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Local Ecology Research Papers

Bird community composition and diversity in tallgrass prairie and a bordering prairie-forest ecotone as summer transitions to autumn in southeast Minnesota

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Abstract:

Bird communities are important to understand because they are a critical component of ecosystems throughout the world. In this study, the composition of the avian community in St Olaf College's Natural Lands in Northfield, Minnesota is examined, specifically a restored prairie and bordering ecotone. Four sites were examined for the presence of species to uncover differences in biodiversity as summer transitioned to fall. Two of the sites were defined as ecotone sites, with the Big Pond site being a wetland/forest, and the Coyote Pond East site being an oak savanna habitat. The other two sites, Northwest Prairie and Dragonfly Pond, were in the restored prairie. Across sites, song sparrows, American robins, and barn swallows were most common. Canada geese, mallards, killdeer, and blue jays were also frequently observed in the ecotone sites. The two ecotone sites were both more diverse than the two prairie sites across all measurements. This verifies what other studies have found in that more species reside in ecotones compared to the habitat they border. Additionally, as summer transitioned to fall, all four sites were found to decrease rapidly in biodiversity, largely due to the changes in temperature, although the ecotone sites retained species whereas the prairie was void of any birds. These findings support the commonly held idea that higher biodiversity is found at ecotones where different habitats meet as well as provide useful information on seasonal changes in biodiversity in tallgrass prairies and adjacent ecotones.

Keywords:

Community ecology, ornithology, ecotone, tallgrass prairie, wetland, forest, biodiversity

Introduction:

Ecologists have long studied birds for how fascinating they are. The theory of evolution is in part due to research on birds by Darwin himself (Darwin 1859), but there is still much work to be done in understanding avian communities. Avian communities are often regarded as being quite dynamic, thanks to their ability to fly, and they are very receptive to changes in environmental conditions. They have also been noted to be great indicators of environmental conditions, and thus environmental harm as well (Gregory and Strein 2010). What is still relatively unknown about bird communities is how they differ in composition with respect to different microhabitats, and the ecotone that bridges the two habitats.

The habitat type specific to this study is the tallgrass prairie. Tallgrass prairies have suffered the greatest loss of habitat in North America compared to other habitat types (Boren et al. 1999). Fragmentation and land use changes have seriously hurt the birds that inhabit tallgrass prairies as well (Herse et al. 2020). Studies have shown that prairies, and the community of birds they hold, are best preserved/restored when the total area of the continuous prairie is maximized, although most often prairie restorations are smaller patches of land (Herse et al. 2020). Whether or not an ecotone, which is essentially a border between two habitats/ecosystems, may be a positive incorporation to these restoration projects is relatively unclear. By having records related to the community of birds found within a prairie, and how it may differ compared to the community in a bordering prairie-forest ecotone, more holistic restoration and conservation projects may ensue.

Similar to how prairies have historically been wiped out for agricultural purposes, wetlands have as well (Dugan 1993). Wetlands are also incredibly important habitats for many species of birds that rely on the unique features of wetlands (Dugan 1993). The compositional

differences between a wetland and a prairie that it borders are not well documented, but records of this would be useful for restoration efforts of both prairies and wetlands.

Ecotones are understood to be holders of greater biodiversity than either habitat bordered by the ecotone (Duchardt et al. 2018). Past studies have shown that across ecotones, bird community composition changes dramatically, with ecotones having much higher species richness (Boren et al. 1999). However, the composition of these communities is not well understood. It has also been noted that what draws a certain assortment of avian species to a specific habitat type is not due to the general structure of these plants, but rather more specific characteristics of the plant species themselves (Rotenberry 1985). This reaffirms that native species must be restored to their native habitat in order to restore, and better management of invasive species that threaten these native ecosystems is critical to our environmental health. This relates to ecotones in that they have the potential to facilitate nonnative and woody species into tallgrass prairies, although further research is needed (Prather et al. 2017).

St Olaf College, located in Northfield, Minnesota, has been working on tall grass prairie restoration projects for several decades now, with about 150 acres of successfully restored prairie to date (St Olaf College 2020). The restored prairies consist of 10 native grass species, and over 25 species of forbs, making a heterogeneous habitat that attracts a variety of birds (St Olaf College 2020). However, St Olaf has little information on how bird communities differ in different microhabitats within their Natural Lands, and thus this study would provide the college much needed information.

The goals of this project were to build a better understanding of how avian community diversity differs as one moves from a pure tallgrass prairie habitat to the ecotone connecting the prairie to forested habitat. This would ultimately help the school better understand how its

restoration projects have fostered habitats for different bird communities, as well as add to the existing information supporting conservation and restoration projects such as those in the St Olaf Natural Lands. In the future, the information could also be compared with to see how climatic or environmental changes have possibly altered these avian communities. Specifically, this study aimed to: 1) better understand how avian community diversity and composition differs in a tallgrass prairie compared to an ecotone bridging the prairie and a forest; 2) observe changes in avian diversity in these microhabitats as summer progresses to autumn (September to October); 3) identify how prairie-forest ecotones may allow for a prairie to have a higher species richness than a prairie lacking this type of ecotone.

Methods:

Data Collection:

Data was collected at four sites in the St Olaf Natural Lands, located in Northfield, Minnesota, USA. Two sites are defined as ecotone sites, with the site named Big Pond being located on an ecotone where the prairie meets a wetland, and the site Coyote Pond East being an ecotone where the prairie meets an oak savanna. The two prairie sites, Northwest Prairie and Dragonfly Pond are located away from any structure, thus being purely prairie habitat. The locations of the sites are noted on the included map of the St Olaf Natural Lands (Fig. 1).

I arrived at the first site for sampling at sunrise two mornings each week between September 22 and October 22, for a total of 9 days of sampling. Sampling was done at all four sites each day I went out to reduce bias from differences in weather. While at each site, I used binoculars and a DSLR camera to identify the species and the numbers of each. Only birds within around 50 yards in front of me were recorded. The species and number of individuals for

that species was recorded at each site. Sampling took place for 15 minutes at each site, and the initial site was rotated through each time so that I did not begin sampling at the same site each day.

Data Analysis:

With the data collected, species richness, Shannon, and Simpson index values were calculated. The Shannon and Simpson index values both relate to diversity, with higher values suggesting higher diversity. A species accumulation curve was also generated to show the observations of novel species over time. Linear regression models of the number of species observed that day for each site were generated using R Studio, version 3.5, to show effects of seasonality and temperature changes on the avian community's composition and diversity over the course of the study. A frequency table was also created to determine what frequency each species was observed at for each site.

Results:

As depicted in Table 1, Big Pond had 195 birds recorded from 17 different species, the highest number of individuals and species of all four sites. 130 of those individuals at Big Pond were of the three waterfowl species recorded: Canada geese; mallards; and killdeer. The majority of the rest of those birds observed were American robins and song sparrows. Coyote Pond East had 125 individuals recorded from 10 different species (Table 1). A majority of these individuals were song sparrows (66), with American robins, barn swallows, and blue jays also being commonly recorded here. There were 65 individuals from 8 species recorded at the Northwest Prairie site, with a vast majority of those birds being song sparrows (39). 23 birds from 3 species were recorded at Dragonfly Pond, 16 of which were song sparrows (Table 1). The only two

species recorded at all four sites were song sparrows and barn swallows, although song sparrows were much more numerous.

As depicted in Table 2, Big Pond was found to be the most diverse, with a species richness of 17, a Shannon index value of 0.86, and a Simpson index value of 0.78. Coyote Pond East was second most diverse, with a species richness of 10, a Shannon index value of 0.67, and a Simpson index value of 0.68. The Northwest Prairie site had a species richness of 8, a Shannon index value of 0.6, and a Simpson index value of 0.62. Dragonfly Pond had the lowest species richness of just 3, with a Shannon index value of 0.35, and a Simpson index value of 0.48.

Table 3 represents the frequency of each species at each site. The significant results from this table are that of the song sparrow, which was observed 8 of 9 sampling days at Coyote Pond East, and very frequently at the other sites as well. Barn swallows were also observed at each site, but at very low frequencies. American robins were observed a majority of the days (5/9) at Coyote Pond East and relatively frequently at Big Pond (3/9 days) (Table 3). Canada geese and mallards were observed at Big Pond 7 of the 9 sampling days (Table 3).

Figure 2 shows the diversity exhibited by Big Pond as compared to the other sites. Immediately in the study, after just two days of sampling, over 10 species had already been recorded, whereas Coyote Pond East, Northwest Prairie, and Dragonfly Pond were significantly less. Coyote Pond East and Northwest Prairie followed similar trends of novel species being observed at a consistent pace, with Coyote Pond East being consistently higher. No new species were observed at Dragonfly Pond after the first day of sampling ($p < 0.001$, Fig. 2).

Figure 3 shows the rate at which species observations decreased as the temperatures dropped. All four sites showed a dramatic decrease in diversity, but the two prairie sites became relatively void of birds, whereas the two ecotone sites were inhabited by just a few species (those that do not migrate such as blue jays or cardinals) after temperatures fell. The total temperature

difference from September 22 to October 22 was 30° F, falling from 60° F to 30° F, or 15.5° C to -1.11° C.

Discussion:

Our results show that the ecotone bordering the prairie holds a greater number of species than the prairie itself in terms of species diversity and species richness. These findings support the previously held ideas that ecotones in general hold greater avian diversity than the habitats that they border (Duchardt et al. 2018; Boren et al. 1999). The importance of this is that prairie restorations may be more successful in terms of providing habitat for a diverse community of birds if there is more structure along the edges. Birds play important roles as seed dispersers and pollinators in many ecosystems, and if more birds are able to survive in the area then perhaps the plant community will benefit from this (Prather et al. 2017). However, the presence of perches for birds on the edges of tallgrass prairies has the potential to facilitate the encroachment of woody species through the same mechanism of seed dispersal, which is not good for a tallgrass prairie ecosystem (Prather et al. 2017). Regardless of whether encroachment of woody species occurs, proper management, including controlled burns, would likely ward off any unwanted species and maintain a community native tallgrass prairie species. Thus, the benefits an ecotone provides to a tallgrass prairie by increasing avian diversity has the potential to increase the health and resilience of a prairie ecosystem.

The decrease in species across all four sites as temperature drop came as no surprise, but the fact that the ecotone retained species throughout the course of the study suggests that it may allow for birds to be less affected by dramatic changes in environmental conditions. As climate change continues to worsen, the environment is expected to become more turbulent, with more frequent and intense bouts of temperature changes, precipitation, and storms. The ecotone

retained species despite the untimely coldspell that came through southeastern Minnesota, where temperatures dropped below freezing for several days, which may allow avian species to be more resilient when it comes to sudden changes in the conditions. Climate change has already been shown to be affecting the timing of prairie bird migrations rather dramatically, and this is expected to continue to worsen in the future (Swanson and Palmer 2009). If ecotones make it so birds can remain where they would be despite the fluctuating weather, this could possibly make the ecosystem more resilient to these varying environmental conditions.

Finally, the composition of the bird community in the prairie and the bordering ecotone suggests that the historical prairie bird community has not been fully restored, but it is similar to that of historically undisturbed northern tallgrass prairies (Kendeigh 1941). The most abundant bird in the prairie and the bordering ecotone, song sparrows, is most commonly associated with forest edges, and not the true prairie. The song sparrows benefit from the ecotone as it provides areas to perch and build nests, and they overwhelm the other species more characteristic of prairies in doing so. The fact that the song sparrow is so overwhelmingly dominant in the prairie suggests the prairie has not regained its true historical avian community in terms of composition, which is due to the bordering ecotone. However, despite the song sparrows abundance, the barn swallows that were commonly observed in the prairie early on alongside the American goldfinches and yellow rumped warblers suggest that the community is still characteristic of historical prairies in this region. These findings suggest that the prairie is being successfully restored in terms of both vegetation and wildlife, although the bordering ecotone is influencing the prairie in the composition of its avian community.

The findings of this study can be summarized in that ecotones support greater biodiversity than the habitat it borders, which can make the avian community of that ecosystem more resilient if environmental conditions happen to change more than the historical norm.

These results are not new findings necessarily, but rather support the work of others who have found similar results when it comes to biodiversity and ecotones. As prairie restorations continue to increase in numbers across the Great Plains region of North America, perhaps ecotones may need a greater consideration when it comes to the planning stage, as they can greatly influence the composition and diversity of the prairie's avian community.

Literature Cited:

Boren, J.C., Criner, T., Engle, D.M., Palmer, M.W., Masters, R.E. 1999. Land use change effects on breeding bird community composition. Journal of Range Management 52:420–430. https://www.researchgate.net/publication/271812731_Land_Use_Change_Effects_on_Breeding_Bird_Community_Composition

Darwin, C. and L. Kebler. 1859. On the origin of species by means of natural selection, or, the preservation of favoured races in the struggle for life. London: Murray, J.

Duchardt, C. J., Porensky, L. M., Augustine, D. J., Beck, J. L. 2018. Disturbance shapes avian communities on grassland-sagebrush ecotone. Ecosphere 9:1-19. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.2483

Dugan, P. 1993. Wetlands in Danger: a World Conservation Atlas. Oxford University Press.

Gregory, R. and A. Strein. 2010. Wild bird indicators: using composite population trends of birds as measures of environmental health. Ornithological Science 9:3-22. https://www.jstage.jst.go.jp/article/osj/9/1/9_1_3/_pdf/-char/ja

Herse, M.R., With, K.A,. and Boyle, W.A. 2020. Grassland fragmentation affects declining tallgrass prairie birds most where large amounts of grassland remain. Landscape Ecology 1-14. https://doi.org/10.1007/s10980-020-01064-y

Kendeigh, S.C. 1941. Birds of a prairie community. The Condor 43:165-174. https://doi.org/10.2307/1364328

Prather, C.M., Huyn,. A., and Pennings, S.C. Woody structure facilitates invasion of woody plants by providing perches for birds. Ecology and Evolution 7:8032-8039. http://dx.doi.org.ezproxy.stolaf.edu/10.1002/ece3.3314

Rotenberry, J. 1985. The role of habitat in avian community composition: physiognomy or floristics? Oecologia 67:213-217. https://link.springer.com/article/10.1007/BF00384286

Swanson, D.L. and Palmer, J.S. 2009. Spring migration phenology of birds in the Northern Prairie region is correlated with local climate change. Journal of Field Ornithology 80:351-363.

St Olaf College. 2020. Prairie | Habitats | Natural Lands. https://wp.stolaf.edu/naturallands/prairies/

St Olaf College. 2019. Maps | Natural Lands. https://wp.stolaf.edu/naturallands/files/2019/02/Natural-Lands-Version-2019b_use.pdf

Table 1. Species counts at each site.

Species	Big Pond	Coyote Pond East	Northwest Prairie	Dragonfly Pond
American Crow	5	0	0	0
American Goldfinch	0	2	2	0
American Robin	13	16	3	0
Barn Swallow	3	13	8	5
Black-Capped Chickadee	12	0	2	0
Blue Jay	1	14	0	0
Canada Goose	53	0	0	0
Cooper's Hawk	1	0	0	0
Dark-eyed Junco	5	6	0	0
Eastern Bluebird	1	0	0	0
Harris's Sparrow	0	1	0	0
House Wren	0	0	5	2
Killdeer	8	4	0	0
Mallard	69	0	0	0
Northern Cardinal	6	0	0	0
Northern Harrier	1	0	0	0
Sandhill Crane	0	1	0	0
Song Sparrow	11	66	39	16
Red Bellied Woodpecker	0	0	1	0
Redwing Blackbird	2	0	0	0
White Crowned Sparrow	2	0	0	0
Yellow Rumped Warbler	2	2	5	0
Total	195	125	65	23

Table 2. Species richness, shannon index, and simpson index values.

	Big Pond	Coyote Pond East	NW Prairie	Dragonfly Pond
Richness	17	10	8	3

Shannon (H')	0.86	0.67	0.6	0.35
Simpson (Ds)	0.79	0.68	0.62	0.48

Table 3. Frequency of observations of each species across sites (number of days species was observed over the total number of sampling days at site).

	Frequency			
Species	Big Pond	Coyote Pond East	NW Prairie	Dragonfly Pond
American Crow	0.11	0.00	0.00	0.00
American Goldfinch	0.00	0.11	0.22	0.00
American Robin	0.33	0.56	0.11	0.00
Barn Swallow	0.11	0.22	0.22	0.22
Black-Capped Chickadee	0.22	0.00	0.11	0.00
Blue Jay	0.11	0.44	0.00	0.00
Canada Goose	0.78	0.00	0.00	0.00
Cooper's Hawk	0.11	0.00	0.00	0.00
Dark-eyed Junco	0.33	0.11	0.00	0.00
Eastern Bluebird	0.11	0.00	0.00	0.00
Harris's Sparrow	0.00	0.11	0.00	0.00
House Wren	0.00	0.00	0.33	0.11
Killdeer	0.44	0.44	0.00	0.00
Mallard	0.78	0.00	0.00	0.00
Northern Cardinal	0.44	0.00	0.00	0.00
Northern Harrier	0.11	0.00	0.00	0.00
Sandhill Crane	0.00	0.11	0.00	0.00
Song Sparrow	0.11	0.89	0.78	0.44
Red Bellied Woodpecker	0.00	0.11	0.00	0.00
Redwing Blackbird	0.11	0.00	0.00	0.00
White Crowned Sparrow	0.11	0.00	0.00	0.00
Yellow Rumped Warbler	0.11	0.11	0.11	0.00

St. Olaf College Natural Lands

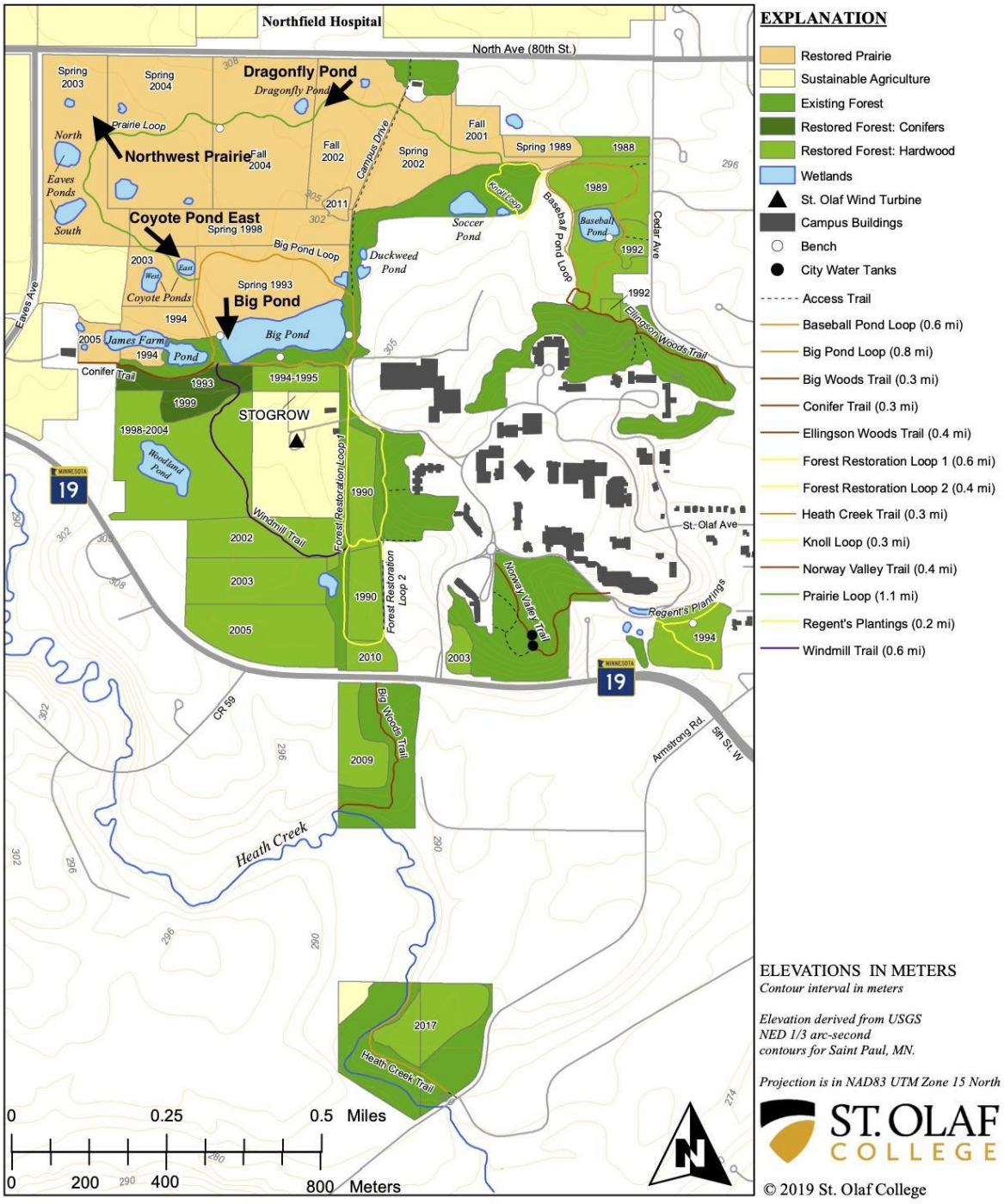

Figure 1. Map of St Olaf College's Natural Lands

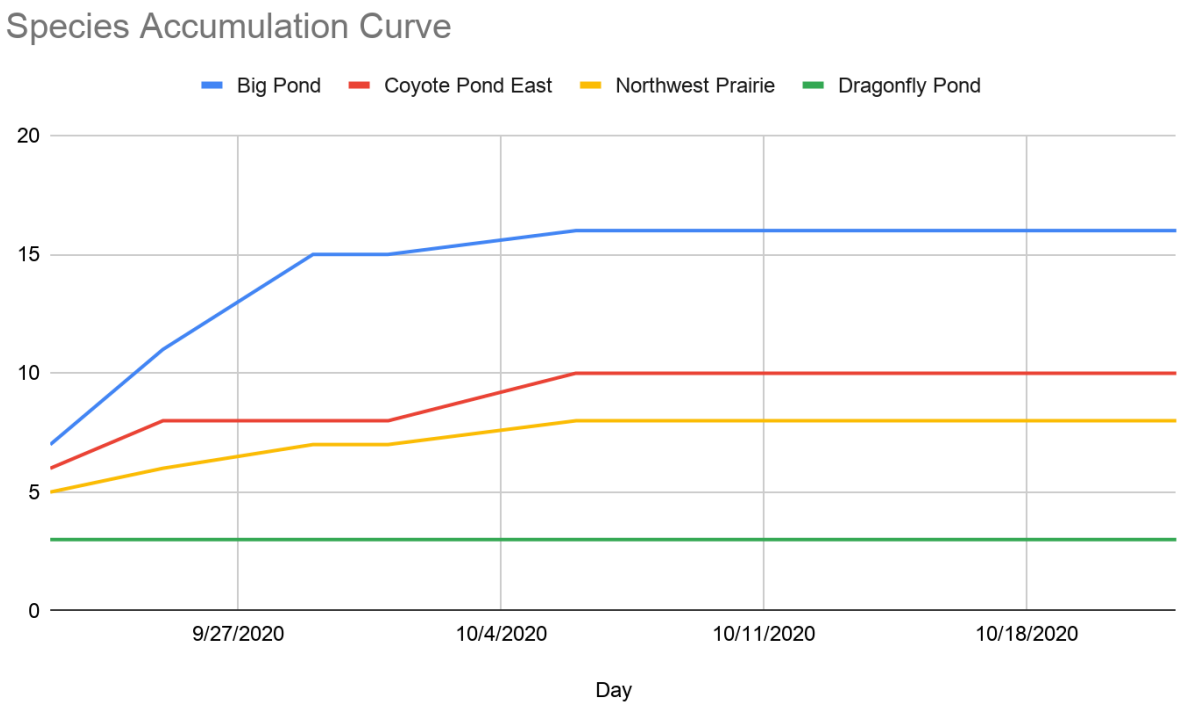

Figure 2. Species accumulation curve for each site.

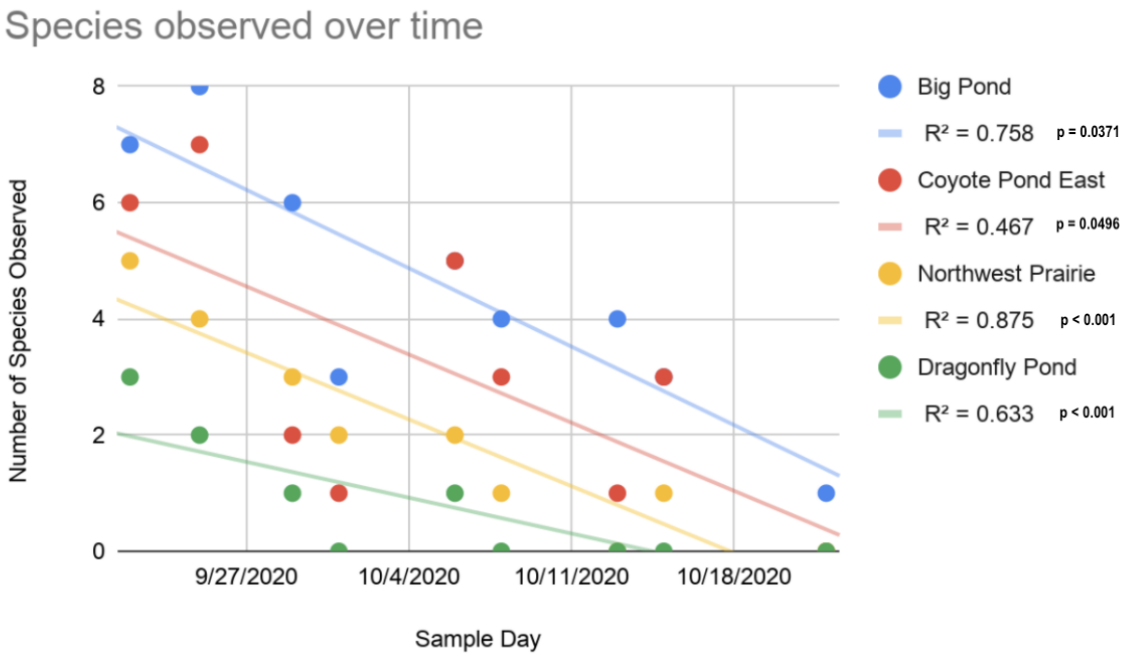

Figure 3. Species diversity as a function of time for each site.