Jun 27th, 3:40 PM - 5:00 PM

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iEMSs International Congress on Environmental Modelling and Software

9th International Congress on Environmental Modelling and Software
Fort Collins, Colorado, USA, Mazdak Arabi, Olaf David, Jack Carlson, Daniel P. Ames (Eds.)
https://scholarsarchive.byu.edu/iemssconference/2018/

Modeling dynamics of ecological systems with geospatial networks and agents

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Abstract: Landscape connectivity networks are composed of sets of nodes representing georeferenced habitat patches that link together based on the maximum dispersal distance of a species of interest. Graph theory is used to measure the structure and connectivity of resulting networks to inform dispersal patterns, identify key habitat patches, and assess how changes in structure disrupts dispersal patterns. Despite their potential, landscape connectivity networks are mostly static representations, formed using maximum dispersal distance only, and thus do not account for network structure as a function of variation in habitat patch attributes and complex spatio-temporal dispersal dynamics. The main objective of this research study is to develop a modelling approach that integrates networks and agent-based modelling (ABM) for the representation of a dynamic dispersal network of the ecological system, emerald ash borer (EAB) forest insect infestation. The approach develops a network agent-based model (N-ABM) that integrates an ABM and dynamic spatial networks to simulate spatio-temporal patterns of the EAB infestation at the individual scale and generates spatial network structures of EAB dispersal as the phenomenon infests ash trees. The model approach is programmed in Java and is implemented in Repast Simphony, a free and open source agent-based modelling and simulation platform, using geospatial datasets representing the location of ash trees suitable for EAB infestation across the eastern part of North America as a case study. The simulated spatial networks are characterized using graph theory measures, identifying important dispersal pathways and habitat patches that exacerbate EAB dispersal and quantifying the effectiveness of the removal of habitat patches in disrupting dispersal.

***Keywords**:* Spatial networks; Agent-based modelling; Ecological modelling; Forest insect infestation; Geographic information systems