From Right-of-Way to Greenway: Parameters for the Ecological Function of Midwestern Rail-Trail Corridors

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Abstract

Within the Corn Belt ecoregion of the USA, large tracts of public land for conservation are sparse. At the same time, in recent decades, over 25,000 miles of abandoned railroad corridors have been converted for use as recreational trails in the United States. In this context, rail-trails represent valuable public infrastructure for human movement and recreation. But to what extent do railtrails also facilitate wildlife movement and habitat in a highly altered agricultural landscape? How could they be managed to maximize benefits for non-human organisms? If trail managers were to approach rail-trails as green infrastructure, how could this new way of thinking benefit species of concern as well as conservation planning efforts broadly?

We examine two rail-trails in the Corn Belt as case studies to address these guiding questions. Utilizing publicly available GIS data and spatial analysis, we highlight structural characteristics of the trail corridor and discuss our findings with respect to key concepts in landscape ecology. We examine width, connectivity, quality, and context as structural elements (Smith & Hellmund 1993, Hilty et al. 2019). We bolster our landscape analysis with insight from interviews with trail managers who describe current management regimes and limitations. Finally, taking these conversations into account, we conclude with opportunities for the design and management of rail-trail corridors from a landscape architecture perspective, presenting conceptual designs for unique landscape contexts.

We approach rail-trail corridors in the agricultural landscape as novel ecosystems (Hobbs et al. 2009) ripe for experimentation. Instead of a restoration focus, for instance, these linear corridors present an opportunity for “hypernature.” Hypernature is a design strategy in which landscape elements and plantings are exaggerated, amplified versions of natural systems (Mclean 2019). We explore this concept within the trail right-of-way, seeking to exaggerate ecological function while also balancing the needs of human users. Our explorative design study offers guidance for trail corridors in highly altered agricultural landscapes, where the ecological function of these linear features is highly consequential.

Introduction

Rail-trails inherit key aspects of the railroads that came before them – their alignment, radical earthworks, and plant communities emerging after the construction of the railroad. A mix of biotic and abiotic changes create new patterns and ecological relationships. While rail-trail corridors were not designed to function as ecological corridors, they often function as de facto ecological corridors. This may be especially true in agricultural contexts where the vegetative structure and species diversity of a rail-trail corridor contrasts sharply with adjacent monoculture croplands. Though they are linear, with limited right-of-way width, the contribution of these corridors to the larger landscape matrix is worthy of study. Rail-trail corridors contain a mix of historical and emergent ecologies, which require a broad set of management tools. Further, management and design intervention must also reconcile ecological goals with the experience of trail users. This paper seeks to characterize and describe key parameters of rail-trial corridors, and to consider strategies and frameworks that might advance the function of these corridors.

Background and Literature Review

In human-altered and fragmented landscapes, patches of high-quality habitat and corridors that connect them are vital to maintaining ecological functions of the landscape. These functions include support for biodiversity, maintaining ecosystem services, and creating resilience against environmental stressors. Corridors allow for the movement and flow of genetic material through the landscape while also serving as core habitat for many species. The performance of an ecological corridor or greenway is determined by a set of key parameters: the width of the corridor, its connectivity and continuity, the habitat quality of the corridor, and the surrounding landscape context (Hilty 2009, Smith and Hellmund 1993).

Trail advocates, like the Rails-to-Trails Conservancy, have described trails as tools for conservation, noting that they "preserve important natural landscapes, provide needed links between fragmented habitats and offer tremendous opportunities for protecting plant and animal species" (1999). However, the character and context of trails vary widely--does this assumption apply to all types of trails? Rail-trails are a type of trail corridor that repurposes abandoned railroad rights-of-way. The initial construction of railroads often involved significant alterations to the landscape, including grading modifications, soil compaction, hydrological changes, and the disruption of plant communities, all of which contribute to habitat loss, transformation, and fragmentation (Barrientos et al. 2018). Additionally, the disturbed conditions of rail corridors—characterized by exposed soils, altered hydrology, and increased edge effects—make them particularly susceptible to the colonization of non-native plant species (Nemec et al. 2011).

However, in the Western Corn Belt Plains ecoregion of the United States, the landscape is highly altered and fragmented by large-scale and intensive agriculture. In this context, the linear land associated with rail-trail right-of-way may offer great opportunity for increasing habitat quality and connectivity in the wider landscape. Because the trail corridor is itself altered, both biotically and abiotically, it may be considered a "novel ecosystem" (Hobbs et al. 2009). Biotic changes can include declines or local extinctions of species and/or significant invasions of species from elsewhere. Abiotic changes can include changes to the hydrological regime, geology, soils, or topography (Hobbs et al. 2009, 602). Novel ecosystems are characterized by significantly altered species composition and abiotic conditions, distinguishing them from "hybrid ecosystems" which retain the potential for restoration to a historic state (Hobbs et al. 2009).

The management of novel and hybrid ecosystems might require challenging traditional notions of restoration and conservation. A novel ecosystem that is stable, resilient, and provides ecosystem services may not be a good candidate for restoration to a historical system, particularly if doing so would require a large amount of resources. Instead, these ecosystems might be evaluated based on their functions and services, with management strategies aimed at optimizing ecological performance rather than restoring past conditions.While rail-trails may not function as pristine conservation sites, they offer a unique opportunity to design and manage for ecological function, enhance habitat connectivity, and reimagine conservation strategies within highly altered landscapes.

In the field of landscape architecture, the concept of "hypernature" describes a design strategy that seeks to exaggerate and amplify the characteristics of natural systems (Meyer 2008, Rinaldi 2014). This might involve plantings that are denser than typically found in natural systems, or arranging abiotic features like stone to exaggerate natural patterns. Traditionally, hypernature has been discussed in terms of aesthetic quality of landscape elements and their relationship to the human experience. However, the concept of hypernature has not been explored in relation to ecological function. That is, could a "hypernatural" landscape exaggerate both the aesthetic qualities and ecological function of its natural elements? It is unclear if there is a relationship between hypernature as a design aesthetic and the ecological performance of such landscapes.

This study bridges concepts from landscape architectural theory and corridor ecology to explore their implications for midwestern rail-trail corridors. We begin by analysing existing corridors through spatial analysis and interviews with trail managers, then propose new pathways for their management and design.

Methods and Data

This study employs a mixed-methods approach to examine the landscape-ecological function of rail-trail corridors in the Corn Belt region. The study uses both GIS methods and a qualitative thematic analysis of interviews with trail managers. The combination of these methods offers a more comprehensive understanding of corridors studied. We used GIS to understand spatial characteristics of the corridor and their relationship to context, and open-ended surveys to understand perceptions and landscape management regimes. The study follows a case study design, focusing on two adjacent rail-trails. The selection of these trails was based on their accessibility, their relationship to the larger landscape matrix, and their popularity as recreational destinations. This approach allows for an in-depth exploration of the ecological function of these trails, which may be extrapolated to trails in similar landscape contexts. The trails are managed by two different jurisdictions, which also allows for comparison of trail management strategies and practices.

Data

Spatial data for the two selected trails was acquired through public sources. Data for trail centerlines and roadways was downloaded from the Iowa Department of Transportation. Data for property boundaries, i.e. trail right-of-way (ROW), was downloaded from county sources. Land cover data was accessed through the USGS Multi-Resolution Land Characteristics Consortium.

The land cover data is at 30meter resolution and is classified using a modified version of the Anderson Land Cover Classification System (Anderson 1976).

GIS Methods

ROW width was sampled every 200 linear feet along the trail centerline. 200 feet was established as the sampling distance to capture major changes in ROW width and trail context. The Study Line Editor Toolset (Wasserman 2019) was used to generate cross sections perpendicular to the trail centerline every 200 feet along the corridor. These cross section lines were trimmed using the ROW boundaries. The ROW cross section lines were manually inspected, and areas where the trail does not utilize a former railroad corridor were removed. The resulting set of ROW cross section lines only include former rail ROW. The total number of cross sectional ROW samples is 746.

The landcover raster was reclassified into 4 categories: riparian/wetland, agricultural, upland woodland/grassland, and urban/developed. The four categories were developed to create a more meaningful results that reflect local landscape typologies. The reclassification strategy is mapped in Table 1.

Table 1. Reclassification Scheme

New Class	MRLC Class
Riparian/Wetland	Open Water Woody Wetlands Emergent Herbaceous Wetlands
Agricultural	Cultivated Crops Pasture/Hay
Upland Woodland/Grassland	Deciduous Forest Evergreen Forest Mixed Forest Shrub/Scrub Grassland/Herbaceous
Urban/Developed	Developed Open Space Developed Low Intensity Developed Medium Intensity Developed High Intensity Barren Land

Using the reclassified land cover raster, the dominant land cover group was calculated every 200 feet along the trail. For each ROW cross section, a 200 foot buffer was applied to create polygons that encompassed the area immediately outside of the trail. The polygons typically represent 4-5 acres, depending on the ROW width. The distance of 200 feet was chosen so that the majority of the polygon extended beyond the trail ROW, in order to capture the context beyond the ROW.

Zonal statistics were used to calculate the majority value within the polygon, i.e. the landcover class that occurs most often within the polygon. This represents the dominant land cover context for each ROW cross sectional sample. Each intersection of the trail and a roadway was calculated, and each crossing was classified by the characteristics of the roadway, e.g. Annual Average Daily Traffic (AADT).

Interviews

Semi-structured interviews were conducted with trail managers of the two case study trails. These managers, responsible for the day-to-day operations and long-term planning of the trails, provided insights into the perceived ecological function of each trail, the challenges in maintaining them, and their potential to contribute to the larger landscape ecology. The interview questions focused on: the role of the trail in habitat connectivity; management practices that affect the ecological integrity of the trail corridors; observed benefits of disruptions to local flora and fauna; and future management plans related to ecological conservation. The interviews were transcribed, coded, and analysed thematically. The integration of quantitative GIS methods and qualitative interview data allow for a more comprehensive understanding of the ecological function of the rail-trail corridors.

Results

Through the GIS analysis, we observed that the width and context of the trail right-of-way vary throughout the corridor. We found that the narrowest ROW conditions were associated with urban/developed areas and agricultural areas. Larger ROW conditions were associated with upland woodland and grassland areas and riparian areas. Table 2 summarizes the relationship between land cover context and the trail right-of-way width. Figure 1 shows land cover context across the study area.

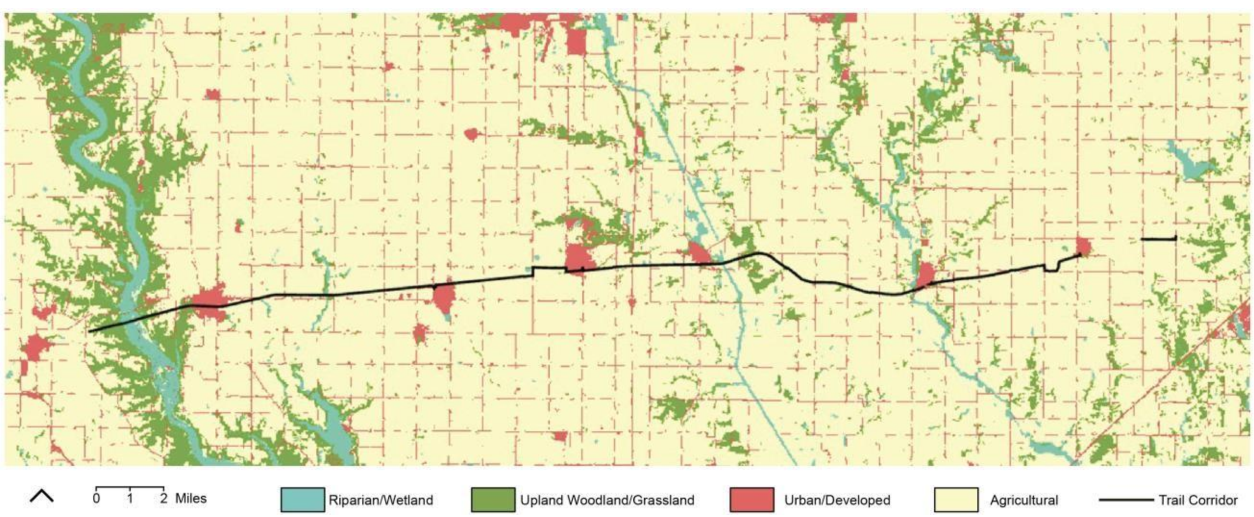

Figure 1. Map of Reclassified Land Cover in Relation to Trail Corridor

Table 2. Context of the Right of Way

Land Cover Context	Percentage of Total	Median ROW Width (ft)
Riparian/Wetland	2.9%	194.6
Agricultural	67.6%	135.6
Upland Woodland/Grassland	23.1%	200.0
Urban/Developed	6.4%	125.8

In regards to connectivity, we identified two types of connectivity related to the corridor: 1.) the connection between the trail corridor and large habitat patches and 2.) breaks in connectivity related to roadway crossings or gaps where the former rail corridor was lost to private ownership. Patches of habitat along the corridor include large river valley systems and the small communities that along the trail, where tree cover and vegetative structure is much greater than surrounding agricultural land. Corridor connectivity is interrupted by roadway crossings approximately once per mile in the study area. Crossings vary by the width of roadway; the annualized average daily traffic (AADT), which ranges from 50 vehicles per day to 48,000 vehicles per day; and whether a crossing is grade-separated. 3 of the 39 crossings in the study area are grade-separated.

Trail Manager Interviews

Conversations focused on the ecological quality of the corridors (e.g. plant communities, wildlife habitat, etc.), as well as the approach to managing the land. Below are key themes identified from the interviews:

Goals & Objectives for Trail Corridors
Land managers expressed that they view the trail corridors as ecological corridors. One agency promotes and manages the trail as a continuous corridor for flora and fauna. Another agency does not have a conservation management plan for the trail. But despite limited resources for conservation activities (like invasive species management, planting, burning, etc.), the agency considers it a conservation corridor by virtue of the fact that it is protected from development and farming.

Connecting People with Nature
Land managers expressed an overwhelming opportunity to introduce people with natural landscapes and ecosystems. The trail is a gateway that connects people with types of environments they otherwise would not interact with.

Invasive Species
Woodland areas have mulberries, honeysuckle, buckthorn, and garlic mustard. Prairie areas have multiflora rose, ragweed, and Canada thistle, queen anne's lace, sweet clover, brome, and wild parsnip. The prairie areas are also threatened by woody encroachment of species like autumn olive and mulberry.

Adjacent Land Use
Adjacent land use is a major factor in the ecosystems and management of the trail right-of-way. For the trails studied, adjacent agriculture presented the most issues. Issues include over spraying of farm chemicals into the trial ROW; faulty drainage due to tile drainage crossing or emptying into the trail ROW; and transverse trail crossings for farm equipment.

Management Activities
In these areas, managers deploy resources for prescribed fire, chemical application, and mechanical removal of invasive and undesirable species. In more degraded areas, with greater populations of invasive species and fewer native plant communities, it is an uphill battle with limited resources.

Discussion and Conclusion

Rail-trail corridors are heterogeneous landscapes, with ecological significance varying based on their width, connectivity, and surrounding land use. Within the right-of-way there is variability in the quality and composition of biotic and abiotic features. Hobbs et al. (2014) suggests that a patchwork of historical, hybrid, and novel ecosystems requires a landscape management framework that incorporates ecosystems "across the spectrum of degrees of alteration" to provide "a fuller set of options for how and when to intervene, uses limited resources more effectively, and increases the chances of achieving management goals" (Hobbs et al. 2014, 1). This is exemplified by the management strategy discussed by one agency: trail managers prioritize the highest quality areas along the trail. When trail managers have limited resources, they pick battles that they can win.

The concept of hypernature offers a potential alternative to conservation of historic ecosystems, proposing ecological enhancement broadly and embracing novel ecosystems along a heterogenous corridor – while designing an engaging aesthetic for human users. For instance, denser plantings, exaggerated topographic features, or strategically placed habitat structures can enhance biodiversity while reinforcing the trail's identity as a conservation corridor. However, hypernature as a strategy for ecological corridors requires further exploration: what specific ecological functions ought to be amplified? How should trail managers balance hypernature's aesthetic and ecological goals?

A key consideration in future rail-trail corridor design is which species should be prioritized for conservation and habitat enhancement. Hilty et al. 2018 suggest that establishing a focal species might help us understand specific requirements for design. Focal species might be keystone species, umbrella species, flagship species, indicator species, specialist species, or vulnerable species (Hilty et al. 2018). Each of these designations has different implications for design and management of a landscape. As an example, we explored design strategies to enhance habitat for the Pileated Woodpecker (*Dryocopus pileatus*), considered a keystone species in our study area. Such design exploration could be expanded to develop hypernature strategies tailored to multiple species and ecosystem services; enhancing the ecological value and function of rail-trail corridors for a larger web of flora and fauna. The approach of hypernature builds on knowledge of wildlife ecology and biology, while integrating cultural considerations through aesthetic design.

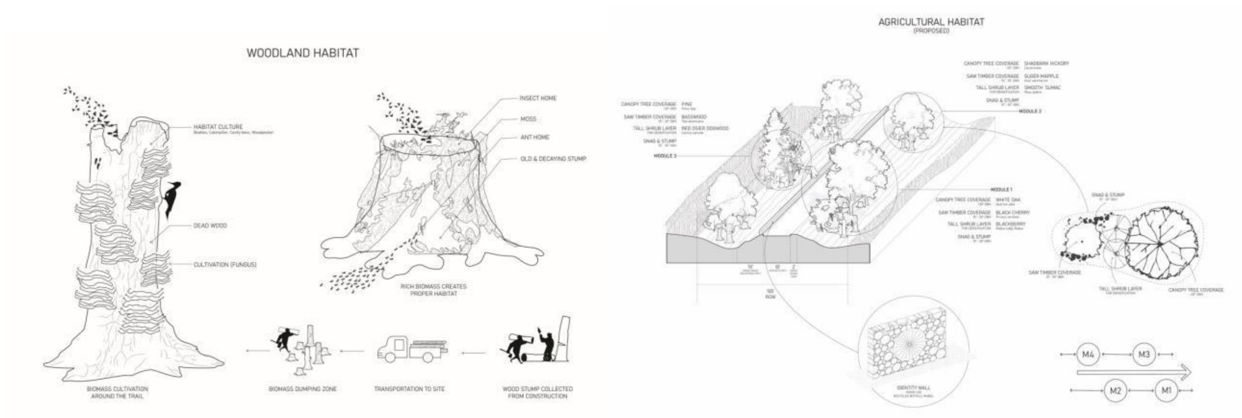

Figure 2. Design sketches exploring the habitat needs of the Pileated Woodpecker, a keystone species, and how they might be accommodated within the trail right-of-way. Elements such as seat walls integrate wildlife habitat and human use of the corridor.

This study uses principles of landscape ecology to discuss rail-trail corridors as novel ecosystem spaces, emphasizing their potential as conservation corridors within agricultural landscapes. Our spatial analysis revealed significant variability in corridor width, connectivity, and land use context. Understanding this variability might guide conservation efforts, e.g. acquiring land to widen corridors in strategic locations or mitigating problematic vehicular crossings that create barriers for wildlife. Our conversations with trail managers revealed that while rail-trail corridors are considered ecologically important, that is largely because these parcels offer biological and structural diversity outside of an otherwise agriculturally dominated landscape. Segments considered ecologically valuable are prioritized for active management, while the vast majority see little intervention beyond mowing and noxious weed control. Hypernature, a concept from landscape architecture theory, is brought into the conversation as a method of reimagining experimental landscapes that integrate novel ecosystem design and management to amplify key ecological functions in order to offer great benefits for both wildlife and human users. Looking forward, future research in this area might further explore the natural history of rail-trail corridors; explicate the ecosystem services currently provided by rail-trail corridors; or study how hypernatural interventions are perceived by human users.

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