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EXTENDED ABSTRACT

CONSERVATION AND TOURISM IN THE ARAUCANÍA: CARRYING CAPACITY ASSESSMENT IN TRAILS OF PROTECTED AREAS

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1. INTRODUCTION

One of the most effective global conservation strategies is the creation of protected areas, with 302,934 established worldwide, covering 16.30% of the land surface and 8.35% of the marine area. The number of tourists visiting these areas is constantly increasing, with tourism serving as a significant source of income and employment while promoting conservation. However, if not properly managed, tourism can cause environmental degradation, reducing the potential for development. To mitigate such impacts, setting limits on visitor flow is essential.

Several methodologies for determining carrying capacity, such as the Recreation Opportunities Spectrum, Limits of Acceptable Change, and Tourism Carrying Capacity (TCC), have been developed. TCC, developed by Cifuentes et al. (1999), is one of the most widely used methods due to its practicality and effectiveness in forecasting and adjusting actions based on environmental characteristics, ensuring long-term sustainability.

Within tourism carrying capacity, recreational trails are crucial infrastructure in protected areas, serving as primary points of interaction between visitors and the environment. However, increased visitor numbers have led to the unplanned expansion of trails, causing direct and indirect ecological impacts. Therefore, determining appropriate trail use is essential to avoid unacceptable ecological damage.

In Chile, the Araucanía region, with the largest number of protected areas, faces significant challenges in visitor management and conservation. Implementing carrying capacity methodologies is crucial to ensure the ecological integrity of these areas.

2. OBJECTIVES

In the described context, and in order to contribute to the development of strategies that prevent damage or degradation of ecosystems and ensure long-term conservation, this study aims to determine the tourism carrying capacity of the trails in the protected areas of the Araucanía region. The study includes adjustments to the methodology by Cifuentes et al. (1999) through the incorporation of less subjective correction factors, consideration of the seasonality of visitor flows, and a new approach to handling capacity. Furthermore, the proposed methodology allows for the simultaneous analysis of a large number of protected areas through the use of geospatial analysis, significantly optimizing the required resources and time. It is expected that the study will serve as input for evaluating and adjusting visitor management practices, promoting effective conservation and sustainable enjoyment.

3. METHODOLOGY

The Tourist Carrying Capacity (TCC) in protected areas was determined using the methodology proposed by Cifuentes et al. (1999). This process is broken down into three levels: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). The study covered two seasonal periods, summer (November-April) and winter (May-October), due to the marked differences in climatic conditions, biological activity, and visitor demand.

To estimate the PCC, the formula PCC=(mt/sp)*nv was used, where “mt” corresponds to the trail length in meters, “sp” is the space required per person on the trail, and “nv” is the number of daily trips allowed for each visitor, calculated using the formula nv=hv/tv, where “hv” represents the opening time of the protected area, and “tv” is the time required to complete the trail.

The determination of the Real Carrying Capacity (RCC) was made by applying a series of correction factors (Fc) to the PCC, considering specific characteristics of each trail. These factors include accessibility (Fcacc), waterlogging (Fcane), biological aspects (Fcbio), erosion (Fcero), snow periods (Fcniv), precipitation (Fcpre), social factor (Fcsoc), and temperature (Fctem). Each of these factors influences the visitation capacity based on the topographical, climatic, and biological characteristics of the area. For example, Fcacc evaluates terrain slope, Fcane addresses waterlogging issues, Fcbio considers the presence of vulnerable species such as amphibians, Fcero measures the risk of erosion, Fcniv refers to snow accumulation, Fcpre evaluates intense precipitation, Fcsoc manages the density of visitor groups, and Fctem analyzes extreme thermal conditions. Geospatial and climatic data, such as digital elevation models and historical meteorological data, were used to calculate these factors.

The Management Capacity (MC) represents the maximum limit of visits that can be allowed considering the current infrastructure, staff, and available resources for managing the visitor flow in each protected area. MC is evaluated through variables related to the quantity, condition, location, and functionality of the infrastructure and staff. Each of the components forming part of the infrastructure, equipment, and staff variables in the protected areas were directly obtained through consultations with the managers of each protected area.

To estimate the real importance of each variable in the MC, as well as to approximate how the interaction of the observed variables varies across the considered periods (summer/winter), the weighted value of each variable for the period was calculated, defined as: MC=(it*p)+(et*p)+(pt*p), where “it” corresponds to the value of the infrastructure variable for the season (summer/winter), “et” corresponds to the value of the equipment variable for the season (summer/winter), "pt" corresponds to the value of the staff variable for the season (summer/winter), and "p" corresponds to the weighted value representing the relative importance of each variable.

To estimate the relative importance value of each variable, the multicriteria evaluation known as the Analytic Hierarchy Process (AHP; Saaty, 1990) was used. In order to validate the decision-making process from different perspectives, a survey was conducted with experts in territorial planning, tourism, and protected area management.

The task of correcting and homogenizing trails and Fc was carried out using the QGIS 3.4.11 software, while calculations were performed using R 4.3.0 software.

4. RESULTS

Certain factors, such as social aspects, accessibility, trail slope, and exposure to climatic risks, were found to be determinant. Some factors, such as biological aspects, also had an influence, especially during the summer season, playing a key role in species conservation. Regarding MC, once the values of each variable were obtained for each protected area, experts assigned moderate contributions to all of them. According to the weighted scores, the personnel variable was the most relevant in contributing to the MC of the areas. When disaggregating management capacity by protected area, a high level of heterogeneity is observed, indicating significant differences. This could reflect disparities in resource availability, management difficulty, or the specific conditions of each area. Lower values indicate areas requiring special attention or management improvements to prevent issues such as overcrowding or environmental degradation, such as R.N. China Muerta and R.N. Alto Bio-Bío. Meanwhile, the highest values, mainly observed in P.N. Conguillío and R.N. Malalcahuello, indicate MC levels closer to the optimal, which could serve as a reference. ECC showed wide variability between trails and seasons, with some trails exhibiting a high carrying capacity, while others required stricter management to prevent deterioration. Seasonally, a considerable difference was evident, reaching a peak of 4,870 visitors during the summer season and decreasing to 1,350 in the winter season.

5. CONCLUSIONS

The daily tourist carrying capacity determined in the public protected areas managed by the National Forestry Corporation in the Araucanía region will be an essential foundation for promoting a balanced and sustainable use of these valuable natural spaces. Approaching clear limits on the number of visitors not only contributes to the conservation of ecosystems but also prevents their degradation due to excessive visitation.

The research presented introduces innovations in its methodology by considering the seasonality of visitation flows and ecological processes, using correction factors of different natures, and approximating the management capacity to the realities of management. Although developed on a large scale, the variables used had a sufficiently fine resolution to provide applicable results. Furthermore, the research covered numerous protected areas, which allows for generating relevant baseline information to contribute to the creation of an efficient management plan or program for conservation in the evaluated areas.

However, it should be complemented by the implementation of continuous monitoring or follow-up systems that allow for updating and adjusting management strategies based on changes in ecosystems and visitation patterns.

The integration of the results obtained into future management plans will be essential to ensure that both present and future generations can continue enjoying these valuable natural spaces.