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Complex Dynamics in a Model of Management of the Protected Areas

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Abstract : This paper investigates the economic and ecological dynamics that emerge in Protected Areas (PAs) due to interactions between visitors and the animals that live there. 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 and the chance of witnessing the species living 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 regions 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, 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 numerical examples demonstrate. Pontryagin's Maximum Principle was utilised to develop an optimal admission charge policy that maximised social gain and ecosystem conservation.

Keywords : chaos, bifurcation points, dynamical model, optimal control
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