DIFFERENCES IN PLANT DIVERSITY AND DIMENSIONS BETWEEN EDGE AND CONTIGUOUS FOREST HABITATS

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ABSTRACT

During the construction of Purchase College, a large proportion of forest habitat was removed, resulting in many habitat fragments. The plant species diversity, area density, and area coverage of edge and contiguous forests habitats of different fragments on the Purchase College campus were studied to find any differences between these factors. Several significant differences were found: 1) contiguous habitats have higher plant density and overall tree coverage than edge habitats, 2) both contiguous and edge habitats have more shrubs and bushes than trees, and 3) species diversity and area coverage of shrubs and bushes were highly variable between the habitat types. These differences imply that habitat fragmentation affects plant composition and diversity, but also that the ecology of habitat fragments vary widely from one another. Furthermore, ecosystem management decisions should be made based on the individual ecologies and these effects for particular fragments.

Keywords. Diversity; Edge habitat; Forest habitat; Habitat fragmentation; Plant dimensions

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INTRODUCTION

Habitat fragmentation is a widespread result of converting natural landscapes for human developments. This conversion results in the formation of two distinct habitats: outer edge habitats and inner contiguous habitats. When contiguous habitats become edge habitats, there are many changes in its ecological attributes, such as biodiversity, population dynamics, and ecological processes (Hanski et al. 2015, Magnagno et al. 2014, Riutta et al. 2014, Young et al. 1996). Although there are many known types of changes that distinguish edge and contiguous habitats from each other in most fragmented habitats, the degree of change in ecological attributes between these habitats can vary widely from one another in various parts of the world (Haddad et al. 2015, Young et al. 1996). Oftentimes, these changes caused by habitat fragmentation greatly affect the abundance or distribution of certain plant and animal species. The degree of change in abundance or distribution depends on the fragment's size and degree of connectivity, which is why many conservationists advocate for preserving as much contiguous habitat as possible (Damschen et al. 2014, Davies and Margules 1998, Haddad et al. 2015, Hanski 2015, Riutta et al. 2014).

Habitat fragmentation of forests have been shown to result in a variety of biotic as well as abiotic changes that impair ecosystem function; most fragmented forests have a distinct reduction in biodiversity, altered nutrient cycles, decreased biomass, and a reduction in plant and animal dispersal (Damschen et al. 2014, Haddad et al. 2015, Turner et al. 1996, Young et al. 1996). Like in most habitat fragments, the smaller and more isolated forest fragments often have more adverse declines in ecosystem function, and become worse as time passes (Haddad et al. 2015, Hanski 2015, Riutta et al. 2014). Long-term fragmentation experiments have shown that 70% of remaining forest are within 1 km of edge habitat, and that the remaining contiguous habitat within the fragments are vulnerable to facing the declines in ecosystem function as seen in their edge habitats (Haddad et al. 2015).

The construction of Purchase College resulted in deforestation, leading to habitat fragmentation of its forests. Although most of the forest removed during the campus' construction was secondary forest, some of the remnant forest is primary forest which already has distinct ecological attributes from secondary forests. Although it is easy to distinguish edge and contiguous forest habitats on Purchase College's campus visually, we wanted to quantify the differences between the contiguous and edge forest habitats to determine how significant the differences between these habitats were from one another by comparing the diversity and physical dimensions of their plants.

Our objectives were to quantify the plant density in edge and contiguous forest habitats, quantify the abundance of different plant types within each habitat, evaluate species richness of each habitat, and estimate the total area taken up by plants within each habitat. We predicted that contiguous habitats have higher species richness than edge habitats and that plants in contiguous habitats cover more area than those in edge habitats.

METHODS

The edge and contiguous forest habitats near Purchase College's W2 and E2 parking lots were studied for plant species richness, total plant density, total number of plant types, and estimated area coverage.

Field site. The field sites for edge habitat and contiguous forest habitat near Purchase College's West 2 (W2) and East 2 (E2) parking lots (Fig. 1). The field sites were studied during the month of October in 65°F (18°C) weather and no precipitation. Each sampling site had a standard area of 8x8 m (64 m^2) for final calculations, but the area measured per site was 2x2 m (4 m^2). Measurements and counts from each site were multiplied by 4 to estimate the total sample for each forest habitat type (edge and contiguous) from each parking lot. Measuring tape was used to determine where to isolate the field sites to be studied, and marked with stakes.

Figure 1. A total of four sites were studied: 8x8 m (64 m^2) sites were selected to represent edge or contiguous habitats near parking lots W2 and E2.

Total number of plant types. Plants were categorized by discrete plant types in order to count whole, singular organisms: trees and shrubs/bushes. Grasses in small bunches were counted as shrubs/bushes because most grasses are hard to define as singular organisms. The total numbers of trees and shrubs/bushes were counted in positive integers within each site. The total numbers of trees and shrubs/bushes counted in the study site were then multiplied by 4 to estimate the total numbers of trees and shrubs/bushes within the standard area (64 m^2).

Total plant density. The number of plants in each study site was determined by counting the number of individual trees and shrubs/bushes in each sample plot at each site. The total number of trees and shrubs/bushes were added together to determine the total number of plants at each sampling site. The total number of plants was then multiplied by 4 to calculate the total plant density in the standard area (64 m^2). The result was divided by 8 to estimate the total number of plants per m^2.

Plant species richness. The total number of plant species in each plot was determined by identifying distinct each plant species based on their leaf shapes and other physical characteristics, and referring to books that are guides about forest plants.

Estimated Area Coverage. The area covered by the trees and shrubs/bushes was estimated by determining average plant dimensions (tree circumferences, average tree heights, bush area) in each habitat, based on the measurements of individual plants in each plot, and multiplying the average plant dimensions by 4 to estimate the total area coverage within the standard area (64 m^2).

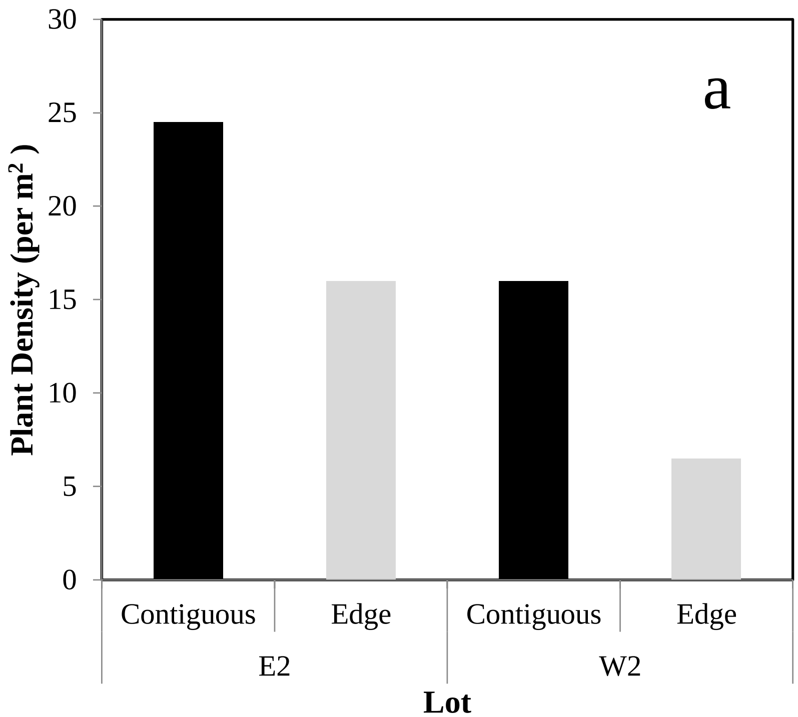
RESULTS

In both parking lots (E2 and W2), the total plant density per m^2 in the contiguous habitats was higher than in the edge habitats (Fig. 2a). All of the plots had proportionately more shrubs/bushes than trees per m^2 (Fig. 2b). The contiguous habitats of both parking lots had more shrubs/bushes than the edge habitats. However, the edge habitat of E2 had more trees than its contiguous habitat, while the contiguous habitat of W2 had more trees than its edge habitat.

The plant species richness (total number of plant species) was higher in the contiguous habitat (7 species) than the edge habitat (4 species) of parking lot E2, but there was a higher species richness in the edge habitat (9 species) than the contiguous habitat (14 species) of W2 (Fig. 3).

Overall, tree coverage was higher in the contiguous habitats than in the edge habitats (Fig. 4). The area coverage of trees based on the estimated average trunk circumference in each plot was higher in the contiguous habitats than in the edge habitats (Fig. 4a), and the estimated average tree height was higher in the contiguous habitats than in the edge habitats of both parking lots (Fig. 4b). Additionally, the tree coverage of the contiguous habitat of W2 (circumference: 110.75 cm, height: 907.5 cm) was higher than the tree coverage of the contiguous habitat of E2 (circumference: 42.5 cm, height: 650 cm).

The area coverage of shrubs/bushes based on the estimated volume in each plot was higher in the edge habitats than in the contiguous habitats of both parking lots (Fig. 5).



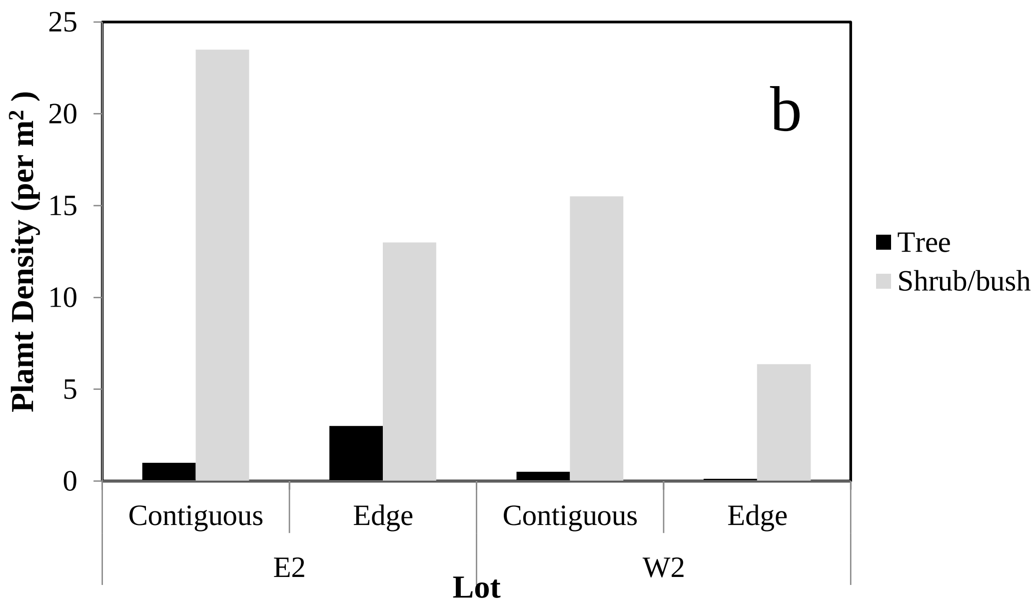


Figure 2. Plant density per m^2. a) The total plant density per m^2 of trees and shrubs/bushes for the contiguous and edge habitats in each parking lot E2 and parking lot W2. The contiguous habitats had a higher total plant density than the edge habitats. b) There were more shrubs/bushes than trees throughout all 4 study plots. The contiguous habitats had more shrubs/bushes than the edge habitats. The edge habitat of E2 had more trees than its contiguous habitat, and the contiguous habitat of W2 had more trees than its edge habitat.

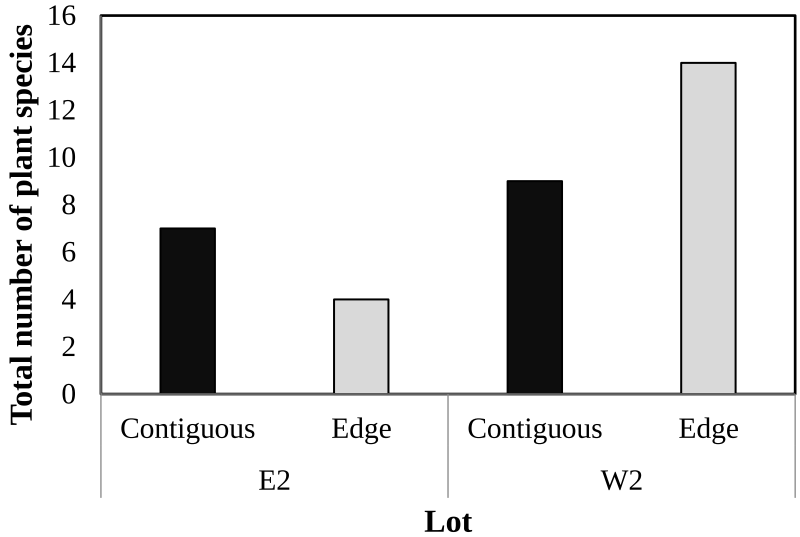


Figure 3. Total number of plant species. The total number of plant species found in the contiguous habitat of E2 was higher than that of its edge habitat, while the total number of plant species found in the edge habitat of W2 was higher than that of its contiguous habitat.

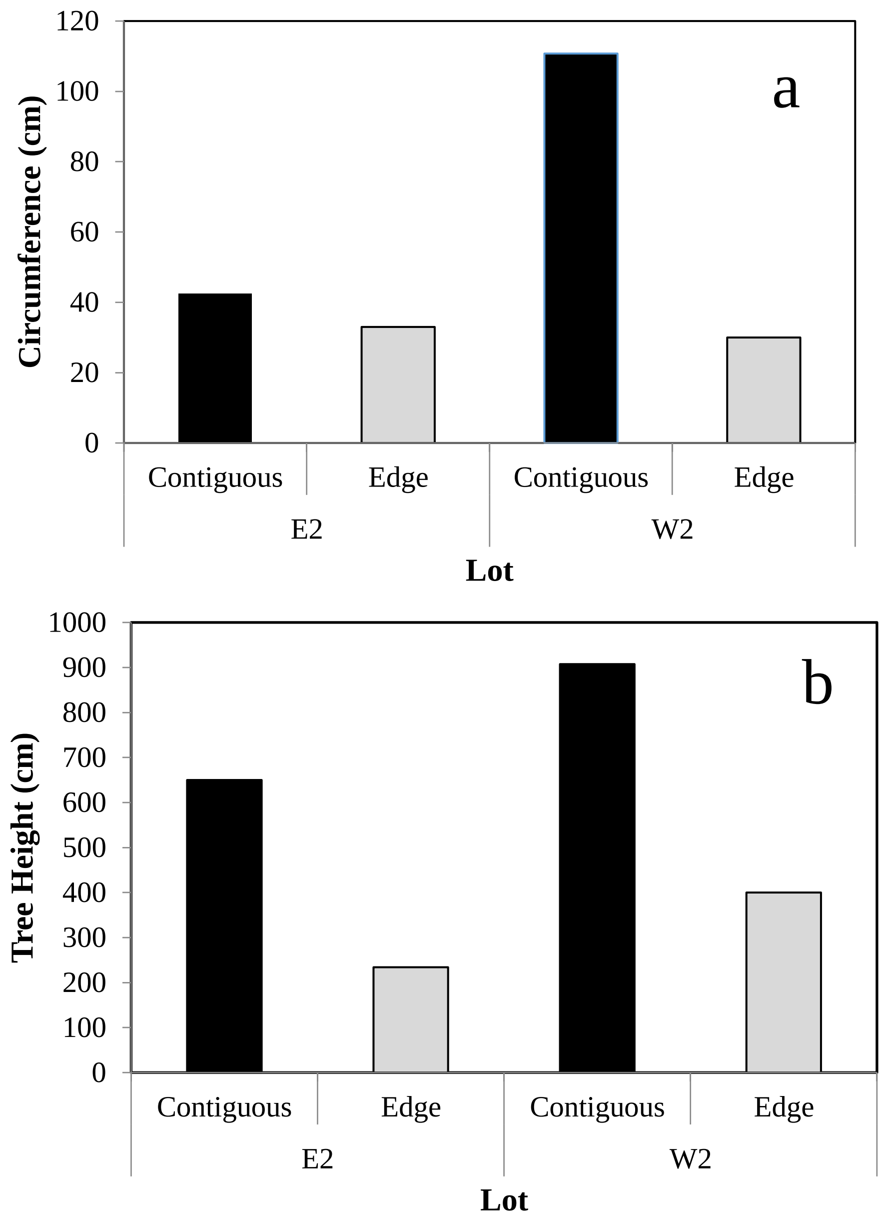


Figure 4. Area coverage of trees. a) The average tree trunk circumference (cm^2) of trees was higher in the contiguous habitats than in the edge habitats of both parking lots. b) On average, the trees in the contiguous habitats were taller than trees in the edge habitats.

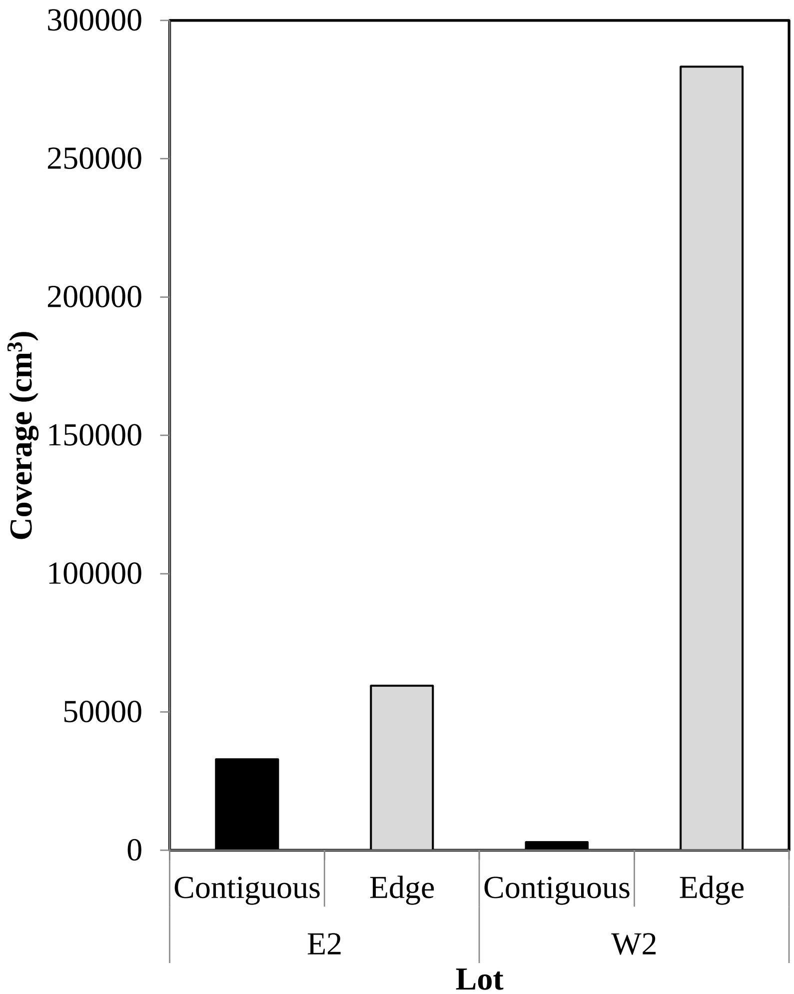


Figure 5. Area coverage of shrubs/bushes (cm^3). The shrubs/bushes in the edge habitats had more area coverage than the shrubs/bushes in the contiguous habitats.

DISCUSSION

Differences between edge and contiguous forest habitat were found by comparing the physical dimensions, composition, and diversity of the plants residing within these habitats. Some of the differences found in this study had more clear relationship than others.

The total plant density and tree coverage were consistently higher in contiguous forest habitats than in the edge forest habitats. These differences were consistent with our prediction that plants in contiguous habitats cover more area than those in edge habitats, indirectly implying that trees in the contiguous habitats have more biomass than trees in the edge habitats (Haddad et al. 2015, Ziegler 2000). Additionally, the trees in W2 were taller (907.5 cm) and had wider trunks (110.75 cm) than the trees in E2 (height: 650 cm, circumference: 42.5 cm), most likely because W2 had primary, old growth forest while E2 had secondary, new growth forest (Ziegler 2000).

Our prediction did not take differences in area coverage between trees and shrubs/bushes into account. The shrub/bush densities were higher than the tree densities in all four lots and the differences in tree density were inconsistent throughout each lot. These results showed that there was an overall higher abundance in shrubs/bushes than trees, but because the area coverage of shrubs/bushes were measured by volume, their area coverage could not be compared against trees.

The differences between tree densities most likely occurred because of differences in nutrient or light availability in each habitat as a result of habitat fragmentation (Haddad et al. 2015). On a broader scale, these differences imply that the ecologies of the habitat fragments vary widely from one another, greatly affecting the abundance and distribution of the trees (Damschen et al. 2014, Riutta et al. 2014).

The differences in species richness were not consistent with our prediction that contiguous habitats have higher species richness than edge habitats. Although the differences in species richness between the contiguous and edge habitats of E2 was consistent with our prediction, these differences in W2 were not consistent, most likely because our prediction did not take plant competition into account. Because the contiguous forest of W2 is a primary forest, the old growth trees outcompete the other plants for space and sunlight because they have larger physical dimensions than those in secondary forests (Ziegler 2000). Furthermore, the trees in the contiguous forests outcompeting other vascular plants is the most probable cause for the higher shrub/bush density in edge habitats than in contiguous habitats (Magnagno et al. 2014).

Further studies should be done on a larger scale and on a frequent basis in order to provide better estimates and predictions for ecological changes in these habitats (Haddad et al. 2015). In order to quantify which type of vascular plant has the highest percentage of biomass in edge and contiguous habitats, the differences in biomass between shrubs, bushes, trees, and grasses should be directly compared in further studies. Furthermore, plant competition should be evaluated by studying the biological characteristics of the plants in each habitat in order to determine which species will most likely outcompete the others, especially when trying to manage invasive species. The differences in these factors between primary versus secondary forests should also be studied in order to encourage habitat preservation (Ziegler 2000). By conducting more thorough studies about what biotic and abiotic factors affect species richness and physical plant dimensions in forest habitats, more informed, individualized decisions for ecosystem management of specific fragmented habitats can be made to prevent further decline in ecosystem function.

CONCLUSIONS

In order to tailor the best ecosystem management strategy for a specific fragmented habitat, long-term studies about the ecological attributes of each fragment and physical characteristics of their plants should be conducted in order to evaluate the ecosystem status of the fragments. By understanding the current status of particular habitat fragments, the most appropriate decisions for these fragments can be made in order to prevent edge effects from spreading to intact contiguous forests. These various edge effects are highly likely to impact the diversity of many ecosystems by affecting their plant and animal species.

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