Spatial, temporal and demographic connectivity: How novel network algorithms can help investigating species connectivity in fragmented landscapes

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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) and dispersal (connectivity). Here I introduce (1) a new generalized network model of habitat connectivity that accounts for the number of dispersing individuals and for long-distance dispersal processes across generations and (2) how to measure spatio-temporal connectivity. I illustrate how this generalized network model can be used to test how stepping-stones are important to promote (i) species range expansion (Black Woodpecker, Spain) and (2) the spread of vector-borne disease (Lyme disease, Ontario) in fragmented landscapes based on wildlife-host movement.

For the Black Woodpecker range expansion example, 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) that cannot be effectively compensated by other factors previously regarded as crucial for long-distance dispersal (fat-tailed dispersal kernels, source population size). Then for the Lyme disease spread example, I compare the probability of infected-tick (*I. scapularis*) spread for a suite of hosts (white-footed mice, American robins and white-tailed deer) in a Lyme-endemic island landscape in Thousand Islands National Park. I show that 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 anticipating the impact of land use changes on species dispersal can be modelled using novel spatio-temporal network algorithms.