The Quantification of Autumn Olive's (*Elaeagnus umbellata)* Structure and its Effect on Bird Behavior

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Abstract

Humans have introduced many non-native plants into environments, often in hope that they would provide better habitat for native wildlife. Autumn Olive, *Elaeagnus umbellata*, was one such species and was introduced throughout the United States from East Asia to attract birds especially for its plentiful fruit. Recent research has shown that some bird species are positively affected by the presence of *E. umbellata*. However, during the past few years, researchers at PCCI have observed a puzzling phenomenon; native birds seem to avoid using and perching in clumps of *E. umbellata* on the property when the shrub does not have ripe fruit. The structure of the invasive may be deterring birds from using it as a perch. The branch diameter, branch density, bird choice between branch structure, bird species diversity, and presence of birds between *E. umbellata* and natives were analyzed to elucidate this interaction. There was no significant difference between *E. umbellata* and the natives, except between the structure of *Prunus sp*. and *E. umbellata*. This corresponds with a trend of more birds using individual *Prunus sp.* during the choice tests, but the sample size was too small to analyze statistically. In addition, roughly two fifths of bird species caught were different between *E. umbellata* and natives. Hawking birds seemed to prefer natives and fruit eaters seemed to prefer *E. umbellata*. This could suggest potential avoidance behavior, but random chance could not be ruled out as an explanation for the differences. Our research indicated that the native birds do not avoid *E. umbellata* during the non-fruiting season and therefore, this invasive shrub may not negatively impact bird distribution as previously thought.

Introduction

In the United States, introductions of non-native plants were common in the past to increase the habitat quality of native fauna (NISC 2001). One such species is the shrub Autumn Olive (*Elaeagnus umbellata*), which has been introduced mainly for the cover and fruit it could provide to wildlife (Allan and Steiner 1972). As with many of these non-native introductions, *E. umbellata* has spread on its own to almost every state in the United States and is now considered a problematic invasive species because it outcompetes native plants (USDA 2011; Swearingen et al. 2002). In states where it is not considered invasive, nurseries still sell *E. umbellata* to consumers. Although it has had clear detrimental effects on native plants from outcompetition for resources, many have continued to assume that *E. umbellata* is beneficial to native wildlife, especially birds.

Several studies have supported the assumption that *E. umbellata* is beneficial to birds. For example, Ahmad et al. (2008) found that its fruits are high in sugars, vitamins, fatty acids, and lycopene. In addition, individual fruits of *E. umbellata* were preferred by European Starlings (*Sturnus vulgaris*) and American Robins (*Turdus migratorius*) when given the choice between fruits of *E. umbellata* and fruits of a native shrub, Common Winterberry (*Ilex vertcillata*) (LaFleur et al. 2007). The spread of this shrub is evidence that birds are actively eating and dispersing the fruits (McCay et al. 2009). Furthermore, *E. umbellata* and related species may have positive impacts on birds.

Schlossberg and King (2010) found native birds placed their nests in invasive shrubs, including *E. umbellata*, more often than expected and that for some species, nest success was higher when in these invasive shrubs. In a related species Russian Olive (*Elaeagnus angustifolia*), Mourning Doves (*Zenaida macroura*), Yellow-breasted Chats (*Icteria virens*), and

Willow Flycatchers (*Empidonax traillii*) nested preferentially in the invasive shrub, although there was no known benefit in doing so at the time (Stoleson and Finch 2001). In addition, E. *umbellata* had less mammalian browsing and grew back faster after browse damage than its paired native, Silky Dogwood (*Cornus amomum*), which would give birds a better substrate for cover and nesting (Knapp et al. 2008). Given these results, it appears that *E. umbellata* has not had a consistent negative effect on native birds as it has on native plants and, indeed, may have positive impacts in some cases.

Given this potential positive impact on some native birds, recent researchers at the Pierce Cedar Creek Institute (PCCI) in Hastings, Michigan have been surprised to observe that birds may be avoiding *E. umbellata* at certain times of the year. During the non-fruiting season, fewer birds were observed in *E. umbellata* compared to native shrubs in paired assessments of focal shrubs around the property, even though data showed that *E. umbellata* had more potential food associated with it at that time of year (Krintz and Eberhardt 2008). Further, American Robins (*Turdus migratorius*) and Northern Cardinals (*Cardinalis cardinalis*) seemed to avoid the shrub as a perching site in assessments of activity budgets in both species (Houghton and Soley 2009). Since *E. umbellata* has had potential positive and negative impacts on birds, what characteristic of the shrub is causing this behavior?

A possible mechanism for this avoidance could be the architecture of the shrub itself. The effect of branch structure on birds is a possible factor in higher nest predation for the American Robin (*Turdus migratorius*) in two other non-native shrubs, Amur Honeysuckle (*Lonicera maackii)* and Common Buckthorn (*Rhamnus cathartica)* (Schmidt and Whelan 1999). Dhondt et al. (2004) found that birds preferred nesting in certain branch configurations of willow/popular clones, although food availability and nesting success were roughly equal in all

clones. Density of branching was a key component of nest site selection of the Yellow Warbler (*Dendroica petechia*) (Knopf and Sedgwick 1992). Additionally, Showler et al. (2002) found that Rodrigues Warblers (*Acrocephalus rodericanus*) preferred shrubs that have dense small branches. In addition, the density of the shrub and surrounding areas was a component in nest site selection in Brewer's Sparrows (*Spizella breweri*) and Green-tailed Towhees (*Pipilo chlorurus*) (Knopf et al. 1990). Substrate deflection also may influence bird behavior when perching on different types of branches (Bonser et al. 1999). Branch density, deflection, and diameter could help explain why birds avoid *E. umbellata* during their daily activities in the two previous PCCI studies. The aims of our study were to clarify the avoidance behavior shown by birds towards *E. umbellata* and to analyze its branch structure and deflection as a potential mechanism for this behavior. We hypothesized that birds will avoid *E. umbellata* and that the branch structure of *E. umbellata* will be significantly different from native shrubs.

Study Area and Methods

The study was performed at the Pierce Cedar Creek Institute in Hastings, Michigan between May 16, 2011 and July 27, 2011. The property contains many different habitats, including deciduous forest, field, prairie, sand prairie, and fen that were used in this study. Each of these habitats contained either a few individual shrubs or dense thickets of *E. umbellata*. Although found mainly in edge or full sun habitats, *E. umbellata* has spread into forested interior habitats at this site. The non-*E. umbellata* sites used in this study were found roughly 3 m to 20 m away from the *E. umbellata* sites, but were still considered in the same habitat. The natives used in comparison to *E. umbellata* were *Prunus sp., Cornus sp., Salix sp.,* and *Crataegus sp*.

To assess the bird abundance and species diversity in *E. umbellata* and non-*E. umbellata* shrub clumps, mist nets were used. Pairs of 10 x 2.5 m mist nets with 16 mm mesh were set up in *E. umbellata* and non- *E. umbellata* shrub clumps for one morning (0600-0830) and evening (1800-2100) each. Data from a total of 15-paired sites were collected (Fig. 1). To

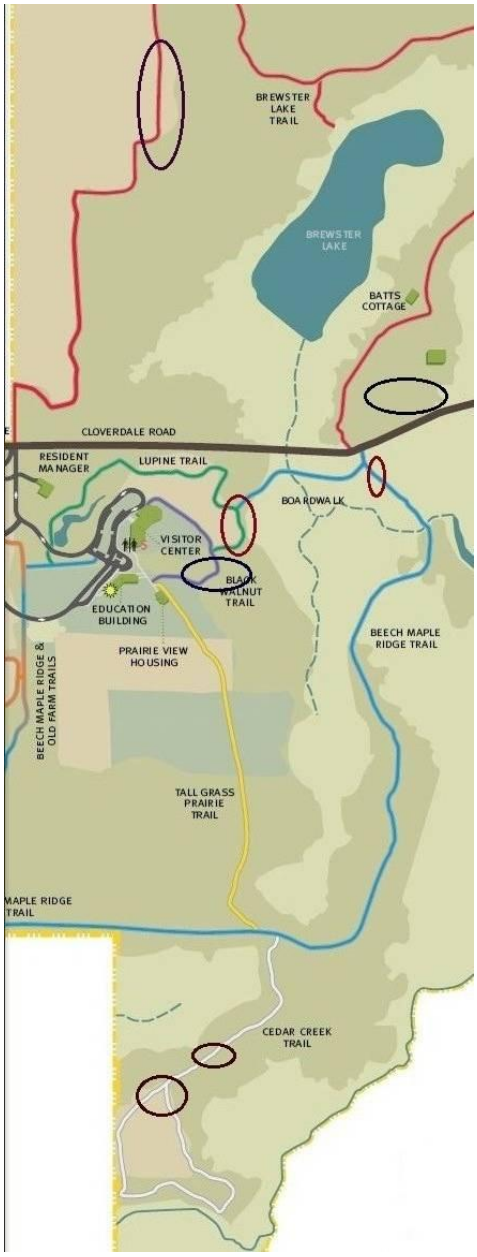

Figure 1: Map of mist net positions at PCCI (Pierce Cedar Creek Institute Trail Map 2011).

accommodate the nets in these dense clumps, 10 m x 1 m paths were cleared first of vegetation so the net would not get caught. Netting was done for ten mornings and ten evenings from May 24, 2011 to July 14, 2011. Number and species of captured birds were recorded every half an hour for a sample size of 36 half-hour intervals that had at least one bird capture in one net of a pair. Data were analyzed using a paired *t*-test.

Point Counts were used to assess bird abundance and species diversity in areas of high-density *E. umbellata* and non-*E. umbellata*. The point counts were done in the same area as Krintz and Eberhardt (2008) throughout the month of July 2011 (Fig. 2). Two paired *E. umbellata* and non-*E. umbellata* sites per area were assessed in the morning (0600-0800) for a

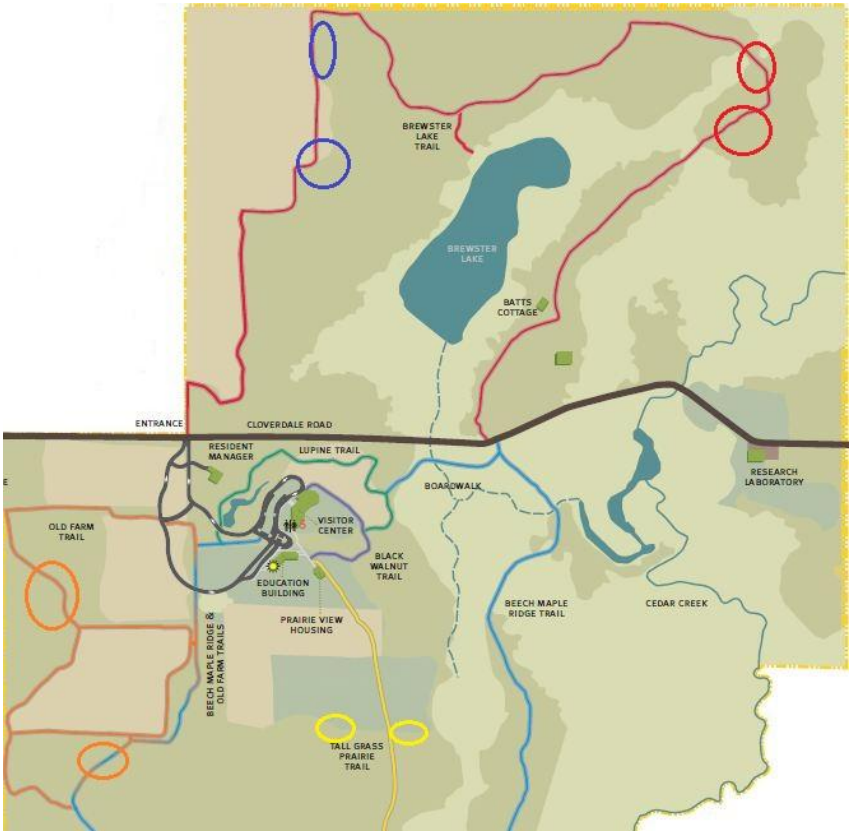

Figure 2: Map of point count sites at PCCI (Pierce Cedar Creek Institute Trail Map 2011). Orange=ORG, Yellow=YLW, Blue=FLD, Red=RED

sample size of eight paired sites that were added to Krintz and Eberhardt's data set. Each point count site was along a trail or firebreak and was spaced out roughly 10 m to 20 m from the other points. At each site, a random two-digit number of steps were walked into the area of interest, *E. umbellata* or non-*E. umbellata*, after 3 minutes data were taken. For 15 minutes, number and species of birds heard, seen (with or without binoculars) or both were recorded, but not ones flying over the observation site. The combined data set was analyzed with a Wilcoxon Signed Rank Test.

The quantification of branch structure of *E. umbellata* and natives was done to seek out a potential difference that may explain why birds may be avoiding the invasive. The sampling procedure was modified from the methodology used by Showler et al. (2002) and Knopf and Cannon (1982) in studies of bird habitat characteristics. Branching structure and deflection data were collected throughout June 2011 and July 2011 on 10 mature individual *E. umbellata*, *Prunus sp.*, *Cornus sp.*, and *Crataegus sp.* found in full to near full sun habitats around the property (Fig 3). Shrub branching characteristics were quantified by counting and measuring all dead and living woody twigs within a 2.5 cm wide sampling transect for a sample size of 61 branches for *E. umbellata*, 31 for *Prunus sp.*, 55 for *Cornus sp*. and 51 for *Crataegus sp.* Sampling transects were one meter in length and placed in a N-S cardinal direction horizontally through the center of the shrub determined by both its total height and width from the E-W cardinal direction.

Deflection of the branches was tested by measuring the grams needed to deflect an individual twig to a certain degree within the focal shrub. This was done by randomly sampling five relatively horizontal outer branches of these individual shrubs near breast height and

attaching a Pesola scale to the outermost 4 cm. If there were not five reachable branches on the shrub, only the reachable ones were measured for a smaller sample size. The scale was pulled

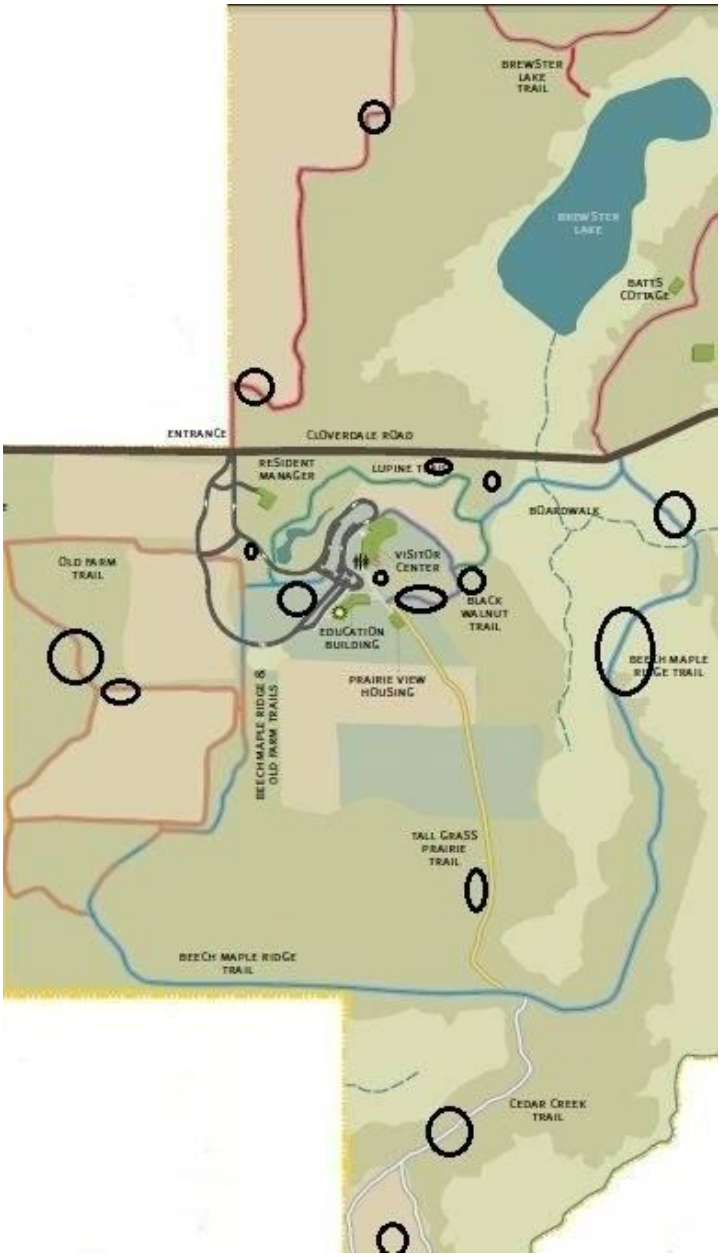

Figure 3: Map of shrub locations where branching structure data was taken (Pierce Cedar Creek Institute Trail Map 2011).

upwards until the branch was at a 45° angle from its normal position on the shrub. This upward deflection is a measure of the stiffness of the branch and is inversely related to the amount of

energy a bird needs to exert at take-off (Bonser et al. 1999). The grams that were needed to lift the branch to a 45° angle were recorded for 50 branches of *E. umbellata, Prunus sp.*, and *Crataegus sp*. and for 48 of *Cornus sp*. Branch measurements were analyzed using ANOVA.

To assess whether birds would choose a native branch over an *E. umbellata* branch when feeding, 20 choice tests were conducted from May 27, 2011 to July 18, 2011 (Fig. 4). Four pairs of cylindrical feeders without perches were placed in an *E. umbellata* individual and a native individual so the outer branches would act as perches for a least one of the feeder openings. A pair was placed close enough together so both feeders could be seen at once, if this was feasible. If not, the pair was watched separately. The feeders were filled with black oil sunflower seed

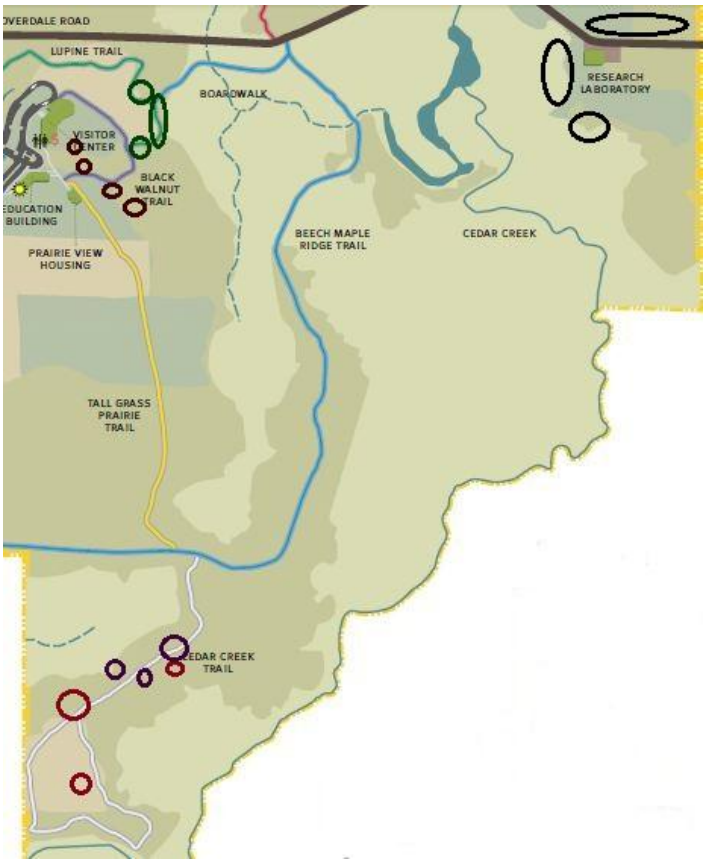

Figure 4: Map of feeder choice test sites (Pierce Cedar Creek Institute Trail Map 2011).

and left in place for birds to find and start using them. They were checked every day then refilled and repositioned if needed.

After a two to seven day acclimation period, data were taken either in the morning (0900-1200) or evening (1800-2100). At the start of each observation, a pre-weighed amount of seed was placed into the feeder and left for thirty minutes. Data were taken fifteen minutes later from a distance where the feeders could still be seen but positive bird identification required binoculars (4 m to 7 m). This distance varied with the terrain and vegetation. The number, species, and feeding of visitors was recorded for 30 minutes. Another 30-minute data collection period was repeated on a pair of feeders, if there were no visits to the first session and this period was used for data analysis instead of the first session. In addition, total seed removal rate after 24 hours and evidence of mammalian visits that would change these rates was recorded. HCO ScoutGuard® SG550 Infrared Scouting Trail Cameras were placed on two feeder pairs to determine the mammalian visitors. Data were analyzed using a paired *t*-test.

Results

Mist Netting within Shrub Clumps:

A total of 54 birds were caught over 57.5 trapping hours that spanned almost two months. Twenty-eight birds were caught in the *E. umbellata* nets including 2 recaptures and 26 birds were caught in non-*E. umbellata* with no recaptures. An average 0.25 birds/30 min (±0.54) were caught in *E. umbellata* and 0.23 birds/30 min (±0.53) were caught in non-*E. umbellata* (Fig. 5). A paired *t*-test showed that there was no significant difference in the number of captures between *E. umbellata* and non-*E. umbellata* ($t_{captures}$=0.27, d.f.=112, p= 0.79). A total of 16 species were caught in *E. umbellata* and 15 total species were caught in non-*E. umbellata* (Table1). Nine of these species were common in both habitats. A paired *t*-test on the nine common species caught

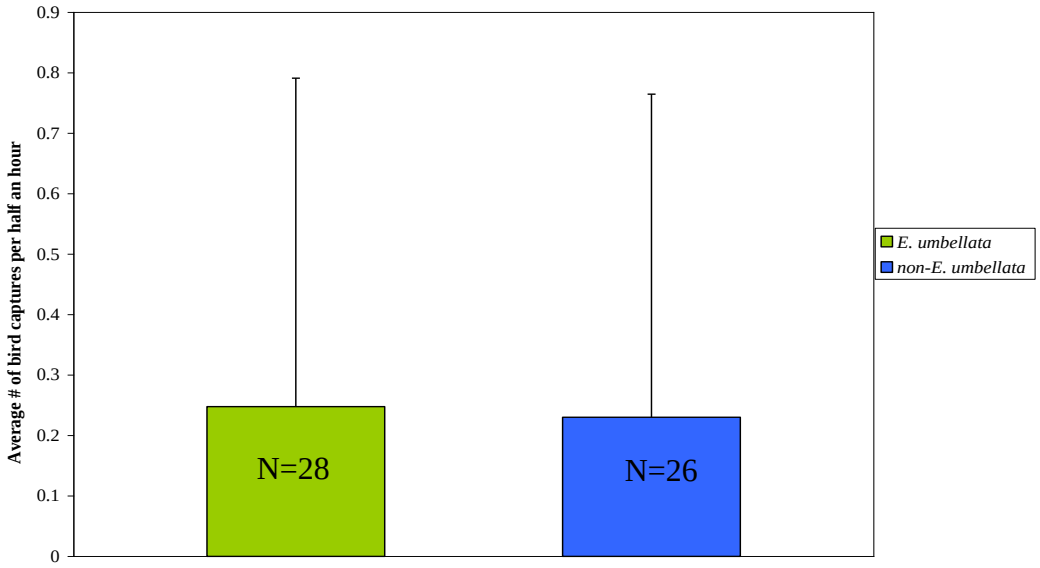

Figure 5: Average bird captures per half an hour of *E. umbellata* compared to native shrub clumps. Vertical bars are +1 SD.

Table 1: Species and number of birds captured in *E. umbellata* compared to native shrub clumps.

E. umbellata		Non-*E. umbellata*	
Species	#	Species	#
Yellow Warbler (*Dendroica petechia*)*†‡	1	Yellow Warbler (*Dendroica petechia*)*†‡	1
Eastern Bluebird(*Sialia sialis*)*†‡	1	Eastern Bluebird(*Sialia sialis*)*†‡	1
Ruby-Throated Hummingbird (*Archilochus colubris*)*	2	Ruby-Throated Hummingbird(*Archilochus colubris*)*	1
American Robin (*Turdus migratorius*)*‡	2	American Robin (*Turdus migratorius*)*‡	2
Indigo Bunting (*Passerina cyanea*)*‡	2	Indigo Bunting (*Passerina cyanea*)*‡	1
Common Yellowthroat (*Geothlypis trichas*)*†‡	4	Common Yellowthroat (*Geothlypis trichas*)*†‡	7
House Wren (*Troglodytes aedon*)*	3	House Wren (*Troglodytes aedon*)*	4
Gray Catbird (*Dumetella carolinensis*)*‡	4	Gray Catbird (*Dumetella carolinensis*)*‡	1
Song Sparrow (*Melospiza melodia*)*‡	1	Song Sparrow (*Melospiza melodia*)*‡	1
Wood Thrush (*Hylocichla mustelina*)‡	1	Eastern Phoebe (*Sayornis phoebe*)†‡	1
Blue-winged Warbler (*Vermivora pinus*)	1	American Goldfinch (*Spinus tristis*)‡	1
Black-capped Chickadee (*Poecile atricapillus*)‡	2	Northern Cardinal (*Cardinalis cardinalis*)‡	2
Scarlet Tanager (*Piranga olivacea*)†	1	Field Sparrow (*Spizella pusilla*)	1
Eastern Towhee (*Pipilo erythrophthalmus*)	1	Rose-breasted Grosbeak (*Pheucticus ludovicianus*)†‡	1
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	1	Chipping Sparrow (*Spizella passerina*)†	1
Ovenbird (*Seiurus aurocapillus*)	1		

*denotes species that were common to both types of shrub clumps.
†denotes Hawkers
‡denotes Fruit Eaters

showed no significant difference in the mean number of birds caught between *E. umbellata* and non-*E. umbellata* (t_{common}=2.31, d.f.=8, p=0.84). Food types and feeding methods were determined for each species from the literature (Ehrlich et al. 1998). *Chi*-squared tests were done on the individual birds captured that were more abundant in *E. umbellata* and those that were more abundant in non-*E. umbellata*. The first test showed a significant difference in the number of individuals who were fruit eaters ($X^2_{food\ type}$ =10.67,d.f. = 1, p<0 .005) (Table 2). In addition, the second test showed a significant difference in the number of individuals who use hawking as a feeding method ($X^2_{feeding\ method}$= 13.04, d.f. = 1, p<0.005) (Table 3). Table 1 shows the captured bird species that were fruit eaters and hawkers.

Table 2: *Chi*-squared test contingency table for fruit eaters and shrub type

	Fruit eater	Non fruit eaters
Number of birds caught of species favoring *E. umbellata*	12	2 (excludes hummingbirds)
Number of birds caught of species favoring non-*E. umbellata*	5	13

Table 3: *Chi*-squared test contingency table for hawking feeders and shrub type

	Hawking feeder	Non-hawking feeder
Number of birds caught of species favoring *E. umbellata*	1	13
Number of birds caught of species favoring non-*E. umbellata*	10	8

Point Counts of Number of Species and Individual Birds in *E. umbellata* vs. non- *E. umbellata* Areas:

The data showed a slight trend toward more birds in non-*E. umbellata* for both the number of individuals and species. However when combined with Krintz and Eberhardt's (2008) point count data, a Wilcoxon Signed Rank Test did not show a significant difference in number of species or individuals in *E. umbellata* and non-*E. umbellata* areas ($T_{Species}$= 44.5, N=15, $T_{Critcal}$=25, P=0.05; $T_{Individual}$=43, N=15, $T_{Critcal}$=25, P=0.05). The average number of species and individuals for each location for both studies is summarized in Table 4. There was an average of 6.9 (±1.53) species and 9.79 (±3.52) individuals seen and heard in *E. umbellata* and an average of 7.07 (±2.12) species and 10.59 (±4.61) individuals seen and heard in non-*E. umbellata*.

Table 4: The average number of birds seen and heard during morning point counts in 8 different *E. umbellata* and non-*E. umbellata* locations.

	AVG NUMBER OF SPECIES		AVG NUMBER OF INDIVIDUALS	
TRAIL	***E. umbellata***	**Non-*E. umbellata***	***E. umbellata***	**Non-*E. umbellata***
RED PT 1	8.5	10	13	13
RED PT2	6	7.5	8	15
RED PT 1*	5.5	6	7.8	6.8
RED PT2*	5.5	6.8	6.3	7.5
YLW PT 1	8.5	5.5	9.5	8.5
YLW PT 2	9.5	9.5	15.5	13.5
YLW PT 1*	7.6	5.3	9.3	7
YLW PT 2*	5.3	5	6.3	7.6
FLD PT1	7.5	9	15	16
FLD PT2	8	10.5	16	21
FLD PT 1*	6	5.5	7	8
FLD PT 2*	8.5	4	10.5	4.5
ORG PT 1	6.5	9	11	11.5
ORG PT 2	8	9	10	16
ORG PT 1*	4.5	5	4.5	6.5
ORG PT 2*	5	5.5	7	7.5

* denotes data from Krintz and Eberhardt (2008)

Quantification of Branching Structure of *E. umbellata* and Common Natives:

The average number of branches per transect for *E. umbellata* was 6.1 (±1.45) compared to 3.1 (±1.85) branches per transect for *Prunus sp.*, 5.5 (±2.84) branches per transect for *Cornus sp.*, and 5.1 (±1.45) branches per transect for *Crataegus sp.* (Fig 6). A One-way ANOVA showed a significant difference in the number of branches per transect between *E. umbellata* and

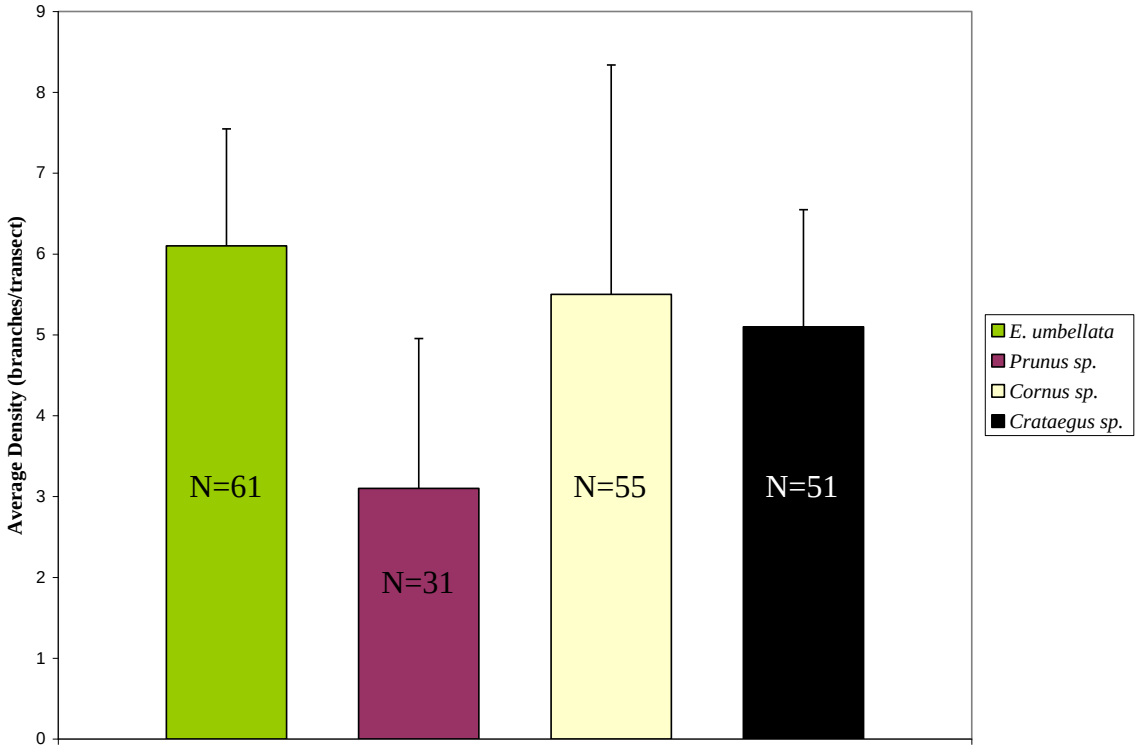

Figure 6: The average density (branches/transect) of *E. umbellata* compared to the natives *Prunus sp.*, *Cornus sp.*, and *Crataegus sp.* Vertical bars are +1 SD.

the natives (F=4.31, d.f. =36, p=0.01). A Tukey's post-hoc test showed a significant difference between *E. umbellata* and *Prunus sp.* ($q_{calculated}$=3.92, $q_{critical}$=3.633, p=0.05). The average diameter of the branches in the transect for each species was 3.7 mm/branch (±2.8) for *E. umbellata*, 8.2 mm/branch (±6.5) for *Prunus sp.*, 3.47 mm/branch (±3.43) for *Cornus sp.*, and 5.8 mm/branch (±12.5) for *Crataegus sp.* (Fig 7). A one-way ANOVA showed a significant difference in branch diameter between *E. umbellata* and natives (F=3.61, d.f. =194, p=0.01).

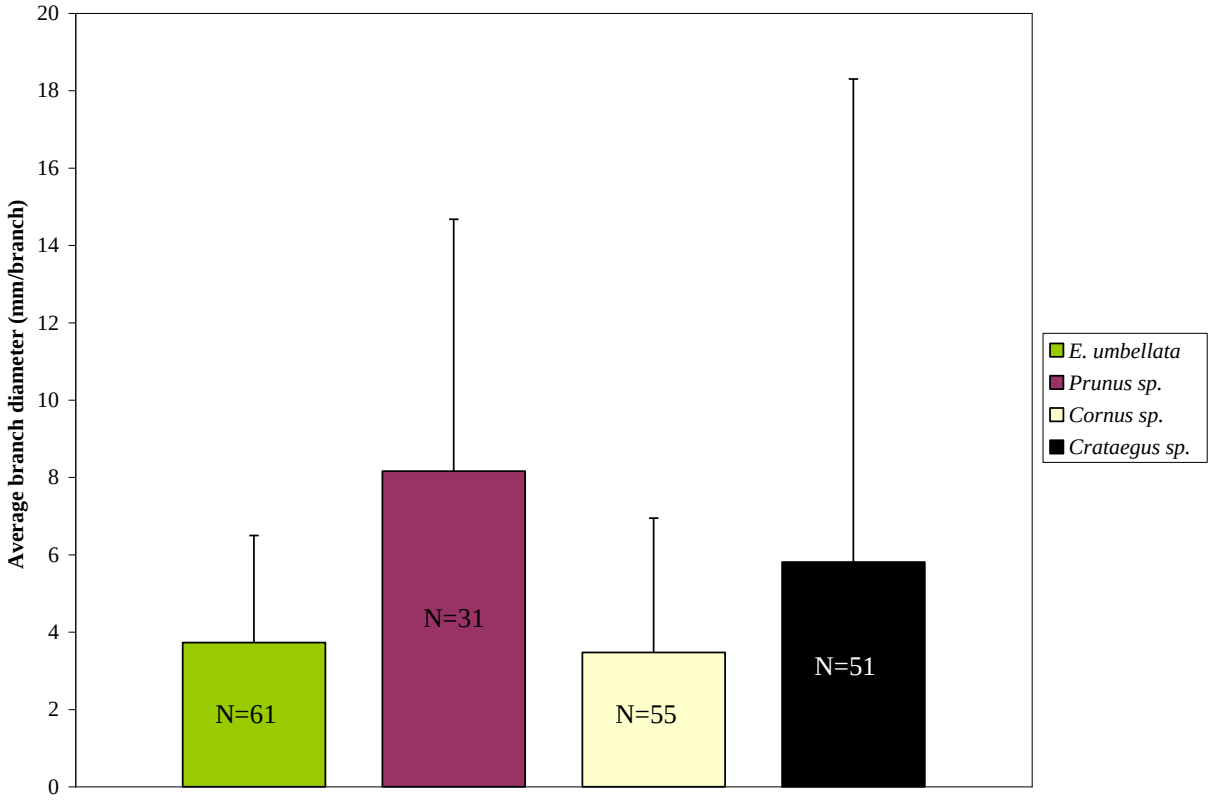

Figure 7: Average branch diameter of *E. umbellata* compared to *Prunus sp.*, *Cornus sp.*, and *Crataegus sp.* Vertical bars are +1SD.

A Tukey's post-hoc test showed that *E. umbellata's* diameter is significantly different from *Prunus sp.* ($q_{calculated}$=4.79, $q_{critical}$=3.845, p=0.05). *E. umbellata* had an average deflection of 22.20 g/branch (±8.09) needed to lift the branch 45°. Similarly, *Prunus sp.* had an average deflection of 23.71 g/branch (±10.77), *Cornus sp.* had an average deflection of 20.29 g/branch (±8.89), and *Crataegus sp.* had an average deflection of 24.89 g/branch (±12.99) needed to lift the branch 45° (Fig 8). A one-way ANOVA showed no significant difference in branch deflection between *E. umbellata* and the natives (F=1.80, d.f. =194, p=0.15).

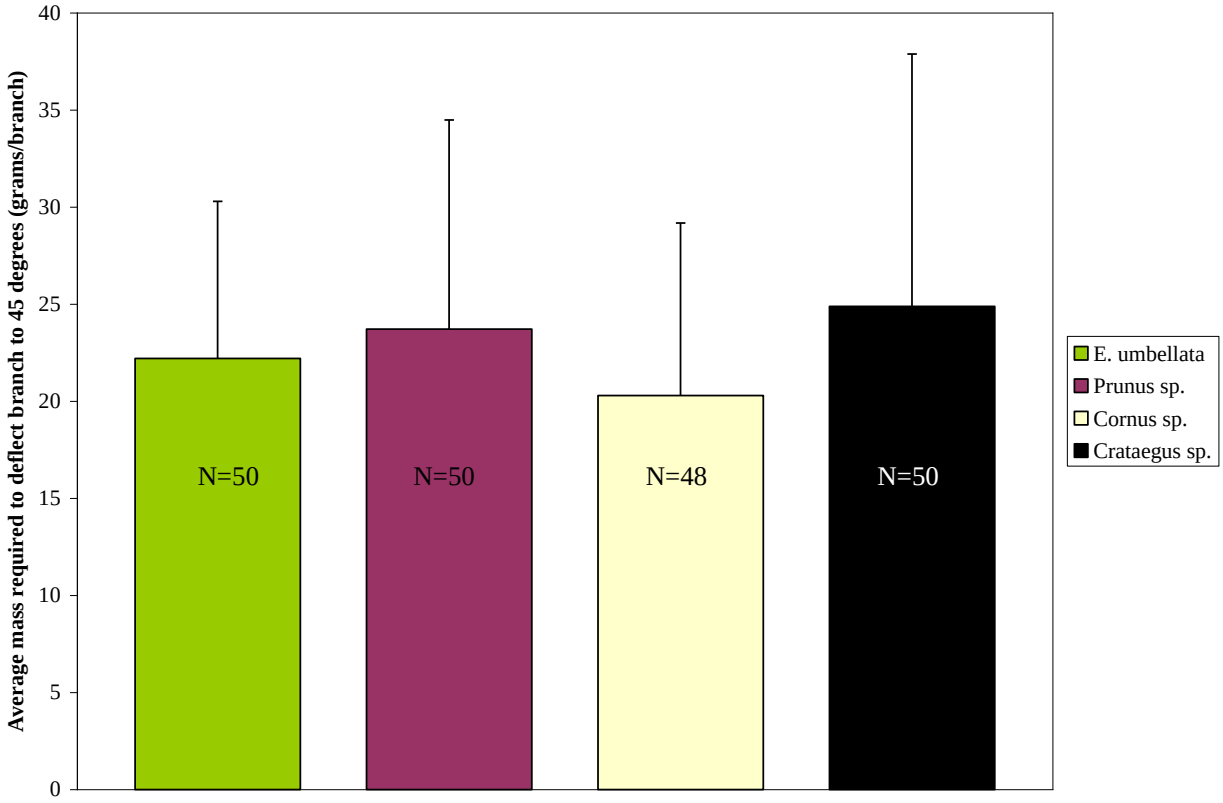

Figure 8: Average mass required to deflect branches to 45° for *E. umbellata* compared to *Prunus sp.*, *Cornus sp.*, and *Crataegus sp.* Vertical bars are +1SD.

Choice Tests of Perching Birds in Branches of Different Species:

The average number of bird visits to the *E. umbellata* feeders was 1.05 birds/30min (±1.36) with a total of 4 Eastern Chipmunk (*Tamias striatus*) visits to these feeders. The non-*E. umbellata* feeders had an average of 0.9 birds/30min (±1.55) with 11 total *T. striatus* visits. In addition, there was an average 4.39 grams of seed/hour (±3.31) taken and an average of 0.30 Northern Raccoon (*Procyon lotor*) visits/day (±0.46) in *E. umbellata*. Non-*E. umbellata* had an average 4.54 grams of seed/hour (±3.84) taken and an average of 0.32 *P. lotor* visits/day (±0.47). Figure 9 summarizes these results. A paired *t*-test showed no significant difference in the

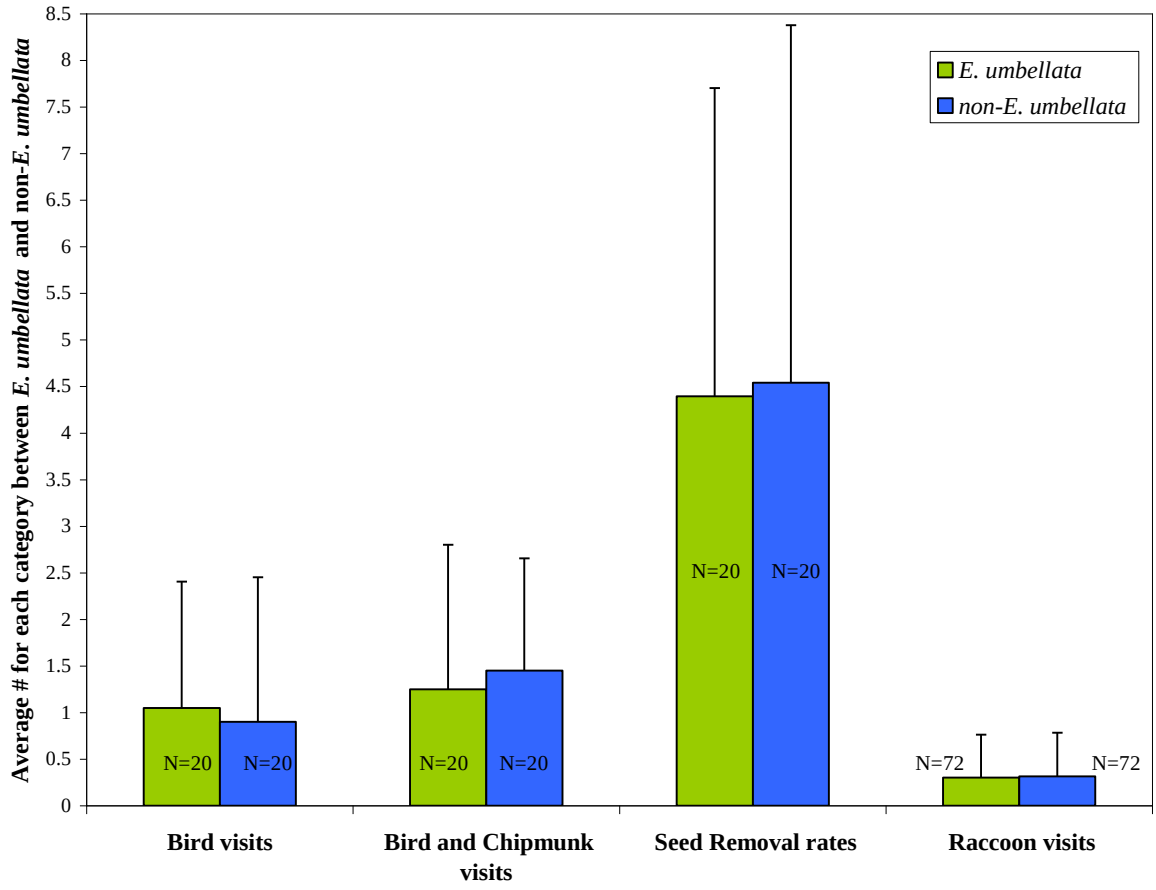

Figure 9: The average number of bird visits (birds/30 min), bird and Eastern Chipmunk visits (birds and chipmunks/30 min), seed removal rates (grams/hour), and Northern Raccoon visits (raccoons/day) for *E. umbellata* and non-*E. umbellata*. Vertical bars are +1SD.

number of bird visits, number of bird and *T. striatus* visits, seed removal rates, and *P. lotor* visits between *E. umbellata* and the natives ($t_{birdvisits}$=-0.46, d.f.=19, p=0.65; $t_{birdchip.visits}$=-0.56, d.f.=19, p=0.58; $t_{seedrates}$=-0.19, d.f.=19, p=0.85; $t_{raccoon}$=-0.26, d.f.=73, p=0.80).

Discussion

Mist Netting within Shrub Clumps:

There was no significant difference in the density and species diversity of birds netted in *E. umbellata* and non-*E. umbellata*. Although the number of species found in either *E.*

umbellata or non-*E. umbellata* were similar, 39% of the species caught were different between the two habitats. This could mean that the species caught exclusively in non-*E. umbellata* are avoiding the invasive shrub. Using Ehrlich et al.'s (1998) information on food type and feeding method for each species, the birds that were caught most frequently and ones that were exclusively caught in *E. umbellata* tended to prefer berries as a food type. Even though these data were collected during the non-fruiting season for *E. umbellata*, this difference could have been from the *E. umbellata* birds preferring to spend their time in shrubs that will bear fruit later. Whereas, the birds caught most frequently and that were exclusively caught in non-*E. umbellata* nets preferred hawking, swooping down from a perch to catch prey, more frequently as a feeding method. In this case, the birds captured in non-*E. umbellata* may have preferred to be in a shrub that was easier for them to hawk from when they were foraging. The density of branches in species such as *Prunus* could be a reason this method is favored in non-*E. umbellata* sites, a low branch density would potentially make prey easier to see and access. One species that was caught exclusively in non-*E. umbellata* was the Northern Cardinal (*C. cardinalis*), which in a previous study was found to spend less time in *E. umbellata* although the shrub was abundant in the area (Houghton and Soley 2009). However, only two *C. cardinalis* were caught overall so a larger sample size is needed to confirm this trend.

Point Counts of Number of Species and Individual Birds in *E. umbellata* vs. non- *E. umbellata* Areas:

In addition to mist netting, the point counts conducted during 2009 and recently showed no significant difference in the number and species diversity of birds in *E. umbellata* compared to non-*E. umbellata* sites. This similarity in findings between the mist netting and point counts gives more validity to the point counts, because point counts are based on distance

approximation and the ability to see quiet birds in low light settings. Although the point count data and mist netting data support the same conclusion that birds do not avoid *E. umbellata*, the shrub is so widespread on the property that the sites with no *E. umbellata* present within 20 m were difficult to find. The *E. umbellata* encroachment from edge to interior non-*E. umbellata* sites was an issue for every site. This current spreading of the *E. umbellata* population may have already displaced species of birds that were living in the non-*E. umbellata* areas, which would have hidden any impact *E. umbellata* might have had on the bird population found in our results.

Quantification of Branching Structure of *E. umbellata* and Common Natives:

Prunus sp. was the only native tested whose branch density and size varied significantly compared to *E. umbellata*. The deflection of *Prunus sp.* branches did not vary significantly and was similar to all species tested. *Cornus sp.* and *Crataegus sp.* did not vary significantly in branching structure including branch density, size, and deflection, but there was a variation in branch density and size between *Prunus sp.* and *E. umbellata*. *Prunus sp.* could be used in further studies to elucidate if the structure of *E. umbellata* deters some species of birds and other fauna.

Choice Tests of Perching Birds in Branches of Different Species:

There were no significant differences in any of the variables measured during the feeder choice tests between *E. umbellata* and the natives tested. However, the number of birds that came to the feeders when being watched was small. The lack of variation could be from the small sample size, but it also could be from the lack of structural difference found in the majority of the perch branches used. *Prunus sp.* was the only native that was found to be structurally different from *E. umbellata*, but it was only used six times as a perch. However, four out of the six times it was used as a perch there were more visits by birds or *T. striatus* for *Prunus sp.* than

for *E. umbellata*. There were a total of two visits to *E. umbellata* compared to 11 for *Prunus sp.* Thus, the larger, less dense branches of *Prunus sp*. may have been more attractive as a perching and feeding site.

The seed removal rate for *E. umbellata* and natives is similar. However, this rate is not just from birds but a combination of birds, *T. striatus*, and *P. lotor*. It is unclear if the seed taken is from an equal number of visits to *E. umbellata* and natives or just to one hungry *T. striatus* or *P.*

lotor (Fig 10). It also does not account for the birds that came to the shrub, but were not seedeaters. In future experiments, the choice tests should be conducted with multiple food attracters and use *Prunus sp.* as a native, because it has been found to be structurally different from *E. umbellata*.

General Conclusions:

In general, we found no overall evidence that birds avoid *E. umbellata* during the non-fruiting season. These data indicate that removing *E. umbellata* from a habitat and replacing with native shrubs is unlikely to increase the bird population as a whole. However, there is a chance it will alter the composition of the bird community, because of the potential positive impact on fruit eaters and a negative effect on birds that feed by hawking. This could be the case in areas that were invaded by *E. umbellata* that previously did not have any fruit bearing plants, but had more open area that would have made hawking easier. Thus, there is still a potential for an avoidance behavior that could not be detected by our overall trapping and census techniques. This is especially true when looking at *Prunus sp.* structure and the positive trend toward more bird and *T. striatus* visits in *Prunus sp.* than *E. umbellata* in feeding trials. However, the sample size was too small to make any conclusions about this trend. In addition, birds that feed by

hawking may prefer the native shrubs and are avoiding *E. umbellata* because it is not a good substrate for that feeding method. Additional research between monocultures of *E. umbellata*

Figure 10: A Northern Raccoon (*P. lotor*) feeding from a *Prunus sp.* choice test feeder on 7/17/2011 at 0514.

and areas where *E. umbellata* has never been present should be conducted to increase the knowledge of bird and *E. umbellata* interactions, including feeding differences. This expansion will help by informing land managers about the potential positive, neutral, or negative impact *E. umbellata* has on their local bird community.

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