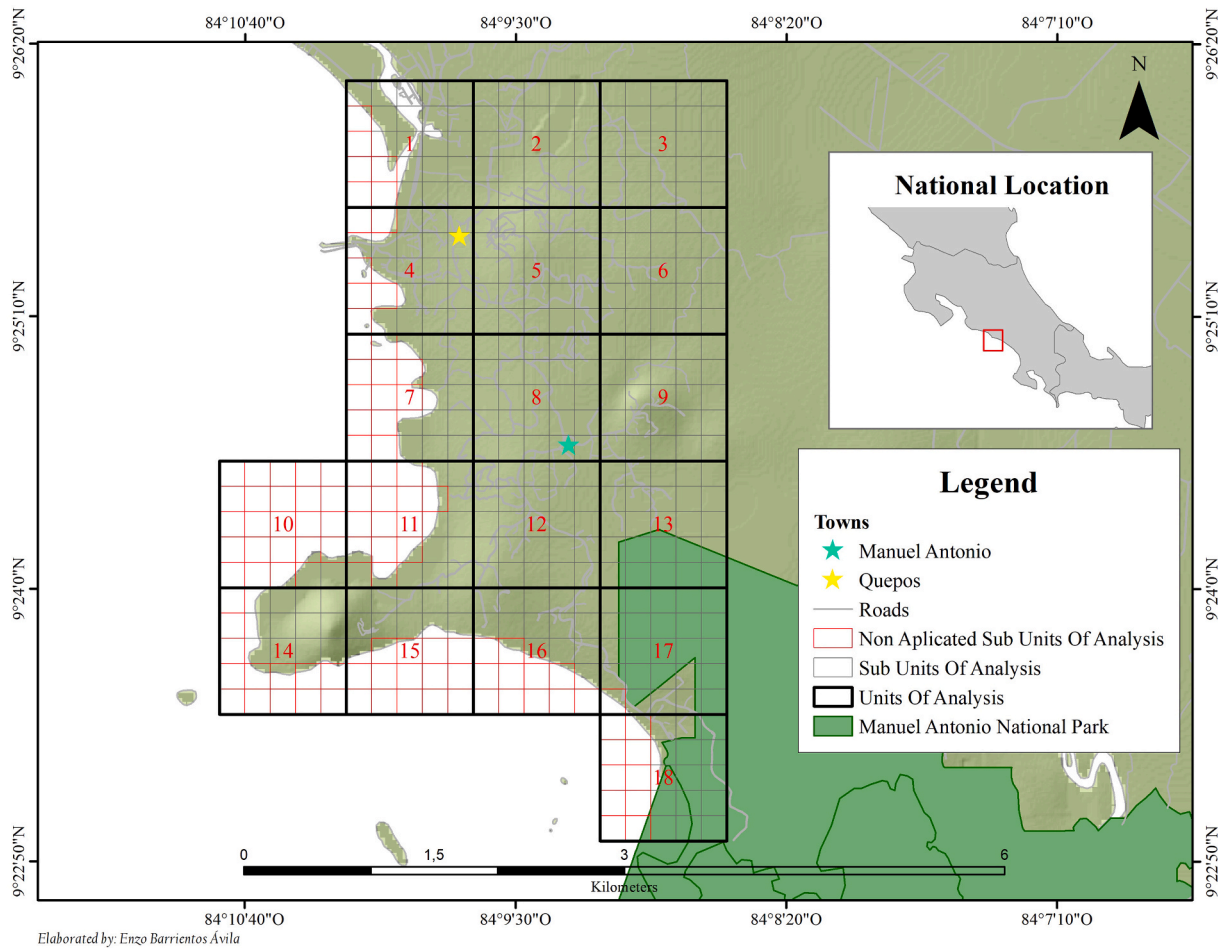


Fig. 1. Units and subunits of analysis in the buffer zone of Manuel Antonio National Park (Costa Rica).

modification of ecosystems at the landscape scale.

To apply this methodology, the study area was divided into 18 units of analysis of 1km². In turn, each unit was divided into 25 regular sub-units of analysis of 0.04 km² (Fig. 1). The land cover of each sub-unit was determined using Landsat 4, 5, and 8 satellite images through an unsupervised classification using the K-means method in ENVI 5.3. After that, a revision and reclassification of each subunit was performed using orthophotos, to obtain the following coverage categories: undisturbed coverage, crops, pastures, and urban areas. To each category a degree of anthropization value between 1 and 0 was assigned as follows: undisturbed coverage (value = 0), crops (value = 0.50), pastures (value = 0.75) and urban areas (value = 1). Once the anthropization values of each sub-unit of analysis have been determined, the relative degree of anthropization per unit of analysis is estimated through the following formula (Eq. (1)).

$$\text{Anthropization index} = \frac{\sum \text{Sub-units of analysis}}{n} \times 100 \quad (1)$$

Where:

Σ Sub-units of analysis = is the sum of the partial anthropization value of all the sub-units of analysis and n = numbers of sub-units of analysis. The interpretation of the results ranges from 0 to 100, where 0 represents null and 100 high anthropization in the respective unit of analysis.

The results of anthropization with the tourist use were related through the location of the tourist infrastructure for the year 2020, the determination of the annual visitation growth rate to the Manuel Antonio National Park, and a bibliographic analysis of 15 technical and scientific sources to support the results.

3. Results

One of the most relevant findings is that according to the units of analysis, comparison between the years 1990, 2000, 2010, and 2020 there was an increase in the anthropization index (52.63%), while only 31.57% showed some decrease (Fig. 2).

The existence of the National Park and its visitation levels motivated the establishment of a great number of tourist enterprises in the north-west sector of the buffer zone (SINAC (Sistema Nacional de Áreas de Conservación), 2013). According to the number of visitors to the protected area, increased in the '80s, the construction of hotels and restaurants begin to expand (Mundis, 1997). In 1988 the hotel capacity was 192 rooms, and in just three years it increased to 394 (ICT (Instituto Costarricense de Turismo), 1992). By 2010, 98 hotels and cabins were identified with a high percentage of foreign ownership (ICT (Instituto Costarricense de Turismo), 2010; Takeda, 2012). In 2015 the number of micros, small, and medium tourism companies installed in the area amounted to 173 (Cooprena, 2015). The annual visitation growth rate to the Manuel Antonio National Park between 1979 and 2019 is 1704.36%, and in the period under study (1990–2019) this growth reached 291.77%, becoming the most visited protected area in Costa Rica. These values are accompanied by a similar trend in the dynamics of anthropization (138% growth rate between 1990 and 2020) (Table 1).

The highest concentration of tourist infrastructure occurs mainly in those subunits of value = 1 and units with a high value of anthropization index. In 2020, 501 different types of tourism or vacation-related infrastructure were identified. There is a high concentration in UA number 12 (25.35%) and 8 (13.77%) conforming the biggest touristic

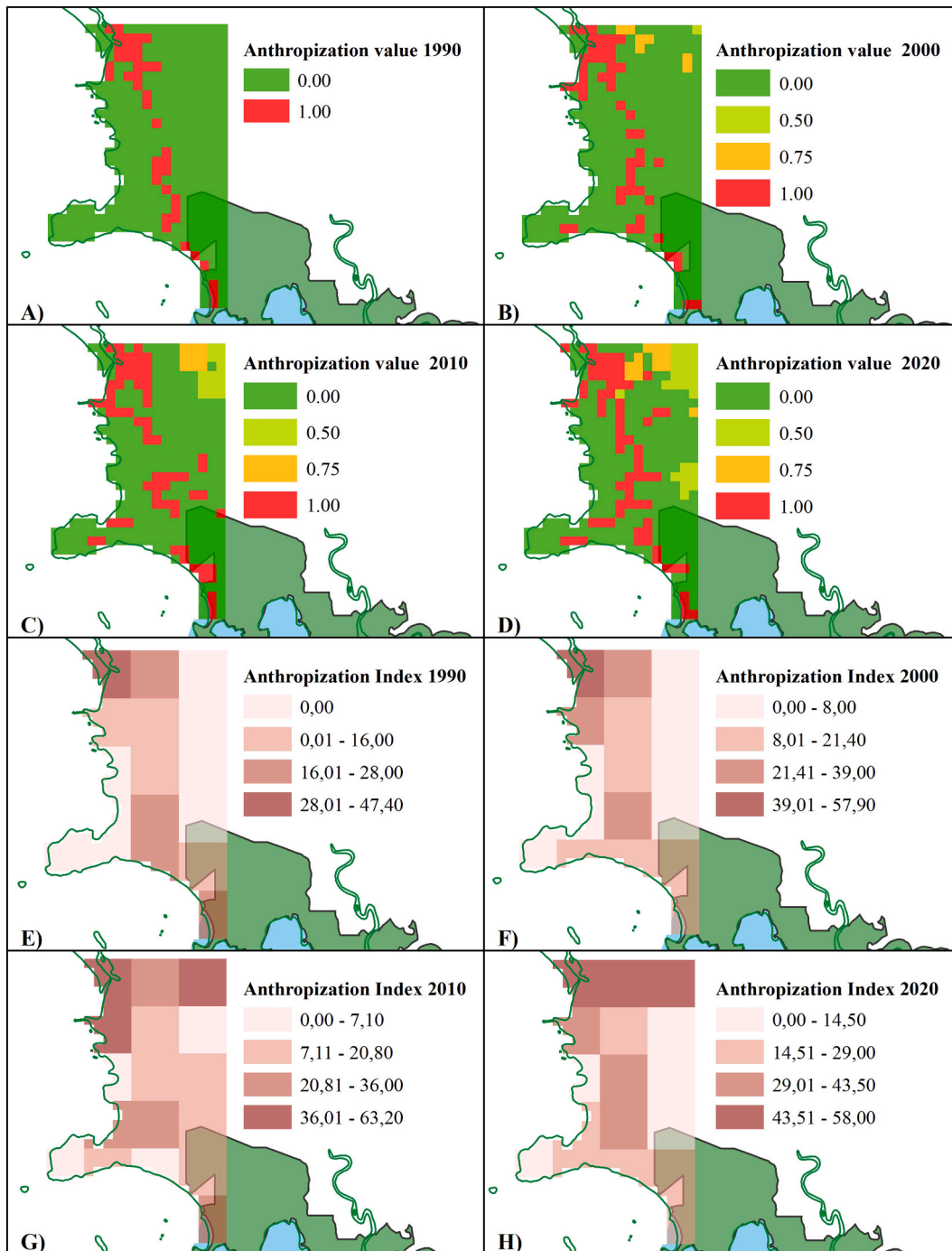


Fig. 2. Degree of anthropization and anthropization index in the buffer zone of Manuel Antonio National Park (1990, 2000, 2010, and 2020).

Table 1
Tourism and anthropization process (1990–2019).

Year	National Park entries	National Park entries growth rate (%)	Anthropization index (%) (mean)	Anthropization index growth rate (%)
1990	131,011		11.02	
1992	165,584	26.39		
1994	128,023	-22.68		
1996	104,807	-18.13		
1998	131,448	25.42		
2000	147,759	19.74	15.37	39.47
2002	167,034	13.04		
2004	166,189	-0.51		
2006	229,461	38.07		
2008	307,867	34.17		
2010	273,660	-11.11	22.61	47.10
2012	359,564	49.91		
2014	379,608	5.57		
2016	437,430	15.23		
2018	524,835	19.98		
2019	513,268	-2.20		
2020	224762*	-56.21	25.69	13.6

Note: *Year influenced by COVID-19.

cluster (Fig. 3). Much of the infrastructure dedicated to tourism is located near to the main route (route 618), approximately 7 km of road between Quepos and Manuel Antonio. Due to the extension of the units of analysis, the number 18 involved part of the public use zone of Manuel Antonio National Park, where it is possible to observe that there are four subunits with high anthropization values, which correspond to tourist infrastructure (trails).

4. Discussion and conclusions

The dynamics of and land cover is the result of intricated socio-ecological interactions (Gallant et al., 2004). For that reason, one of the limitations of this study was the difficulty in establishing a clear cause-effect relationship. However, through the analysis of the results of anthropization, location of tourism infrastructure, visitation statistics and triangulated with documentary review in the period 1990–2000, the tourism industry was identified as one of the primary forces of landscape

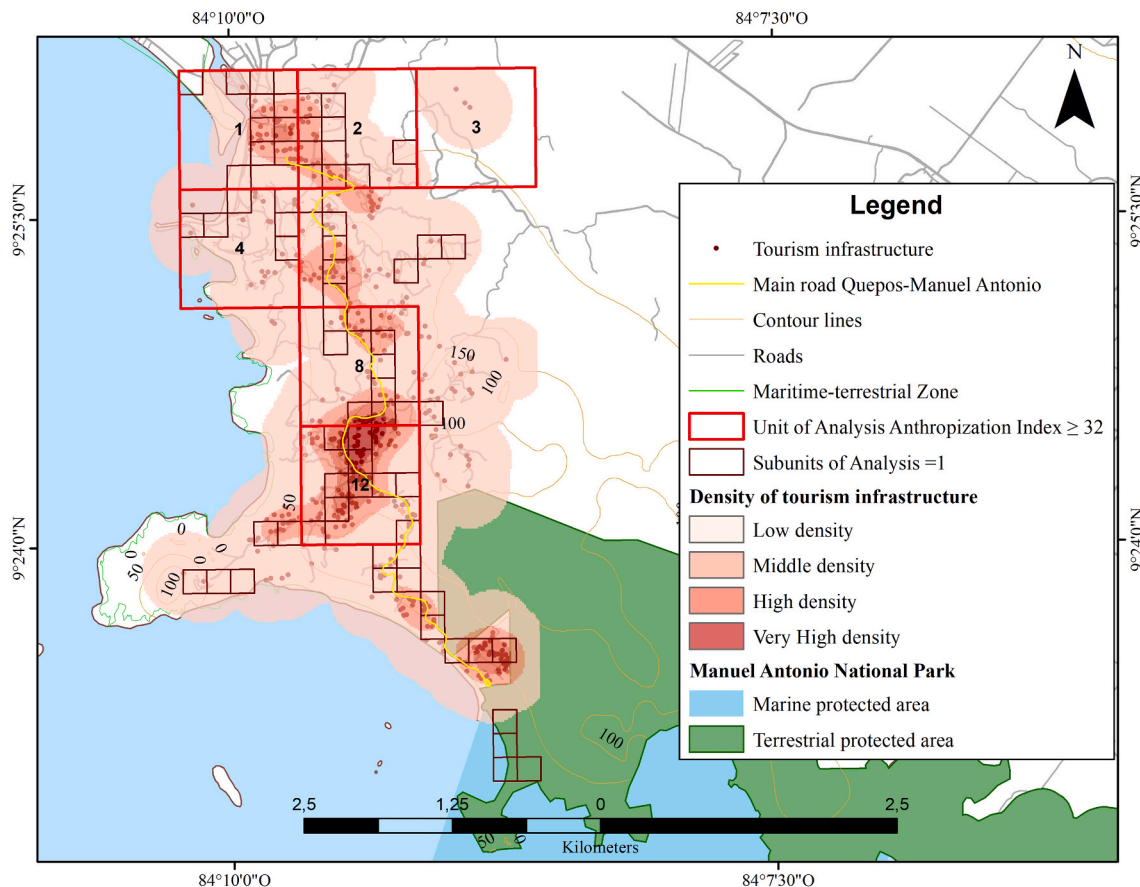


Fig. 3. Tourist infrastructure between Manuel Antonio and Quepos, and units and subunits of analysis with the highest anthropization value, 2020.

modification. A trend of increased anthropization was identified in the buffer zone, especially in the touristic zones. The identification of temporal and spatial patterns of anthropization in this research is an input in the generation of conservation strategies through the protection and restoration of ecosystems which is the basis of ecotourism.

For conservation purposes, it is essential to have biological corridors and improve the quality of the surface water of the buffer zone that flow into the national park.

The results offer some clues to determine new lines of research: 1) the role of attractive coastal protected areas to influence the impact on the landscape, 2) the pressures in the coastal protected areas related to the increased offer of tourist services, and 3) the socio-ecological effects of anthropization close to protected areas.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.annale.2022.100072>.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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