Abstract

This doctoral thesis focuses on some invasion problems, proposing and investigating several mathematical models for understanding, prediction, and decision-making in certain real-world situations. Analytical, numerical, and control methods are used to explore equilibrium points, with their feasibility and local stability conditions, bifurcations, and multistability. The thesis is divided into three parts, each containing two chapters, followed by concluding remarks and possible future developments. A preliminary chapter outlining the theoretical framework in which the thesis is situated precedes these three parts. It contains some useful recalls related to the Z-type control method and geometric considerations in ODE models in the case of boundary interactions. The first part discusses some possible management strategies for a lagomorph invasion in some Italian regions. The Z-type control method is used to provide suggestions to ecosystem managers in two different invasion scenarios, namely with and without disease-carrier invaders. Then, the second part focuses on the theoretical investigation of two situations in which individualistic generalist predators invade regions where herding prey live to kill and eat them. At first, prey aggregation, using appropriate geometric considerations, is combined with the predator satiation phenomenon. Next, the interference of predators in the functional response denominator and the prey benefit increase with the herd size growth are also included. Finally, the third part evaluates the impacts of migrations on the biodiversity of affected regions. Migrant populations can seriously damage native species, even leading to their extinction. Moreover, biological invasions can also occur. These possible negative effects are explored, considering different possible migrant-resident interactions. The two examined scenarios are the migrant interference and predation on the residential species. In the fifth chapter, we assume that the migration crosses the region of interest and interacts with a native predator-prey system. In the sixth chapter, instead, we consider a migratory flow that affects only marginally the territory and only one residential population that interacts significantly with the migrants. The thesis also contains an appendix, which briefly summarizes some research works not included in the main body of the manuscript. They concern two epidemic models with cautionary response in the presence of asymptomatic infected, an African two-way competition trophic chain, SSA systems in developing countries, and amphibian interactions in aquatic ecosystems.