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A 3D Model of the Sustainable Management of the Natural Environment in National Parks

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Abstract : This paper investigates the economic and ecological dynamics that emerge in Protected Areas (PAs) as a result of interactions between visitors to the area and the animals that live there. We suppose that the PAs contain two species whose interactions are determined by the Lotka-Volterra equations system. Visitors' decisions to visit PAs are influenced by the entrance cost required to enter the park as well as the chance of witnessing the species that live there. Visitors have contradictory effects on the species and thus on the sustainability of the protected areas: on the one hand, an increase in the number of tourists damages the natural habitat of the areas and thus the species living there; on the other hand, it increases the total amount of entrance fees that the managing body of the PAs can use to perform defensive expenditures that protect the species from extinction. For a given set of parameter values, the existence of saddle-node bifurcation, Hopf bifurcation, homoclinic orbits, and a Bogdanov–Takens bifurcation of codimension two has been investigated. The system displays periodic doubling and chaotic solutions, as demonstrated by numerical examples. Pontryagin's Maximum Principle was utilized to develop an optimal admission charge policy that maximized both social gain and ecosystem conservation.

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