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Spatial, directional, and spatio-temporal network algorithms in ecological studies

Given current climate and land use change, species movement in intensively human-modified landscapes is impeded by landscape cover types as well as the distances among remnant habitat patches. It is important to determine to what degree habitat patches scattered throughout the landscape may function as stepping stones facilitating dispersal among otherwise isolated habitat. To this end connectivity metrics can be used; however, such metrics do not account for species abundance and population dynamics that also affect species dispersal and persistence. Hence one needs to model the spatio-temporal dynamic of population dynamics (demography), dispersal (connectivity), and the directionally of species migration. Here I present how network theory (1) can be spatialized, (2) can account for the number of dispersing individuals and long-distance dispersal processes across generations, (3) can be directional, and (4) can measure spatio-temporal connectivity. I illustrate how these methods can be used to investigate species range expansion (Black Woodpecker, Spain), spread of vector-borne disease (Lyme disease, Ontario), and forest dynamics. I show that the loss of intermediate and large stepping-stone habitat patches can cause a sharp decline in the distance that can be traversed by species (critical spatial thresholds). Yet the presence of stepping-stone habitat is critical for short- and long-distance invasion of both the tick vector and the pathogen by mice and deer. Last, I show that the impact of land use changes on species dispersal can be modelled using novel spatio-temporal network algorithms.