Habitat connectivity and the spread of invasive species: how humans facilitate the distribution of exotic pests

Invasive species can cause a wide array of social, economic and ecological disturbances within a region. Once established, an invasive can be a major cause of ecosystem degradation and biodiversity loss (Gavier-Pizarro, 2010). In addition, they can also drastically alter resource use in natural systems and introduce new diseases that can negatively affect native species and human health (Gulezian, 2012). Thus, it is important to understand how these exotic invaders spread and what environmental conditions create suitable habitat for invasive species. By identifying how a particular invasive is distributed across a landscape, we can devise effective means to control and manage the continued spread of the species. This paper examines the role habitat connectivity plays in facilitating invasive species movement across a region. Habitat connectivity can be influenced by a variety of anthropogenic (i.e. roads, ditches, houses, soil alteration) and natural factors. Understanding how humans may contribute to the spread of some species will be critical in helping solve problems associated with them. I present here an overview of literature that examines different ways in which anthropogenic habitat fragmentation and land use has exacerbated the spread of different invasive species. The articles reviewed studied the movements of a variety of different invasives among many different locations. A majority of the literature looks at how humans can increase connectivity and thus help facilitate the spread of invasive species. Unintended corridors are often made within natural habitats that can create avenues into previously isolated habitats.

A majority of the peer-reviewed literature I found on the spread of invasive species focused on invasive plant species. I feel that this warrants the assumption that perhaps invasive plants are among the hardest to control and can cause rapid destruction to a region once they are established. There were interesting studies that examined the
role of human-constructed corridors which increase the spread of invasive plants into new areas by the construction of roads, drainage ditches and other transportation routes or public-rights-of-ways. Because of their spatial configuration as highly connected networks, anthropogenic liner wetlands (i.e. drainage ditches along highways or agricultural lowlands) have the potential to serve as corridors to facilitate movement of an invasive into habitats they intersect (Maheu-Giroux, 2007). Roads leading into and throughout isolated habitats, either anthropogenic (farmland) or natural areas, can disperse invasive plants that colonize on neighboring landscapes (Meunier, 2012). roadside ditches create a perfect habitat for wetland invasive plants because they are cleared of natural flora and receive constant nutrients from runoff. Special attention must be given in the planning of roads that lead into pristine habitats such as nature preserves or parks and agriculture lands. Not only could invasive plants choke out natural species within parks, but also pose a threat to important agricultural crops (Meunier, 2012).

Invasive plants can also spread within areas that have provided suitable conditions due in part because of past anthropogenic land uses that alter soil composition. I found this very interesting because I have never considered the spread of an invasive due to preferred soil chemistry influenced by past practices on the land. For instance, one study found a high abundance of an invasive plant in soils that contained heavy metals from nearby wastewater treatment and biosolid processing facilities (Gulezian, 2012). Contaminated soils may also reduce competition between native and invasive species by restricting natural vegetation’s ability to grow in these areas. Historical land uses must be examined in order to determine where an invasive may spread and what chemical compositions within soils allow certain invasive plant species to grow (McDonald, 2008).

The spread and distribution of any invasive species however, are often affected directly by the habitat suitability and spatial configuration of landscape patches (Wang, 2011). In other words, the proximity to which preferred habitat patches are located to one another can be a key factor in the spread of any invasive. Such close proximity of habitat patches can be influenced and/or exacerbated by anthropogenic fragmentation of the landscape. Of particular concern is the ability for pests to invade agricultural landscapes and destroy valuable food crops and threaten food security. How we configure agricultural landscapes may create a highly connective web to which an
invasive pest can move through (Margosian, 2009). These negative effects can cause tremendous economic loss to a region and control measures could be difficult due to high connectivity.

Some studies outline how heterogeneity in general can create circumstances that make an area more prone to invaders. A heterogenic landscape can create a wide variety of different habitat patches within a region and thus increase the likelihood an invasive species could establish itself (Vuilleumier, 2011). Heterogeneity within a region could be caused by many different acts of anthropogenic fragmentation. Housing developments for example, create suitable edge habitats that may be favorable for an invasive (Gavier-Pizarro, 2010). Similar with the construction of roads and linear drainage wetlands, housing developments must be carefully planned in order to reduce the potential for an invasive to colonize. A heterogenic landscape can provide easy movement among an invasive species by providing many different habitats to which it may favor.

The task of controlling the spread of invasive species seems to be a never-ending process. The world is more connected than ever before, connecting habitats from across the world through many different anthropogenic functions. The transportation of goods and services around the world increases the probability exotic species will be introduced to new areas. It is thus important to realize how anthropogenic land uses and fragmentation of landscapes can influence distributions of non-native species. The studies I explored have outlined a wide range of different practices that humans have undertaken which connect different landscapes together and facilitate the spread of invasive species. Some management solutions seem to be simple, others more complex. However, recognizing what actions are causing the problem is the first step towards finding a solution to the problem.

In my opinion, I feel as though the problem of invasive species spreading across broad landscapes is inevitable. It seems impossible to prevent exotics from spreading and invasive species from establishing new niches in new regions because of how connected our world is today. This is not to say that we should give up on attempts to control very problematic invasions however. For example, protecting agricultural lands from pests that could destroy food crops should be a very high priority. Based on the literature, there seems to be some practical measures that can be taken in order to stop or at least
slow the spread of some exotics. These measures should be explored in order to protect biodiversity and conservation of natural habitats. Recognizing how we influence connectivity is a vital part of containing invasive species from entering previously isolated habitats and destroying natural regional landscapes.
Annotated Bibliography


This study examines the relationship between housing developments and invasive plant species abundance in New England. The authors state that in addition to other anthropogenic land use changes such as roads and ditches, housing developments can increase invasive plant species richness in the region. Housing developments can create suitable edge habitats for invaders by fragmenting the landscape allowing it easier for invasive plants to spread.

Recognizing that housing developments can influence the abundance of invasive species in an area is very important to both managers of invasive species and urban developers. It may also be important to individual landowners so that they can help control and manage appropriately against the spread of exotic invasive plants. It was also noted that each housing development is different, and the authors warn that management for one housing development might not work for another.


This was the first of two papers I found that examined the role soil contamination may have on the spread of an invasive plant species. The authors suggest that some contaminated soils are conducive to invasive species establishment but restrict native plant growth. In particular, this study follows the spread of C. maculatum (poison hemlock) in Cook County, IL along roadside ditches and drainage corridors. The spread of the plant seemed to thrive in areas that report high levels of heavy metal contaminants in the soil from nearby wastewater treatment plants and biosolid processing facilities.

I find it interesting that there may be connections between sources of anthropogenic soil contamination and the spread of invasive species. I have typically considered only physical alterations of the environment (i.e. habitat fragmentation, land use changes, establishing corridors) to be the primary causes of invasive spread. However, there seems to be growing literature about sources of human-induced soil contamination to harbor the spread of certain
invasive species. This may have tremendous influences on how to manage the future spread of any invasive.


This paper examined the spread of the invasive plant *Phragmites australis* (common reed) between linear anthropogenic wetlands within areas of southern Quebec, Canada. Anthropogenic wetlands included drainage ditches along highways, agricultural lowlands and railroads. The goal of this study was to determine how the interaction between the network of linear anthropogenic wetlands and adjacent land use/land cover facilitated the spread of *P. australis*.

The authors noted a few results that I found interesting about how *P. australis* spreads throughout different areas via the connectedness of these linear wetlands. One, they found evidence that the plant was present within drainage ditches that receive salts from road maintenance runoff operations (salting roads for ice during the winter). This suggests that the plant may have a higher degree of tolerance than previously thought towards saline conditions. This could reduce competition within native plants and contribute to the spread of *P. australis*. Second, distributed within agricultural drainage ditches, *P. australis* may serve, at least temporarily, to capture heavy loads of nutrients and herbicides before they reach natural aquatic ecosystems. Lastly, the spread of this invasive was present mostly in areas where these linear wetlands intersected with wild landscapes. In other words, isolated patches of native wetlands found little evidence of the invasive compared with areas that were intersected by such linear wetlands that contained *P. australis*. This may confirm the assumption that these anthropogenic corridors indeed increase the spread of the plant.


This article looked at the vulnerability of highly connected agricultural landscapes to invasive pests and disease. I thought this was a very interesting article because I have been unable to find many other studies that examine the effects invasive species could have on food production in the U.S. The vulnerability of our agricultural crops would seem like a very obvious and high priority concern. The authors explore the connectivity between four different crops in the U.S.: maize, wheat, soybeans and cotton. They state the security of national food supplies as a viable reason to conduct such analysis. This study seemed to grab my attention more so than others because it presented a very
real problem that could have dramatic effects on nations food security. Connectivity must be evaluated for important food crops in order to manage effectively if and when an invasive pest outbreak occurs.


The paper looks at the influence of historical land use and habitat fragmentation on the presence of four different invasive plant species in the northeastern part of the U.S. They predict that past land use and landscape cover may impact the presence of current invasive species in the area.

What I found most interesting was that historical land uses in the area (i.e. agricultural lands, urban areas, factories, etc.) might have impacted current soil conditions that make the land suitable for invasive species dispersal. Soil characteristics are the most important determinants of invasive plant distribution. Specifically, the authors found that invasive plants were most commonly found within areas that were previously agricultural landscapes. Thus, it may be important to look at historical land use activities when analyzing the spread or vulnerability of an invasive.


The paper looks at the spread of *Galium mollugo*, an invasive plant also known as smooth bedstraw, along edges of paved roads. They suggest that the plant uses paved roadside ditches as corridors to spread into neighboring agricultural fields. Of most concern, they suggest that the construction of new roads into previously isolated areas within national parks may be facilitating invasion from this pest.

It seems very important to acknowledge the influence human-constructed corridors such as roads or ditches can have on the introduction of invasive species. This paper brings into question on how much human infrastructure should be allowed in areas like state or national parks? Paved roads may be constructed to proved easier access for visitors into the park. However, these roads may also provide corridors that facilitate the spread of an invasive and thus degrade the natural functioning of the park or preserve. There seems to be a trade-off between accessibility for visitors to explore a natural landscape within a park and the potential invasion of a pest that can degrade its pristine habitat.

This study examines the movement of invasive plants throughout a network of fragmented landscapes in the eastern part of the U.S. The authors predict that connectivity within fragmented landscapes will influence the spread of invasive species throughout a region and may cause the loss of biodiversity in some areas.

The study was interesting in that it found that the dispersal limitations of exotic plant species was ultimately dependent on the particular specie and that it was only deemed invasive if it had lower dispersal limitations. They are more invasive because they disperse more easily in fragmented landscapes. They suggest that landscape connectivity may be more important to the spread of species with abiotic dispersal than animal-dispersed species.


I found this paper very unique and interesting because it looked at the potential distribution of an invasive plant in response to potential climate change predictions. Using different modeling technology, they estimated the distribution of the invasive as that climate is estimated to change in the region. They outline that management of any invasive plant should take into consideration of climate change because positive and/or negative responses by the invasive can occur. For instance, changing climate could make current areas unsuitable for an invasive to occupy and thus management should take that into consideration when deciding on how to deal with the issue going forward. In addition, climate change could act as corridors in the sense it could cause the invasive to move to previously unoccupied areas. It should be noted, however, that this type of invasive planning is mostly used in long-term predictions of how to control spread.


This study looked at the spread of the invasive plant purple loosestrife throughout parts of Minnesota. The study sought to determine factors that contribute to large-scale spatial distribution of the invasive plant by using a hierarchical approach in order to reduce the complexity of the landscape scale.
The study identified three types of land use/land cover that contained the most abundant concentrations of loosestrife: wetlands, open water edges and developed open spaces. In addition, the authors looked at the availability of the plants favored habitat types, its spatial neighborhood and propagule pressure in regard to its dispersal.

Along with determining the preferred land use/land cover habitats used by purple loosestrife, the study found that distribution is dependent on a number of land use factors that may influence the level of disturbance suitable for loosestrife growth. For instance, neighboring disturbances that affect the drainage an area can create suitable habitat for loosestrife to grow.


In this study, the authors examine how spatial heterogeneity influences the introduction and persistence of invasive species in an area. Also, heterogeneity can influence how long an exotic may take to establish and the difficulty in effectively eradicating the invasive once established. They put emphasis on the effectiveness of invasive control methods with considerations related to spatial scale.

The study finds that heterogeneity promotes invasion but also increases the time until invasion. They state that heterogeneity matters because it promotes a few habitats within a region that can give an advantage to an intruder. Once established, the intruder can develop a source of continuous spread if the proper time has elapsed. I find it interesting that heterogeneity may increase the regions vulnerability to the establishment of exotic species because it provides a higher probability it can find suitable habitat.


This study looked at the spread of the invasive pest the rice water weevil within a particular province in China. The objective of the study was to quantify the spread pattern of the weevil and explore landscape structural factors responsible for the observed spread pattern. The authors wanted to identify connectivity avenues that increase the spread of the weevil.

Over the course of 9 years, the study was able to track and map the directional pattern at which the invasive pest was moving. They identified 3 distinct directions that the weevil was spreading most rapidly. I found it interesting that the study was able to show how connectivity of prime weevil habitat between
rice paddies was the likely cause of distribution of the pest over a broad area. Not only were they able to identify how and where likely connections between good habitats were located, but that they also discussed the natural barriers that prevented the weevils spread inland. Their findings relates directly to how human-induced landscape fragmentation can increase the spread of invasive species.