An Analysis of Habitat Structure and Corridor Connectivity for Wildlife at the Pierce Cedar Creek Institute

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Introduction

The world we live in is constantly in the state of change. With the human population of the country and even the world continually rising, it is necessary to consider how human disturbance of ecosystems has an impact on those systems and their biotic diversity. One way used to monitor these changes is to look at the landscape level ecology of sites in order to determine how patches, corridors, and matrices combine in unique ways to create a landscape mosaic through which the biodiversity of various systems might flow (Forman 1999).

An analysis of the composition of the landscape in an area makes it possible to determine the connectivity of its various mosaic pieces and the biotic potential of organisms to move within that landscape . Kozova, Smitalova, and Vizyova (1986) have noted that the ecological stability of a system is tied to the network connectivity of that system and the system of corridors, source habitats, sink habitats and nodes which exist within the system. Corridors can be defined as those linear landscape features which provide organisms the ability to move from one patch of habitat to another, but will not necessary provide the means for the organism to reproduce within that area. Conversely, nodes are habitat patches or collections of patches which provide the ability the resources for the survivorship, reproduction and movement of the organism. If the habitat patch allows for stable or growing populations, it is considered a source habitat, while if the habitat patch depends on the immigration of organisms, it is considered a sink habitat (Rosenberg et al. 1997, Pulliam 1988). Nodes are those patches between habitat nodes which do not provide the resources of a source or sink, yet provide critical linking points within the matrix habitat while moving between source habitats.

These networks provide habitat for various species, conduits for the flow and movement of species along the corridors, and barriers which can restrict the flow of species within the landscape matrix (Forman 1999). The ability of organisms to move within this network of habitats is governed by a number of factors. The natural history of the organism is a key component which needs to be considered in the ability to move within the network (Danielson and Anderson 1999, Wiegand, Revilla, and Moloney 2002). Each organism will respond to the network structure in a different manner. The degree to which the habitat is fragmented is also an important consideration which may effect movement (Andrén 1994). While fragmentation is a major concern, how that habitat is fragmented is very important. The landscape matrix between these fragmented habitats may be a key component in the ability of organisms to move between the source habitats (Gason et al. 1999, Mabry and Barrett 2002, Kozakiewicz 1993, Åberg et al 1995). For some species, crossing the matrix between these source habitats may not be considered without the presence of a corridor (Gill 1978, Stamps et al. 1987). However, studies have started to call into question both the importance of connecting corridors and especially their value in relation to greenway construction in urban settings (Beier and Noss 1998, Rosenberg et al. 1997).

The Pierce Cedar Creek Institute (PCCI), located in Barry Co., MI, is one such landscape which has yet to have its network studied and modeled. The fact that the system has had little human intrusion over the last 30 years makes it a valuable site for looking at and modeling how organisms might use network strategies to move within the landscape. Yet, though the PCCI itself has remained a fairly stable system over the last 30+ years, the areas surrounding the Institute have been actively in use, primarily as agricultural lands, and do play a role in understanding the landscape network connectivity for the PCCI itself, especially as it relates to larger vertebrate species.

In order to begin to effectively assess and model networks within the PCCI and surrounding landscape, it is necessary to first construct baseline data of the site. Future research projects will then use this constructed landscape mosaic model to conduct additional modeling of species utilization of the networks within the landscape mosaic. This baseline research study includes mapping of the landscape matrix of the PCCI property and establishing a preliminary model of potential network corridors, source/sink habitats, linkages, and flows within the mosaic patchwork.

Methods

To develop a baseline map of the landscape mosaic of the PCCI property and its corridor connectivity, the research team made use of a variety of cartographic techniques. These pieces were used in a series of phase analyses to create a series of maps for use in developing models of networks in future research.

Phase 1: Analysis and mapping of aerial map data

In the first phase of the project, the student researcher and faculty mentor constructed a grid and map of the site using source information from existing GIS property descriptions obtained from the Barry County zoning office. Other source information (transportation corridors, water and wetland data, topographic data, etc.) was also incorporated into the mapping to create a multidimensional working perspective of the landscape in and around the PCCI site. A boundary map of the PCCI property was downloaded into ESRI's ArcGIS and a grid was constructed by dividing the property into 50 meter increments. This grid map created a working document to be used for ground proofing and was used to resolve conflicts between the 2004 aerial image data, other source information and the current framework geography.

Phase 2: Field Proofing GIS map data

The grid developed in ArcGIS was downloaded into a Thales MobileMapper GPS unit to provide a background image for the field proofing of the site. This field proofing allowed the researchers to determine the extent to which the 2004 aerial image data and other data was consistent in the description of the site, append computer maps to represent ecological data which was not visible from the aerial maps, and correct for changes in the mosaic which have occurred since the creation of the aerial photographs. The gridded system of analysis required the researchers to walk the gridlines as they appeared on the Thales GPS unit. Each time the researcher arrived at an intersection point of two gridlines, the habitat type at that location was identified and recorded onto the GPS unit. While walking, the researcher also logged data for the boundaries of wetland areas, streams, fences, roads, trails, and wildlife trails that happened to occur between intersection points on the grid.

Data collected from the field proofing of the site was downloaded to ArcGIS and incorporated into the aerial imagery and other data related to the PCCI site. This allowed for the beginning of the third phase of the research.

Phase 3: Network Analysis

Using the map data generated from interpretation of the aerial imagery and field proofing, the researchers constructed a model of the habitat matrix of the PCCI site. An analysis of this model allowed the researchers to create a model of potential wildlife corridors, nodes, and gaps on the PCCI site. The designation of the corridor networks was divided into two separate maps, one for land habitats and one for wetland habitats, given the divergence between these two major designations of habitat types. Wildlife trails visible in the aerial imagery were also noted as corridors. Areas which acted as waypoints along these trails (tree islands and other smaller forested areas) were defined as nodes. Major habitat areas within the mosaic were defined as source habitats (Kozova et al. 1986, Rosenberg et al. 1997). This research does not allow for the addition of sink habitats as this is related to specific species. The researchers calculated the areas of land ecosystems, wetland ecosystems, and open water areas using the calculate area tool located in the ArcGIS Toolbox. These values were copied and pasted into Excel for data analysis. Because this project is the collection of baseline map data, this aspect of the project is only a preliminary analysis of networks within the landscape, with future research investigating more species specific use of networks.

Results

Analysis of aerial imagery and data collected during field proofing allowed the researchers to create a baseline map of the landscape mosaic found on PCCI (Figure 1). From this map, the researchers calculated the areas of land ecosystems, wetland ecosystems, and open water polygons using ArcGIS. Four basic ecosystem types were found on the PCCI property. These include: old fields and prairies, dry forests, coniferous wetlands, and non-forested wetlands. Figure 2 illustrates that of the four types of ecosystems, the dry forests were found to be most prevalent by covering 41% of the total property area. The dry forests were composed of seven major forest types, including:

Black Cherry/Maple, Beech/Maple, Maple, Hickory, Walnut, Oak, and Upland

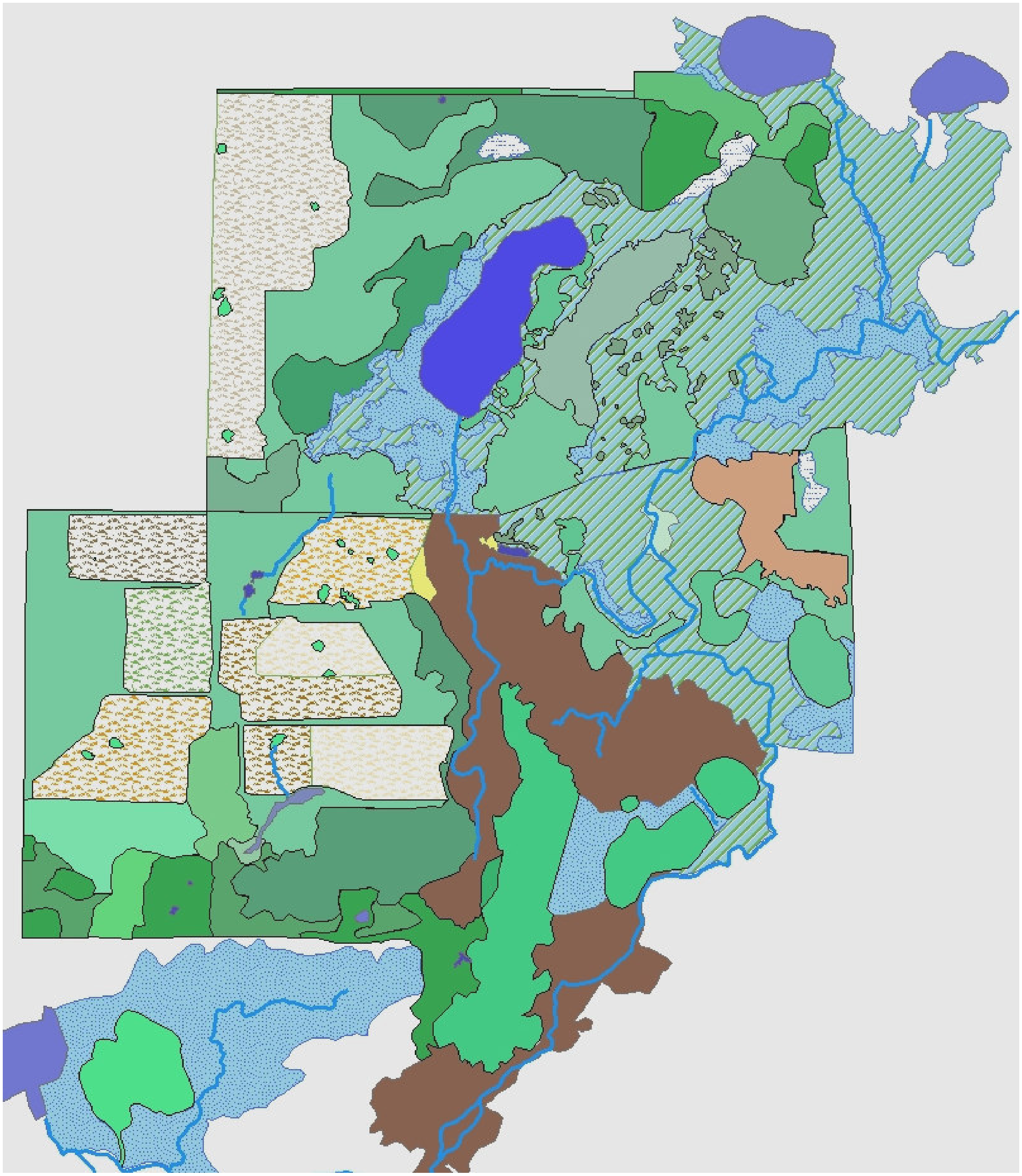

Figure 1. Habitat analysis of the PCCI Property

trees/shrubs. Upland trees/shrubs were the most abundant of these forest types, comprising 40% of the total dry forest area (Figure 3).

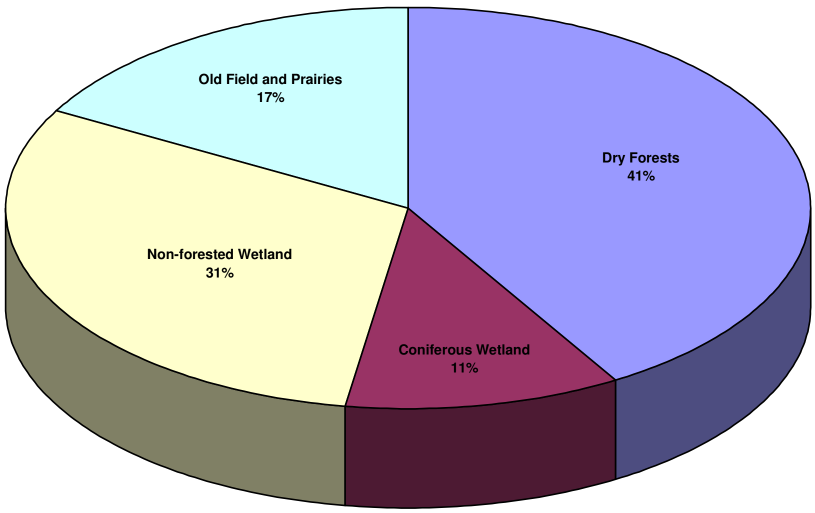

Figure 2. Basic Ecosystem Types based on Percentage

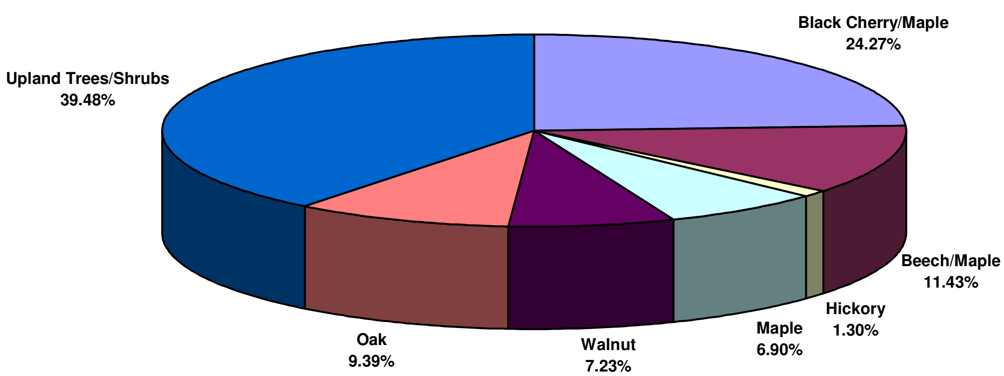

Figure 3. PCCI Dry Forest Types based on Percentage

The PCCI wetlands were composed of a variety of wetland types including vernal ponds, wet meadows, coniferous wetlands, deciduous swamps, deciduous wetlands, emergent wetlands, mixed wet vegetation, and fen/sedge wetlands. Figure 4 exhibits that almost 56% of the total wetland area is made up of the fen/sedge wetlands, while Figure

5 shows that of the total wetland area only 5.42% is open water while the other 94.58% is vegetated wetland.

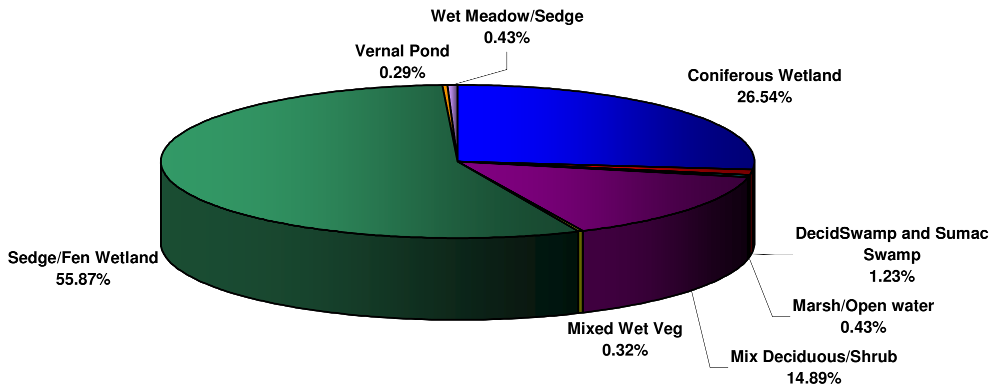

Figure 4. PCCI Wetland Ecosystems based on Percentage

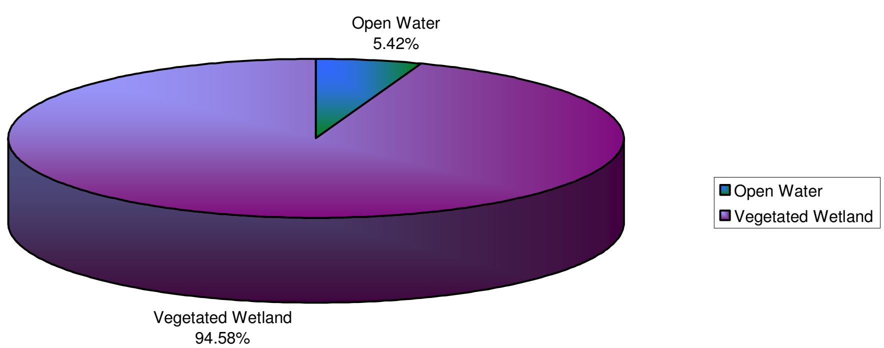

Figure 5. Comparison between PCCI Open Water and Vegetated Wetland Ecosystems

An analysis of the network of the PCCI site based on the above habitat analysis shows that the PCCI site contains a complex and rich land network system (Figure 6). An analysis of the land ecosystems on the site shows a total of 612 corridors and linkages and 226 nodes and source/sink habitats. Using formulas from Forman (1999) this demonstrates a gamma index for network connectivity of 0.911 and an alpha index for network circuitry of 0.866 (Table 1).

The wetland ecosystems (Figure 7), though large in size, show a lesser degree of connectivity, with a gamma index for network connectivity of 0.275 and an alpha index for network circuitry of -0.099 (Table 1).

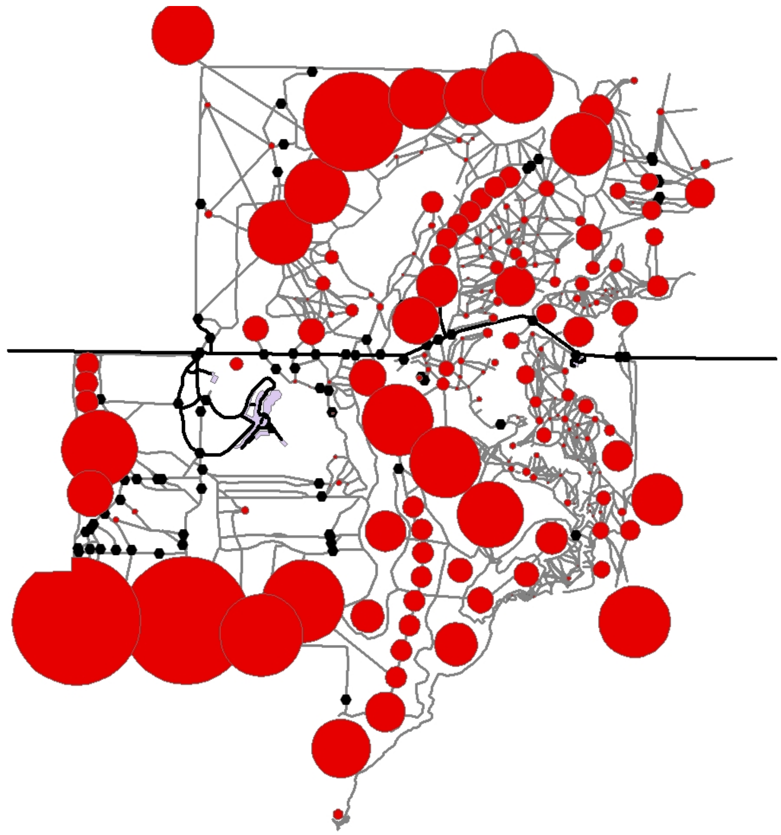

Figure 6. Network structure of land ecosystems at the Pierce Cedar Creek Institute.

Table 1
Comparison of the gamma and alpha indices for connectivity and circuitry at PCCI

System Type	Nodes (V)	Linkages (L)	Connectivity (γ)	Circuitry (α)
Land Ecosystems	226	612	0.911	0.866
Wetland Ecosystems	48	38	0.275	-0.099

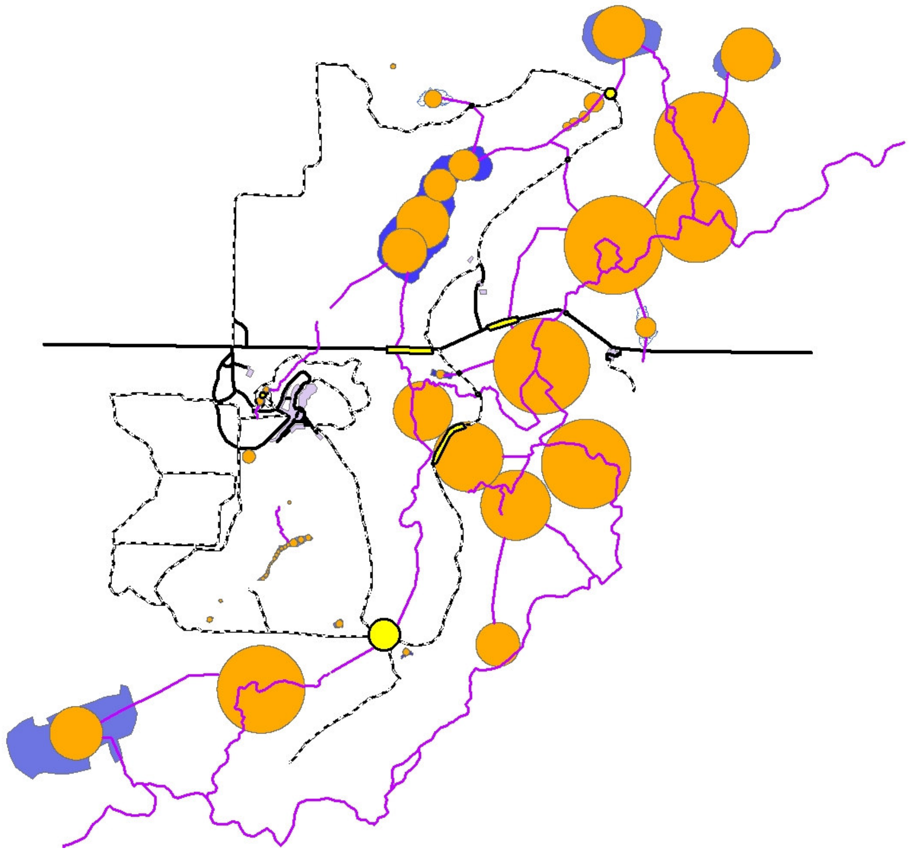

Figure 6. Network structure of wetland ecosystems at the Pierce Cedar Creek Institute.

Discussion

The purpose of this research was to create a baseline survey of the habitat types of the PCCI sites and from this develop an initial model of the networks occurring within the landscape mosaic. This survey shows that the PCCI site has a rich mix of both land and wetland ecosystems which support a high level of connectivity and circuitry. A comparison of the land ecosystems at PCCI with another natural area site in Grand Rapids, MI (Blandford Nature Center) shows that the degree of connectivity and circuitry at the PCCI site is quite high in comparison (Table 2) (Lemberg and Keys, 1999). The degree of connectivity on this site raises some interesting questions regarding the movement of organisms across the landscape mosaic. Further research opportunities will explore some of the potential ways in which organisms use this rich system.

Table 2
Comparison of connectivity and circuitry between two natural area sites

Area	Nodes (V)	Linkages (L)	Connectivity (γ)	Circuitry (α)
PCCI	226	612	0.911	0.866
Blandford Nature Center	21	22	0.39	0.05

The degree to which the aerial imagery indicates that organisms travel across the matrix between various source habitats also helps support the research of others who have theorized that the use of the matrix between source habitats may be as important as the use of corridors between those source habitats (Mabry and Barrett 2002, Bolger et al. 2001, Beier and Noss 1998).

Potential for Future Research

In conducting this research a number of issues were seen as potential future research projects using this research as the baseline for which it was developed. As research was conducted, it was noted that there was a preponderance of wildlife trails cutting through source habitats. These trails were of a significant nature and were extremely well traveled. This has raised questions as to the nature of the use of these well established trails and the potential ability of allowing edge predators deeper access to source habitats than would have initially occurred.

Field proofing also showed a high number of invasive species beginning to establish large populations within the wetland corridors. Future research may focus on the migration of these plant species within the corridors. The ability to predict the migration rate may allow for effective management of invasive species in the future.

It is hoped that this baseline research will enable future researchers to establish areas of further study, and will serve as a guide to create ideas and stimulate thought on the movement of organisms within the PCCI site.

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Note: Full scale versions of these maps with their associated legends are available in the map archives located in the PCCI Wet Laboratory. GIS files of the research are available from the lead researcher by request.