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Arthropod Communities and Red-headed Woodpecker (*Melanerpes erythrocephalus*) Habitat Selection

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ABSTRACT Red-headed woodpecker populations are near-threatened. Their habitat selection and reproductive success may be related to the availability of arthropods. We sampled the arthropod community within 0.04 ha plots surrounding known nests and compared these findings to plots without nests in the same fragments of forest or park in Cook County, IL. After 14 days, the traps were recovered, yielding close to 45,000 arthropods across 10 orders. Nest and control site differences were not statistically significant. Differences between park and forest diversity were not statistically significant either, but the greater diversity values in forests were consistent with expectations. We conclude that factors other than arthropod availability are likely controlling red-headed woodpecker habitat selection.

INTRODUCTION

Red-headed woodpecker (*Melanerpes erthyrocephalus*: RHWO) population sizes declined during the 20th century [Sauer et al. 1997, Smith et al. 2000]. The species is now classified as "near-threatened" by the International Union for the Conservation of Nature [IUCN 2013]. Loss of biodiversity in an ecosystem can trigger changes in the abundance of disease vectors, which may increase transmission rates of infectious diseases for humans, plants, or other animal species [Pongsiri et al. 2009]. As a result, it becomes valuable to research potential factors that may contribute to the decline of RHWO populations [Smith et al. 2000].

RHWO are an omnivorous bird species that supplement their diet with small animals (e.g., flying insects, beetles, lizards), mostly during the summer months [Smith et al. 2000, Venables and Collopy 1989]. Historical records of the diet indicate that RHWO may feed on spiders [Bailey 1920], honeybees [Roberts 1932], grasshoppers [Jackson 1976], adult beetles, ants, and cicadas [Beal 1911]. A quantitative analysis of the contents of over 400 RHWO stomachs from across the species' entire range showed that about 34% of the annual diet consisted of animal material [Beal 1911]. In comparison, the

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winter diet of RHWO consists of up to 96% plant material [Williams and Batzli 1979]. Arthropods are the primary animal prey that RHWO feed on, and the most common foraging behaviors for obtaining arthropods are fly-catching (80% of their foraging effort) and bark gleaning (6% of foraging effort) [Beal 1911, Venables and Collopy 1989, Smith et al. 2000]. Together, these results indicate that RHWO summer nutrition may be largely dependent on the availability of potential arthropod prey.

RHWO territories are distributed in relatively open patches of deciduous woodland, as well as urban areas where they are found in golf courses [Bull 1974], parks, and cemeteries, as long as the habitat surpasses a threshold of dead wood availability to provide substrate for nesting [Smith et al. 2000]. Individual RHWO may migrate in the winter if the food supply seems inadequate, and northern populations in the late spring and summer months are comprised of both permanent resident and migrant birds [Smith et al. 2000]. Chicago sits just north of the midpoint of the RHWO range, which covers the majority of the United States west of the Rocky Mountains, and portions of Canada near the border [Smith et al. 2000]. Biotic factors that may affect nest site selection could be interspecific competition, such as with the European Starling (*Sturnus vulgaris*) [Ingold 1989], or the availability of food sources such as hard-mast [Smith et al. 2000]. Arthropod abundance has been measured to understand nest-tree selection for a related woodpecker species, the red-cockaded woodpecker [Horn and Hanula 2002], but this study is the first to measure habitat scale arthropod abundance and diversity in the vicinity of RHWO nests.

The availability of food influences the survival, growth rate, and fecundity of an organism, so to research this in respect to the RHWO, we assessed the arthropod community around RHWO nest cavities in relation to nearby areas without nests. The objective was to determine if the arthropod community plays a potential role in RHWO nest site selection. We asked the question: is there a difference in arthropod abundance and diversity between RHWO nest sites and non-nest control sites? If RHWO select nest sites based on the availability of arthropods, we would predict that nest sites would have arthropod communities that are more diverse and abundant compared to a random nearby control site.

METHODS

STUDY SITES AND PLOT DESIGN

We used reports from the Bird Conservation Network and the Audubon Society Chicago Region to identify 16 RHWO nest trees that were active in 2012, either in Cook County Forest Preserves (CCFP, n=11) or Chicago City Parks (CCP, n=5; Figure 1; Rosehill Cemetery was grouped with the city parks due to its manicured grass lawn). In the summer of 2013, around each nest we measured a 0.04-hectare plot (circle with 11.3m radius) to gather information on RHWO habitat characteristics, including species, size, and decay class for all trees within the plot. For each nest plot, we established two paired control plots that were a minimum of 100m away from the nest tree in the same patch of forest or park, centered on a control tree with diameter at breast height greater than 40 cm.

STICKY TRAP CONSTRUCTION, SETUP

The design of the CD sticky traps was adapted from Bar-Ness et al. (2011). Sticky traps were chosen as the collection method that is most relevant to RHWO because it has the tendency to catch flying insects and arthropods that crawl along the bark, in addition to being highly replicable and inexpensive. We removed the CD mounting crown and lid from each case, and brushed Tanglefoot® sticky trap glue evenly across the inside front panel to create a trapping surface of 175 cm^2 (12.5 cm x 14 cm). In July and August 2013, we set up four sticky traps along the perimeter of each plot, facing outward from the nest tree in each of the four cardinal directions. We fastened the traps flat against each tree, approximately 3 m off the ground, using two strands of 20-guage galvanized steel wire that were threaded through the pre-drilled holes in the corners of the CD case and then around the tree. We collected the traps after 14 days, and closed each one by reattaching the CD case lid.

STICKY TRAP PROCESSING

We photographed each trap using a Nikon® DSLR camera, and then analyzed the images using the cell counter plug-in on ImageJ 1.47 for Mac [Rasband 1997-2012]. We counted and classified every arthropod to order (e.g., Diptera, Hempitera). To confirm or correct the classification of the arthropods on the images, we also inspected each sticky trap under a Nikon® 50x zoom dissection microscope.

DATA ANALYSIS AND STATISTICAL METHODS

We extracted three continuous variables from each of the 48 plots. These variables include abundance, the mean number of arthropods on the four traps; and two measurements of species diversity; order richness, which represents the total number of orders found across the four traps, and Shannon's index of diversity. To calculate a single control for comparison with each nest plot, we averaged the values for the two control plots. We used two-factor ANOVA (α=0.05) to test for differences in the mean responses of each of these continuous variables between site types (nest and control sites) and habitat types (CCP and CCFP). The data were analyzed using R 3.0.2 for Mac.

RESULTS

PRIMARY OUTCOMES

Of the 192 sticky traps that were deployed, 191 were recovered (99.5% success rate). A total of 44,954 arthropods were identified across three classes and ten total orders, with an overall Shannon's index of 0.188 for the entire sample. The ten orders found, listed with examples in order from most to least abundant, were: Diptera (flies, n=43,387), Hemiptera (true bugs, leaf hoppers, n=976), Coleoptera (beetles, n=379), Araneae (spiders, n=118), Hymenoptera (ants, bees, n=89), Opiliones (harvestmen, n=5) Lepidoptera (butterflies, n=1), Pseudoscorpionida (psuedoscorpions, n=1), Isopoda (isopods, n=1), Dermaptera (earwigs, n=1).

ABUNDANCE

Among all 48 plots, the average number of arthropods per trap was 235.3±147.8 (mean±SD), but there was considerable variation between plots. The three lowest plots had a mean of 68, 102.75, and 108 arthropods per trap, while the three highest plots had a mean of 444.25, 469.25, and 1006 arthropods per trap. The mean total abundance of arthropods was actually lower in nest plots (224.0±107.5 arthropods per trap) than in control plots (240.9±133.5 arthropods/trap), but the difference was not statistically significant (*P*=0.720, **Figure 2A**). CCFP (242.6±121.3) had more arthropods per trap than CCP (219.0±94.8), but again the difference was not statistically significant (*P*=0.620, **Figure 2A**). There was no interaction between nest presence and location within Chicago on arthropod abundance (*P*=0.954, **Figure 2B**).

RICHNESS

When considering all 48 plots, the average order richness was 4.54±0.87, with a range from 3-6. Order richness was marginally lower for nest plots (4.3±1.0) than control plots (4.7±0.6) but the difference was not statistically significant (P=0.097, Figure 3A). CCFP (4.7±0.5) had higher order richness than CCP (4.2±0.6), and this difference was nearly statistically significant (P=0.065, Figure 3A). There was no interaction between nest presence and location within Chicago (P=0.721, Figure 3B). Only six orders of arthropods were found across the CCP, while 50% more orders (9) were found in CCFP. Opiliones, Lepidoptera, Pseudoscorpionida, and Isopoda were found only in CCFP, while Dermaptera was only found in CCP. Diptera, Hempitera, Coleoptera, Araneae, and Hymenoptera were found in both.

SHANNON'S INDEX OF DIVERSITY

The mean Shannon's index across all plots was 0.200±0.084, with a range from 0.074 to 0.439. Similar to the results from order richness, Shannon's indices were marginally lower for nest plots (0.188±0.087) than control plots (0.206±0.067), but the difference was not statistically significant (P=0.495, Figure 4A). CCFP (0.204±0.065) had on average higher Shannon's indices than CCP (0.190±0.039), but this difference was also not statistically significant (P=0.608, Figure 4A). There was no interaction between nest presence and location within Chicago (P=0.759, Figure 4B).

DISCUSSION

If the arthropod community was much more abundant and diverse in nest sites, then we might conclude that this factor may be of considerable importance for RHWO nest selection. Our results, however, suggest that arthropod abundance and diversity are not key factors in RHWO nest site selection. Overall, the results for abundance, order richness, and Shannon's index refute our prediction that RHWO nest sites would have greater arthropod abundance and diversity. For each of these three variables, the difference between nest and control plots was not statistically significant, however, the trends were consistent among them. Nest plots had lower values for all of our metrics compared to control plots.

All nest locations used in this report were identified as active in 2012, but the arthropod sampling was conducted in 2013; therefore, the fates of the nest cavities in 2013 varied (known active, usurped by a competitor, unusable, unknown or unoccupied). Potentially, RHWO consumption of arthropods in the vicinity of the nest cavity may explain lower abundance and diversity values for nest sites compared to control sites. We cannot be sure, however, that RHWO were active at all nest sites during the sampling period, so we cannot conclude that the difference was due to RHWO consumption.

City park nest sites consistently had the lowest average abundance, richness, and Shannon's index, while forest preserve control sites consistently had the highest. This suggests that nest sites in habitats heavily altered by humans may have less arthropods available compared to a random site in a forest preserve. If summer arthropod availability was truly the most important factor in determining RHWO nest site selection, we would not expect to see less diverse arthropod communities with fewer individuals at some nest sites.

One notable arthropod community was at Wolf Road Prairie (WRP) Forest Preserve. One of the control plots in this native Illinois prairie had an average abundance of 1,006 arthropods per trap, with six different orders represented, tied for the maximum richness of any plot and nearly four times greater than the average abundance. One of these orders did not occur at any other site except WRP, the pseudoscorpion (Pseudoscorpionida). Five orders collected had five or less individuals (opiliones, pseudoscorpionida, isopoda, lepidoptera, and dermaptera), but the fact that four of these five uncommon orders were only found in forest preserves indicates that forest preserves potentially support greater arthropod diversity. The finding that WRP has exceptionally diverse and abundant communities of arthropods would validate the efforts of the countless individuals who have helped to restore and maintain the health of this tall grass prairie [Simpson 2008].

Although the difference in order richness between forests and parks was not statistically significant, the direction is in accordance with our predictions and was consistent with the finding that uncommon orders were present more often in forests. RHWO are clearly opportunistic omnivores with structural adaptations for a general diet, so it seems likely that the presence of these additional arthropod orders would result in greater variety in their diet [Smith et al. 2000]. The fact that we had 11 nests in forest preserves with only 5 in city parks is also consistent with the hypothesis that RHWO might generally be found more where there is greater arthropod availability. This fact may also be a limitation for this study, as it is possible that the sample size of parks (five) was too low to make any statistically powerful conclusions about the differences between forests and parks. The biological significance of this finding is that nest sites in forest preserves seem to provide greater diversity and abundance of arthropod prey compared to city parks, so to help preserve diverse arthropod communities for predators like the RHWO, it seems crucial to preserve and expand forest ecosystems.

The conclusion of this study is that there are not striking differences in the arthropod community between nest and control sites, but there was high variability among plots and striking differences between forest preserves and city parks, suggesting that there may be one or more underlying habitat characteristics that influence arthropod abundance and diversity. For one, the proximity to water may be an important factor as many insect larvae grow in ponds, streams, or other slow moving or standing water [Horak 2013]. In addition, the tree community or overall health of the plants may have consequences for the size and diversity of the arthropod community [Horak 2013]. While the availability of arthropods is probably not the primary underlying factor in RHWO nest site selection and reuse at the scale examined in this study, it may have implications for migratory patterns and fledgling success [Smith et al. 2000]. This study is part of a larger project analyzing RHWO nest site characteristics being conducted in the LaMontagne lab.

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FIGURES

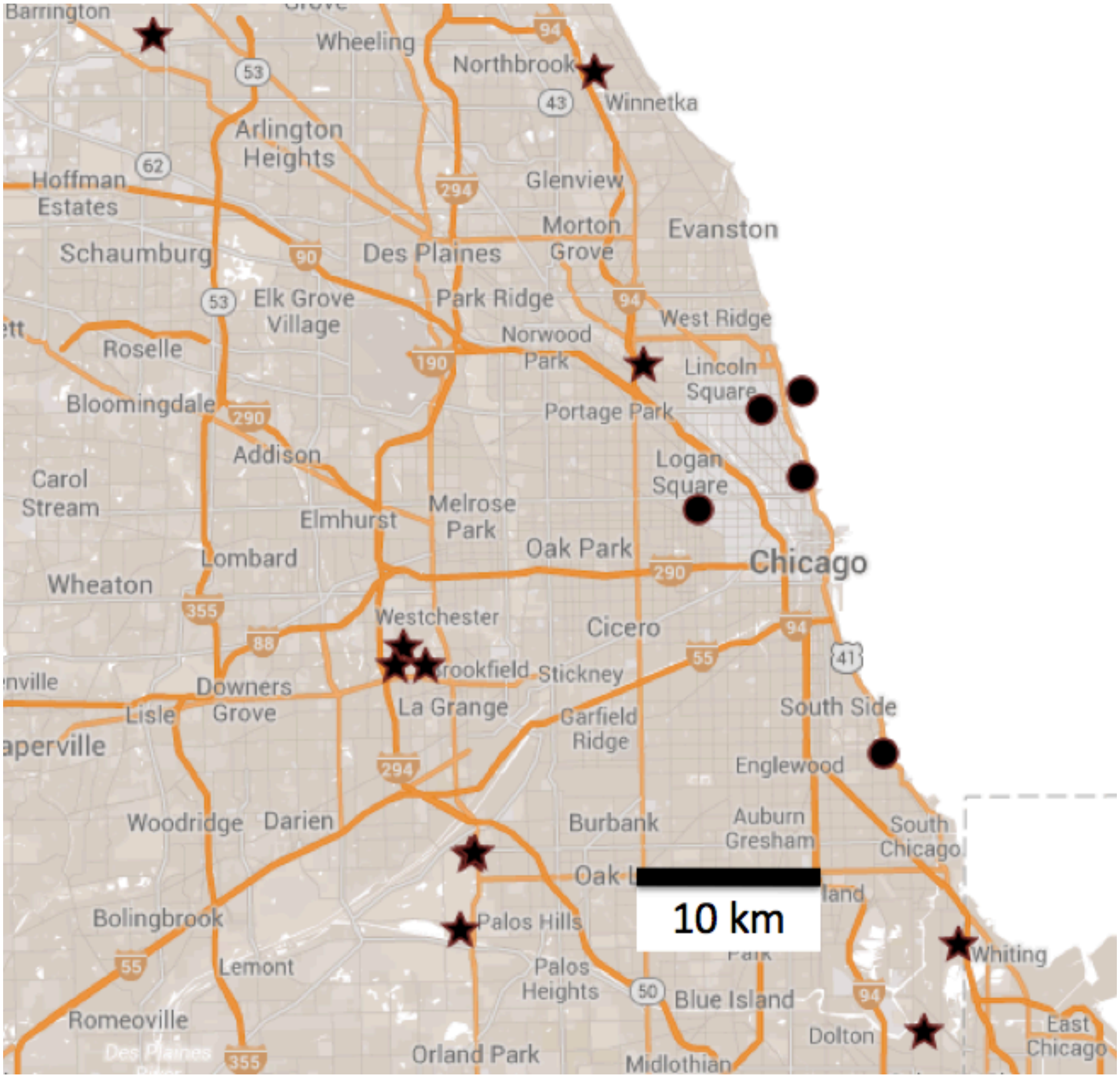

Figure 1: Map of study locations. Stars represent Cook County Forest Preserves, while circles represent Chicago City Parks. Image from Google® maps.

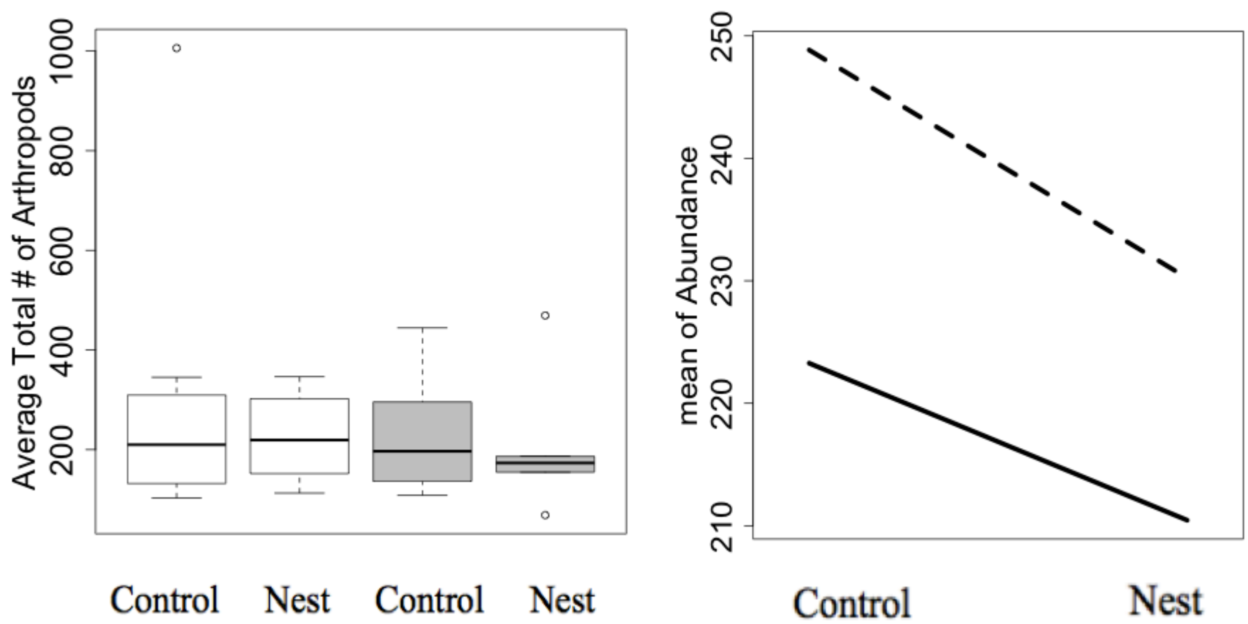

Figure 2: A) boxplot of average arthropod abundance (left) B) interaction plot (right). Cook County Forest Preserve (A: White boxes, B: Dashed line) and Chicago City Parks (A: Grey boxes, B: Solid line)

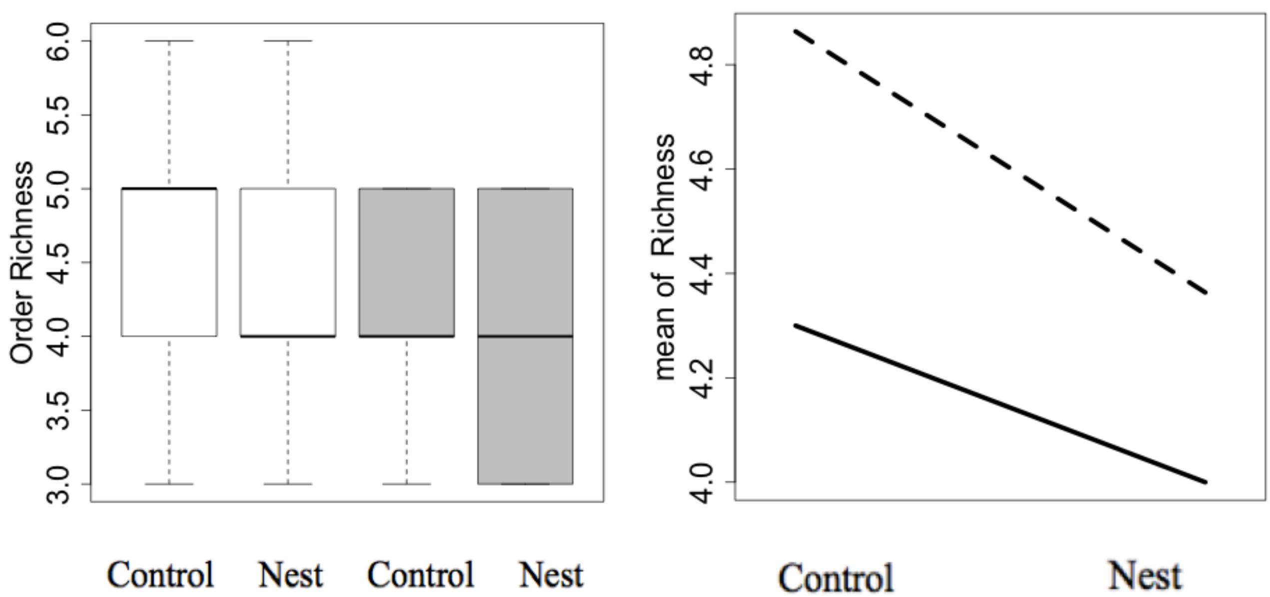

Figure 3: A) boxplot of order richness (left) B) interaction plot (right). Cook County Forest Preserve (A: White boxes, B: Dashed line) and Chicago City Parks (A: Grey boxes, B: Solid line)

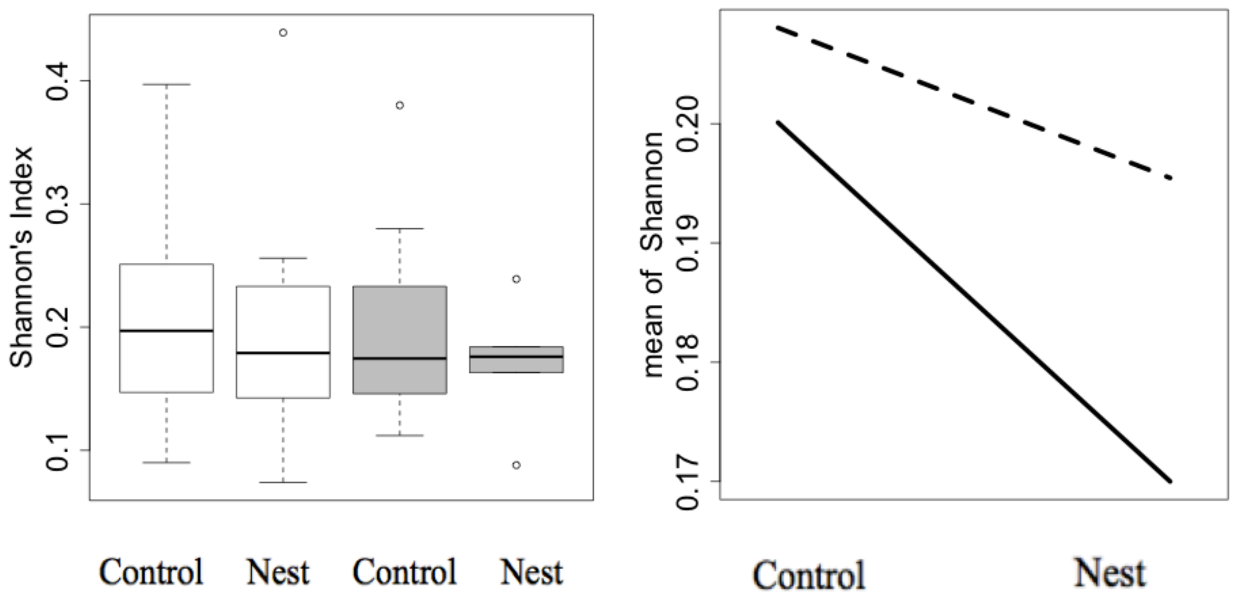

Figure 4: A) boxplot of Shannon's indices (left) B) interaction plot (right). Cook County Forest Preserve (A: White boxes, B: Dashed line) and Chicago City Parks (A: Grey boxes, B: Solid line)

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