Microhabitat Selection of the Endangered Five-Lined Skink
(*Plestiodon fasciatus*) in Rondeau Provincial Park, Ontario

Elizabeth Vincer¹

¹Department of Environment and Resource Studies, University of Waterloo, Waterloo, ON, Canada

Abstract

Microhabitat selection of the endangered Five-lined Skink, *P. fasciatus*, is a critical but understudied component of the species' biological requirements. Threats to this species in southern Ontario are mainly from increased urbanization and associated habitat fragmentation and loss. Due to severe population declines, *P. fasciatus* has been listed as endangered by the Canadian federal government and action must be taken to reverse the decline of the species. My objective was to quantify microhabitat attributes of *P. fasciatus* in order to provide information for the federal Recovery Strategy that will be prepared. I located and measured diurnal microhabitat variables of *P. fasciatus* in Rondeau Provincial Park, Ontario. This study was conducted from September 18 – October 19, 2009 as information is lacking on habitat selection just prior to hibernation. A total of five plots were surveyed and eight observations were recorded during the field season. To determine which variables are important in microhabitat selection, eleven habitat variables were compared between eight occupied and four unoccupied sites at Rondeau. Principle Components Analysis and Analysis of Variance showed that the length and width of the cover objects as well as air and soil temperature were the most significant variables measured. *P. fasciatus* appear to prefer cover that is at least 0.09m wide (*P* < 0.05) and between 0.40m – 2.00m long (*P* < 0.05). High air and soil temperatures (*P* < 0.001) were also significant in predicting use of microhabitat compared to unoccupied sites. This study will contribute towards the general biological information required to create a federal Recovery Strategy for the endangered populations of *P. fasciatus* in southern Ontario.

Introduction

The global loss of biodiversity has prompted the creation of policies towards protecting endangered species, or those species thought to be most at risk of extinction (Baumgartner 2004). An increasing number of the world’s species are becoming endangered and extinct. This has forced scientists, conservationists and government authorities to prioritize and identify species at risk and take action to prevent the further loss of these species as early as possible (Zhou and Jiang 2005). In Canada, since the arrival of the first European settlers, more than 30 species have gone extinct and to date over 500 plant and animal species are considered at risk by the federal government (Champagne 2007). Amphibians and reptiles represent the highest risk status of terrestrial vertebrates, with more species listed as at risk than both mammals and birds (Gardner et al. 2007). Most studies on habitat fragmentation and loss of biodiversity focus on mammals and birds, but reptiles represent an important taxonomic group that can be indicative of regional biodiversity (Berry et al. 2005).

In Canada, there are six species of lizard listed as at risk by the Committee on the Status of Endangered Wildlife In Canada “COSEWIC”. The details of their status are
shown in Table 1. The greatest potential threat to lizard species in Canada is the loss of their habitat (Seburn and Seburn 2000; Quirt et al. 2006; COSEWIC 2007). Only one species of lizard exists in the province of Ontario, the Five-lined skink \([\textit{Plestiodon fasciatus}, \text{Linnaeus 1758}]\) formerly identified as \(\textit{Eumeces fasciatus}\). \(\textit{P. fasciatus}\) has experienced declines in abundance in its southern Ontario populations because of conversion of suitable habitat to agricultural land and urban land used for commercial and recreational purposes (Hecnar and McCloskey 1998).

Table 1. Status of Canadian lizard species listed on the Species At Risk Public Registry by COSEWIC as of February 27, 2008

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Province</th>
<th>Federal Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\textit{Elgaria coerulea})</td>
<td>Northern Alligator lizard</td>
<td>British Columbia</td>
<td>Not at risk</td>
</tr>
<tr>
<td>(\textit{Eumeces fasciatus})</td>
<td>Five-lined Skink</td>
<td>Ontario</td>
<td>Endangered</td>
</tr>
<tr>
<td>(\textit{Eumeces septentrionalis})</td>
<td>Prairie Skink</td>
<td>Manitoba</td>
<td>Endangered</td>
</tr>
<tr>
<td>(\textit{Eumeces skiltonianus})</td>
<td>Western Skink</td>
<td>British Columbia</td>
<td>Special Concern</td>
</tr>
<tr>
<td>(\textit{Phrynosoma douglasii})</td>
<td>Pygmy Short-horned lizard</td>
<td>British Columbia</td>
<td>Extirpated</td>
</tr>
<tr>
<td>(\textit{Phrynosoma hernandesi})</td>
<td>Greater short-horned lizard</td>
<td>British Columbia</td>
<td>Threatened</td>
</tr>
</tbody>
</table>

The percentage of threatened species in an area tends to increase as the level of human presence and activity increases (McKinney 2002). This is likely due to the fact that the areas of land most suitable for human development are often the same areas that support a high degree of species richness (Lugo 2002). High levels of human development and activity has direct implications for \(\textit{P. fasciatus}\) in Ontario because most populations are limited to the southern part of Ontario (see Figure 1). Southern Ontario is the most developed part of the entire country of Canada, and therefore it is apparent that the habitat of \(\textit{P. fasciatus}\) is directly threatened by human presence (Seburn and Seburn 2000). Reptile responses to urban development and impact are considered to be the least understood of all vertebrate taxa in urban environments (Germaine and Wakeling 2001). Even protected areas in Southern Ontario can be considered slightly to moderately...
urbanized due to the paving of roads through the parks and development of cottages in some cases. In order to conserve and protect native species such as *P. fasciatus*, it is critically important to understand the habitat requirements and other life needs of this species that exists within urban remnants of land (Garden et al. 2007).

Studying the habitat selection of *P. fasciatus* is an important aspect to conserving this species. Habitat selection is described as the series of decisions that an organism makes which leads to its decision to settle in one location over another (George and Zack 2001). Microhabitat selection refers to the choosing of certain sites that are used for activities such as reproduction, basking, nesting, predator avoidance, or other biological needs (George and Zack 2001). Habitat selection is one of the most poorly understood ecological processes (Krebs 2001) due to the complex variety of factors that can influence variation in habitat selection (Fortin et al. 2008). Yet it is a central theme in ecology and conservation biology (Quirt et al. 2006) despite the lack of available knowledge on the subject. The suitability of a particular habitat is influenced by a number of variables operating at a number of different spatial and temporal scales, and suitability is constantly changing over time due to both natural and anthropogenic influences (George and Zack 2001). Studies about habitat use and selection are important to understanding the biological requirements of animals as well as the strategies they use to meet these requirements (Guido and Gainelle 2001; Manly et al. 2002). Gathering detailed information on patterns of habitat use through studies is also essential for management and conservation purposes (Scott et al. 2002; Guisan and Thuiller 2005) in order for the designated authorities to make informed decisions.

Microhabitat features are critical for ectothermic species such as lizards, because they use these features to regulate their body temperature relative to ambient temperatures (Avery 1982; Grover 1996). For lizards in particular, this is especially true at higher latitudes (Rosen 1991; Shine and Mason 2004) including southern Ontario. Part of the explanation for this latitudinal trend is that relative to more abundant populations of *P. fasciatus* in the southern United States, skinks in Canada have a shorter active season and in autumn must search for suitable hibernation sites (Powell and Russell 2007). Hibernation sites at higher latitudes (as in Ontario) of a species range must protect the skinks from colder conditions for longer periods of time which means that there will likely be fewer suitable sites for overwintering. Hibernacula are critical habitat features because they must reach below the frost line and be humid enough to prevent overwinter desiccation (Rutherford and Gregory 2003) and their availability may limit the distribution and abundance of populations (Gregory 1982). Knowledge of specific physical characteristics such as the moisture level and range of temperatures of hibernation sites are lacking for *P. fasciatus* (COSEWIC 2007). Since nesting sites are a subset of preferred microsites used by skinks (Howes and Lougheed 2004) it is likely that hibernacula are also a subset of the most optimal cover sites used by the species throughout the active season. It is possible that towards the end of the active season the skinks may only be found near these hibernation sites. Rutherford and Gregory (2003) designated any capture sites of lizards after September 1 to be hibernation sites. Since hibernacula have ideal microclimate conditions, they are extremely important to the persistence of local populations, and more effort and
research needs to be done to identify these sites for species at risk (Ontario Ministry of Natural Resources 2000). There is also currently little understanding of the seasonal habitat use patterns in small lizard species (Rutherford and Gregory 2003), therefore phenology is particularly influential for *P. fasciatus* and phenological responses to weather conditions may be critical in small species at risk, especially as global climate changes progresses (Gienapp et al. 2005).

The Canadian federal Species at Risk Act (“SARA”), recently listed *P. fasciatus* as endangered in April 2007 (COSEWIC 2007) and this was concurrent with the Ontario Endangered Species Act listing of *P. fasciatus* under Schedule 5 as a species of Special Concern (Endangered Species Act 2007). This means that where the species occurs on either federal or provincial land, the skink will be protected along with its critical habitat. Ontario generally defers the creation of a recovery plan for species of Special Concern where one is being written by the federal government (ESA 2007 Chapter 6, Section 12, Subsection 2). A federal recovery strategy is required to be created within one year for any species newly listed as endangered, and the purpose of this strategy is to identify what actions need to be taken towards stopping and reversing the decline of the listed species (SARA 2008). Since *P. fasciatus* was listed as endangered by COSEWIC in April 2007, the recovery strategy is currently being written. While this would seem to be a good first response to declining populations, a brief assessment of all existing federal recovery strategies for species at risk in Canada shows that the majority of documents have had their posting for public review delayed one year past the due date, and the recovery documents that are finalized are limited by a lack of available information on the biology of the species. Recovery strategies in the United States also suffer from lack of information thus undermining their confidence and effectiveness in the preparation of these strategies (McCoy et al. 1999).

Estimating population abundance of *P. fasciatus* is extremely difficult (COSEWIC 2007) as skinks are cryptic. This secretive nature makes the study of their behaviours very difficult under natural conditions (Fitch and von Achen 1977). Currently, there is a restricted understanding of the factors limiting the distributions of lizards in Canada (Powell and Russell 2007). COSEWIC (2007) identified several key factors leading to the decline of *P. fasciatus*, including habitat and microhabitat alteration, illegal collecting for the pet trade, depredation by raccoons and road mortality. Genetic drift and lack of metapopulations could also be limiting factors for these populations. Genetic drift acts strongly in small, fragmented populations to influence the fixation and loss of alleles, which reduces genetic diversity and makes it less likely that a population can adapt to changing conditions (Willi et al. 2006). A metapopulation is described as a collection of partially breeding habitat patches connected by occasionally dispersing individuals and therefore each patch exists with a significant probability of extinction (Smith and Green 2005). Without new genes from outside populations, it is possible that the southern populations of *P. fasciatus* will be threatened by genetic drift more than if there were connections between these populations and other populations from the United States or northern Ontario. The complexity of these limiting factors emphasizes the need for more research to ensure that the recovery strategy for *P. fasciatus* is not a superficial
document that only highlights the need for more information to be collected before any actions can be taken to address the decline of the species.

The main southern populations of *P. fasciatus* occur in two protected areas in Ontario, Rondeau Provincial Park and Point Pelee National Park. Rondeau Provincial Park is located in Kent County, Ontario and Point Pelee National Park is located in Essex County approximately 97km towards the southwest of Rondeau. Rondeau is on a sand spit that extends approximately six miles into Lake Erie (Judd 1957). The combination of low latitudes and the effects of the Great Lakes create a Carolinian ecozone within Kent and Essex county (Carolinian Canada 2003; Environment Canada 2003). The only published data on population trends of these southern Ontario populations are based on a population of *P. fasciatus* in Point Pelee National Park, and this population experienced a three to five fold decline in numbers from 1990 to 1995 (Hecnar and McCloskey 1998). The overall number of different skink populations in southwestern Ontario has also declined since 1984, with seventeen populations recorded prior to this time and the presence of only five populations confirmed since 1995 (Oldham and Weller 2000).

The objective of my study was to identify microhabitat features in Rondeau Provincial Park that *P. fasciatus* used late in the active season, in order to contribute to the fundamental knowledge of the habitat use of this lizard in the Carolinian population. In southern populations, there seems to be strong correlation between the presence of *P. fasciatus* and cover elements such as rocks, woody debris, standing snags, tree cavities and anthropogenic materials (COSEWIC 2007). I tested which types of cover elements were most important for the skinks, and I also tested the relative importance of habitat variables at each site e.g. air and soil temperature, physical dimensions of the cover object, and distance to the closest water source. Little research has been conducted on the habitat selection of skinks so late in the active season; thus, my research may help to identify characteristics of microsites that could potentially be important hibernacula. I compared the features of sites where *P. fasciatus* was sighted to randomly chosen sites that were not occupied.

**Methods**

**Study Area**

The research was conducted within Rondeau Provincial Park (42°19′N, 81°50′W) in Ontario. The Park is designated as a Natural Environment park by the Ontario Ministry of Natural Resources and is approximately 3, 254 ha in size (Ontario Parks 2003). Rondeau is home to one of Canada’s largest Carolinian forests, and includes natural features such as marshland, sand dunes, prairie meadows and oak savannah (Ontario Parks 2003). Rondeau has one of the mildest climates in Ontario as it is located next to the most southerly region in the province and is influenced by the Great Lakes, hence the name “Carolinian Zone” as the climate most closely resembles the trends in North and South Carolina in the United States (Carolinian Canada 2003). Bedrock in the immediate vicinity is the Kettle Point formation which is a black, rich organic shale overlain by a thick layer of glacial till (Pianosi and Weaver 1991). The
mean annual frost free-period and annual mean growing period are the second highest in the province which will contribute to a longer active season for *P. fasciatus* relative to northern Ontario populations. The Rondeau peninsula on which the park is entirely located is a cuspat foreland formed by unique wave action and littoral drift in the Great Lakes. The peninsula consists entirely of sand, with surface accumulations of organic debris and leaf litter (Rondeau Park 2008).

In order to include a variety of potential habitat types in the study design, a grid of 100m x 100m squares was laid over a map of the park and twelve squares were randomly chosen (Excel based seed algorithm). Squares were discarded if they were: more than 75% water, located entirely in the western marshland of the park, adjacent to another selected square or located entirely on private cottage property. The rationale for these discards is that either these squares are unsuitable potential skink habitat, or I could not get access to private property. There was one compromise to a completely random sample, i.e. some discards were made to avoid sampling two adjacent squares and therefore increasing spatial heterogeneity in the sampling design.

I travelled to Rondeau Provincial Park on September 17, 2008 and used a GPS unit to find each of the twelve randomly chosen sites in order to assess whether they were suitable for my study. Out of the initial twelve sites, I chose seven suitable study sites and five of these were randomly chosen to be the final study areas. One site was located along the east beach of the park, one site was located along the south beach, one was located across from the Visitor’s Centre, one was located in the prescribed burn oak savannah forest, and one was located in the forest in the heart of the park.

**Field Work**

The sites were fully sampled a total of four times each, on the dates of September 18, 20, 21 and 25, 2008, between 0900h-1500h. These diurnal periods were chosen because skinks can be more easily found when their body temperature is relatively cool, usually in the early morning, especially in the fall when individuals may be especially slow and sluggish (Konze and McLaren 1997). Most field studies of skink habitat reported researchers visiting the study area, on average, between three to six times over a period of seven to fourteen days (Berry et al. 2005; Hecnar 1994; Herczeg

![Figure 1. South beach plot showing sand beach habitat with woody debris (Vincer 2008).](image)
et al. 2007; Howes and Lougheed 2004; Kerr and Bull 2004; Law and Bradley 1990; Quirt et al. 2006). In order to avoid temporal bias for the survey of each site, the order in which the five sites were visited was chosen randomly at the start of each new survey day, so that each site was not being visited at the same time each day. Each site was searched for a total of one hour to provide consistency between the sites. The sampling technique consisted of a systematic visual encounter search and a flip of all potential cover objects within the 100m x 100m plot. Potential cover objects included woody debris and cover rocks that could physically be lifted, anthropogenic materials such as cinder blocks and wooden boards, and where possible, peeling tree bark and clumps of shrubs were inspected for the presence of a lizard. This type of visual encounter search of potential cover objects is a common search method for reptiles and amphibians (Heyer et al. 1994).

When a skink was sighted (Figure 3) the GPS co-ordinates of the individual’s location were recorded and predetermined habitat variables were measured and recorded on an observation sheet. This observation checklist was created using a modified format of the microhabitat checklist for amphibians suggested by Inger (1994). The habitat variables included air temperature, soil temperature, soil moisture, substrate type, length, width and thickness of the cover object, percentage of vegetation canopy overhanging the site and the distance of the site from the nearest permanent water source and the type of the water source. Variables such as substrate type and percentage of canopy cover were measured in a 1m radius around the point at which the skink was sighted (Du et al. 2006). General variables such as cloud cover, wind strength and precipitation were also noted, along with any other potentially important observations such as other wildlife seen in the area and evidence of human impacts in the area.

In three of the five plots, no individuals of *P. fasciatus* were ever found during the field visits. Thus, more samples were added, chosen along the east beach. These sites were located in the vegetated areas adjacent to and between cottages along the east beach and also at various Beach Access areas. These areas were identified as potentially important habitat for the skinks, as cottage owners frequently brought full pails of skinks to the Visitor’s Centre from their homes for the staff to examine (E. Slavik, personal communication). These strips of land were visited on three separate occasions, and sightings were made on two visits. After three consecutive visits to all sites with no sightings, it was assumed that most (perhaps all) skinks had retreated to hibernacula as the weather was much cooler. The last survey day occurred on October 19, 2008. Previous records of skink sightings in Southern Ontario reported extreme dates of October 27 in 1984 and September 29 in 1985 as the last date of the year that
a skink was observed before winter (Sutherland 1985), so October 19 was a reasonable date to discontinue further field surveys.

On the final day of fieldwork, October 19, 2008, all previous sighting locations were revisited and for each of these sites a random, unoccupied site was chosen for comparison purposes. Unoccupied sites were chosen between 1m and 5m from the point of observation (Howes and Lougheed 2004) in a randomly determined direction. The direction was chosen by facing north and then looking at the direction shown by the second hand of my watch. The distance to measure out from the point of observation was chosen by rolling one die and measuring out the distance that it showed, unless a six was rolled and then the die was rolled again to get a number between one and five. The maximum of five metres was chosen because in late summer and early fall individuals spend long periods of time in the same spot to maintain thermal equilibrium, and rarely range further than about five meters to forage for food (Fitch and von Achen 1977).

Statistical Analysis

Principal Component Analysis “PCA” is a multivariate statistical method used when measures have been obtained on a number of variables and the goal is to develop a smaller set of artificial variables, or principle components, which will account for the majority of the variation present within the original data set (Statistical Analytical Software 2002). PCA has been commonly used in studies on reptile microhabitat traits to determine which variables are the most important in determining reptile presence (Law and Bradley 1990; Melville and Schulte II 2001; Du et al. 2006; Amo et al. 2007). The PCA in this study was used to interpret the relationship between the presence of *P. fasciatus* and habitat characteristics.

Analysis of Variance “ANOVA” is a test for significant differences between means, using the variances within and between groups for the basis of the test (De Veaux et al. 2008). This test will be used to determine which of the Principle Components are having the most significant effects on the microhabitat choice of *P. fasciatus*. These analyses are useful because they estimate the combined importance of all the factors of interest, or variables, as well as comparing the relative importance of individual variables and their interactions (Graham 2001).

Results

In total, there were 8 observations of *P. fasciatus* throughout the sampling period and 4 control measurements. The Principle Components Analysis reduced the 11 measured habitat variables to three components which explained 72% of the total sample variance (Table 2).
Table 2. Loading of variables from the Principle Components Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Components</th>
<th>Components</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Time of Observation</td>
<td>0.00</td>
<td>0.42</td>
<td>-0.38</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>-0.02</td>
<td>0.48</td>
<td>0.42</td>
</tr>
<tr>
<td>Soil Temperature</td>
<td>0.05</td>
<td>0.49</td>
<td>0.34</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>-0.33</td>
<td>0.01</td>
<td>0.34</td>
</tr>
<tr>
<td>Cover Type</td>
<td>-0.30</td>
<td>-0.08</td>
<td>-0.28</td>
</tr>
<tr>
<td>Cover Length</td>
<td>-0.38</td>
<td>0.11</td>
<td>-0.30</td>
</tr>
<tr>
<td>Cover Width</td>
<td>-0.45</td>
<td>-0.01</td>
<td>0.16</td>
</tr>
<tr>
<td>Cover Thickness</td>
<td>-0.48</td>
<td>-0.05</td>
<td>-0.02</td>
</tr>
<tr>
<td>Degree of Decay</td>
<td>0.18</td>
<td>-0.36</td>
<td>0.00</td>
</tr>
<tr>
<td>Canopy Cover</td>
<td>0.13</td>
<td>-0.07</td>
<td>0.26</td>
</tr>
<tr>
<td>Substrate Type</td>
<td>-0.41</td>
<td>-0.09</td>
<td>0.26</td>
</tr>
<tr>
<td>Distance to Water</td>
<td>0.03</td>
<td>0.43</td>
<td>-0.41</td>
</tr>
<tr>
<td><strong>Variance Explained</strong></td>
<td><strong>34%</strong></td>
<td><strong>25%</strong></td>
<td><strong>13%</strong></td>
</tr>
</tbody>
</table>

The PCA generated a graph of the observation points, and this visual representation of the results is shown below in Figure 4. The red circle drawn around the upper cluster of points is for visual purposes only to show the cluster, and does not have statistical significance in terms of the distance between each point in the graph.
Figure 4. Differences in *P. fasciatus* microhabitat composition based on Principle Components Analysis for both occupied and unoccupied sites.

These Principle Components were compared using ANOVA between measurements taken at sites with skinks and measurements taken at sites where skinks were not found. Four of the 11 variables differed significantly (*P* < 0.05): cover length, cover width, air temperature and soil temperature. The F values and P values are shown below in Table 3. Interaction effects between the variables were also tested, but none were significant and therefore they are not reported.
Table 3. Analysis of variance of responses of five lined skink to environmental and structural variables. Analysis was performed using log + 1 transformed data (for homoscedasicity). Only significant effects are reported.

<table>
<thead>
<tr>
<th>Variable</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>9.18</td>
<td>4.23</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Width</td>
<td>9.96</td>
<td>4.48</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>21.45</td>
<td>16.71</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Soil Temperature</td>
<td>18.37</td>
<td>13.90</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

The information presented in Table 3 indicates that the optimal cover length for *P. fasciatus* is between 0.40 – 2.00m, and also that cover width more than 0.09m will promote the use of the cover item by *P. fasciatus*. The results also indicate that at higher air and soil temperatures, there is a greater likelihood that *P. fasciatus* will be found using a cover item that was measured in the study.

**Discussion**

*Microhabitat selection patterns*

It appears that late in the active season and towards the onset of winter, some *P. fasciatus* individuals in Rondeau Provincial Park prefer cover objects that are at least 0.09 m wide and between 0.40 m and 2.00 m long. On days that are warmer and have a high air temperature, the soil temperature will also be warmer which increases the probability that individuals will be found using these cover objects. However, Hecnar (1991) found that temperature did not differ between occupied and unoccupied nest sites of *P. fasciatus*, so this result may be not be a truly significant factor.

Cover objects at least 9 cm wide and 40 cm – 2.00 m long may afford *P. fasciatus* the best opportunities to reach optimal body temperatures late in the active season. Longer cover items may allow individuals to exploit a range of thermal regimes (Quirt et al. 2006) and may provide a higher likelihood for encountering prey items (Seburn 1993). It has been found in previous studies that cover dimensions are one of the most important structural elements for microsite selection in lizard species (Schlesinger and Shine 1994; Webb and Shine 1998; Kearney 2001). This is largely due to lizards being sensitive to the thermal attributes of their habitat (Huey 1991). Hecnar (1994) found that female *P. fasciatus* at Point Pelee National Park preferred large, moderately decayed logs for nesting sites as opposed to smaller logs or cover boards. The prevalence of woody debris as the most common choice of cover object in this study supports the observation at Point Pelee, and the degree of decay of cover materials was also found to be high with the exception of one cinder block and cover board which were completely intact. The preference of decayed woody debris likely has to do with the thermodynamic properties of these cover objects. Ectothermic species may be especially sensitive to local declines in population abundance because of loss of important microhabitat elements that are associated with thermoregulation (Howes and Lougheed 2004).
Most organisms tend to use a variety of different microsites throughout their daily activities (Guido and Gainelle 2001; Vanhooydonck and van Damme 2003) and habitat use of lizards also changes with the season (Dickinson et al 2001). Therefore, it would be useful to obtain measurements of how much time an individual spends at each different microsite throughout the day. Testing what factors drives \textit{P. fasciatus} to use certain microsites would also be beneficial. This could determine if predation, competition, foraging, basking or reproduction are the important factors behind selection of a particular microhabitat. Predation is a factor leading to the decline of \textit{P. fasciatus}, and the costs of leaving a foraging site to seek a refuge site when faced with predation could be reduced when there is greater microhabitat heterogeneity (Wirsing et al. 2007). Habitat heterogeneity in general has the advantage of providing a variety of different niches which can help to maintain overall species diversity (Amo et al. 2007). For \textit{P. fasciatus}, measuring the thermodynamic requirements of different cover objects will be critical in identifying which cover objects are vital to providing optimal conditions for their physiological requirements throughout different life stages.

The degree of shading at the microsite, while important to northern populations of \textit{P. fasciatus}, has been hypothesized to be less significant for the southern populations because it is not necessarily related to a specific type of substrate (Seburn 1993). The results of the PCA and ANOVA indicate that degree of shading as measured by percentage canopy cover was indeed non-significant in this study. Individuals tended to be found in more open areas along the sand dunes with minimal canopy shading. However, this may be related to the fact that searching for and observing \textit{P. fasciatus} in the forested areas at Rondeau is extremely difficult, as they tend to hide in tree bark and rotting logs (Fitch and von Achen 1977; Kerr and Bull 2004). Studies that have quantified canopy cover and lizard abundance generally show a correlation between open areas and higher abundance (Amo et al. 2007). Canopy cover was not found to be significant in this study, but cannot be dismissed as an important factor shaping the microhabitat choice of \textit{P. fasciatus} and should be examined more extensively in the future.

Soil moisture has previously been identified as an important variable in habitat selection. Like temperature, moisture is a critical microhabitat component for ecothermic species (Owens et al. 2008). Hecnar (1991) found that soil moisture under occupied woody debris was significantly higher than moisture measured at adjacent sites, which could help to prevent dessication of \textit{P. fasciatus} during periods of dryness. High soil moisture has also been related to the survival of hatchling lizards in species other than \textit{P. fasciatus} (Warner and Andrews 2002). However, the ANOVA did not detect a significant difference between soil moisture at occupied and unoccupied sites in this study. This could be that since the field visits were late in the summer, moisture variation was less pronounced then it would be in the spring and early summer when Hecnar (1991) measured moisture. Any small scale moisture variations could have been less detectable by the unsophisticated instrumentation used to measure moisture in this study. It will be important to re-evaluate the significance of soil moisture in habitat selection in the future since removal of woody debris can increase the moisture of the soil which has negative effects on lizard abundance (Owens et al. 2008).
Habitat Management

Small organisms such as lizards tend to select habitat at a number of different spatial scales; this emphasizes the need to conserve specific microhabitat features for *P. fasciatus* rather than maintaining “oak savannah” habitat or “dune” habitat in general, in order to achieve effective conservation of this species (Block and Morrison 1998). Sometimes habitat fragments that support high numbers of species are overlooked because they do not fit the description of optimal or natural habitat (McCoy et al. 1999). In this study, the majority of *P. fasciatus* observations were made in areas that were either heavily or moderately used by park visitors and/or cottage owners, and these areas do not necessarily represent the notion of natural habitat. However, this observation is not surprising because lizards can learn to prefer to live around human dwellings due to the increased abundance of insect prey associated with these areas (Pough et al. 2001). Other species such as grasshoppers that depend on the use of microsites have also been found to prefer human altered habitats (Guidan and Gainelle 2001).

Lack of woody debris suitable as microhabitat cover has been attributed to the absence of *P. fasciatus* in areas of high human presence in southern Ontario (Hecnar and M’Closkey 1998). It would be beneficial to produce a spatial map of occupied cover elements throughout the park and document whether or not the cover elements continued to exist in the same location year after year. This is especially important for *P. fasciatus* because individuals are often found in the same location on different occasions (Tyring 1990). If cover items such as woody debris are being removed by visitors or cottage owners for activities such as camp fires, then the Rondeau populations of *P. fasciatus* could suffer major declines in abundance. Cottage owners could be encouraged to provide or maintain rock piles, woody debris piles and other preferable microhabitat elements in their yards and in the natural areas between adjacent cottages. The benefits of decreased insect infestation could be used as an incentive. This cooperation could help to prevent or even reverse the decline of suitable microhabitat features within public areas of Rondeau. Collaboration with private land owners to maintain existing valuable microhabitat structures has allowed the persistence of endangered lizard populations in other areas of the world (Souter et al. 2007), and it is a reasonable suggestion for implementation at Rondeau.

Recovery and Future Studies

*P. fasciatus* was listed as Endangered in April 2007; therefore a federal recovery strategy will be developed within one year of the lizard being listed in order to be in compliance with the Species At Risk Act (SARA 2008). A recovery strategy is essentially a planning tool that identifies what needs to be done in order to stop or reverse the decline of a species. Some of the main sections of a recovery strategy are population size and trends and biological limiting factors (SARA 2008). In light of this, future studies on the populations of *P. fasciatus* at Rondeau Provincial Park will need to address more issues than could be considered in this short study. A current estimate of the population abundance at Rondeau would be extremely useful. This could be obtained by doing a drift fence and pitfall trap survey, which is a much more efficient way of collecting data about abundance then visual encounter surveys (Crosswhite et
Inbreeding depression and the loss of genetic variation is an important aspect of any conservation program, especially ones aimed at protecting small populations of species at risk (Berry 2006). Microsatellite studies and genetic studies have been used on reptile populations around the world to try to assess the probability of these populations becoming extinct (Anderson 2006; Melville et al. 2007; Parham and Papenfuss 2009). Lizards also have lower dispersal abilities compared to other taxa, which could also increase their susceptibility to local extinction (Amo et al. 2007) since there is little or no gene flow occurring between different populations. The need for genetic studies on populations of *P. fasciatus* is apparent.

Prescribed burning is practiced at Rondeau Provincial Park in order to restore the natural successional processes of the black oak savannah. In designated parts of the park that are located close to cottages and the east beach, the forest is burned (Emily Slavik, personal communication). While this practice is important in maintaining the natural oak savannah ecosystem, the impacts on habitat for *P. fasciatus* is unknown. Data collected on the effects of fire on reptile populations report negative, positive and neutral effects, and are too limited to generalize to other sites and scenarios (Smith et al. 2001). There could potentially be a conflict between the preservation of natural ecosystems and the protection of an endangered species, as the burning will remove a lot of woody debris on the forest floor that is important as microhabitat (James and M’Closkey 2003). Also, there is currently no way of knowing if *P. fasciatus* is present within the vegetation of the area that will be burned. Fire is known to cause direct mortality to reptiles (Erwin and Stasiak 1979) who may not be quick enough to escape the blaze. Perhaps an intensive search, capture and release of individuals on the day of the burning would reduce fire related mortality of the *P. fasciatus*.

Global climate change is also considered to be an emerging threat to many species, especially to those at risk. Species abundance and distribution is affected by vital rates including births, deaths, immigration and emigration, which are in turn affected by factors such as climate and resource availability (Hansen et al. 2001). Climate change is expected to cause larger than normal magnitude differences in weather patterns at higher latitudes within the coming decades, and the question of whether a species will be able to adapt to these fluctuating patterns (Guralnick 2006) is relevant for *P. fasciatus*. Marginal populations of *P. fasciatus* at their northern range may become core populations given the rapid rate at which species are shifting their range in response to global climate change (Greenbaum and Komar 2005). Changing climate conditions may also affect the phenology of *P. fasciatus*, as it has already been documented to affect the spring emergence and breeding times of many different taxa (Geinapp et al. 2005). Testing the effects of climate change on *P. fasciatus* will be a critical part of the species’ recovery. Since climate change is more of a global then localized issue, strategies to address this problem will require a level of intense cooperation between public and private stakeholders (Hansen et al. 2001) to effectively address the issue. Long term monitoring programs involving *P. fasciatus* need to incorporate the potential impact of climate change into their objectives.
Conclusions

Conservation initiatives, including recovery strategies, are preferably developed with the most detailed knowledge possible on a species distribution, abundance, life history and habitat requirements (Banks and Skilleter 2007; Souter et al. 2007). Knowledge about the selection of microhabitat sites is especially important for an ectothermic species like *P. fasciatus*. Not only is it important to measure the variables of an occupied microsite, but it is also necessary to understand the factors behind microhabitat selection in order to accurately assess the consequences of different types of land management (Chouteau 2004). Populations of species at risk can be managed more effectively if the most important microhabitat variables are known (Stouffer and Beirregaard 1995; Dickinson et al. 2001). The results of this study can be used as a first step towards identifying important microhabitat components of *P. fasciatus* at Rondeau Provincial Park, and can be applied to other southern populations in different areas of Ontario. More research should be conducted to collect information on this endangered lizard, in order to ensure that the recovery strategy is as detailed and specific as possible which will in turn increase the document’s effectiveness.
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