Report to the Nuttall Ornithological Club

Re: financial support from the Blake-Nuttall fund for the project "**How flexible is bird diet to resource variability during fall migration?"** Sept – Dec, 2016

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Background: We are grateful for the support of the Blake-Nuttall Foundation that allowed us to complete an analysis related to our project on bird-plant interactions during fall migration at Acadia National Park. A longstanding assumption of fall bird migration is that birds require fruit to fuel their migratory flights, which they need to consume in great quantities in migratory stopover habitats. However, nearly all evidence for fruit consumption during fall migration in eastern North America comes from one site – Block Island, Rhode Island (see the work of Jeffrey Parrish in the late 1990's and the more recent work of Scott McWilliams), a habitat with many fruits and little forest cover. Given that other stopover habitats, especially those in northern New England, are more forested and thus likely to have high insect biomass and little fruit or, at the least, have a very different fruiting community, it is uncertain whether patterns observed at Block Island apply more broadly. During migration, birds are known to switch consumption from arthropods to fruit but it is not known when or where the switch occurs; it is entirely possible that in more forested environments, the timing of migration is unrelated to fruit production. A detailed understanding of resource consumption during stopover is critical in the context of climate change. With rising spring temperatures, many plants are producing fruit earlier in the summer or fall than in previous years and arthropod patterns are also changing. Thus, birds may be arriving in migratory stopover habitats after their key resources have peaked in production. Individuals on stopover may be encountering a resource base that differs in its abundance and/or composition and there is concern that they may be unable to consume a sufficient amount of resources to meet their energetic demands.

Objectives: Our objective in this study is to establish the degree of synchrony between the temporal patterns of bird migration, arthropod biomass, and fruit availability at Acadia National Park. Further, it is to establish whether birds consume fruit during fall migration and, if so, establish the principal frugivores, the fruit they consume, and how the pattern of fruit consumption changes during fall migration. Not only does our study provide a window into bird-plant interactions in one of the most important protected areas in the eastern US but it can add information related to bird stopover behavior over a larger portion of the Atlantic flyway than previously known. Besides simply establishing whether birds consume fruit at Acadia, we ask the following specific questions:

- What species of fruit do birds consume?
- What species of birds consume fruit?
- Do both resident and migratory bird species consume fruit?
- Do birds consume the most commonly available fruit species or do they specialize on certain species, regardless of their availability?

Methods: To answer our questions, we collected fecal samples from birds caught in mist-nets in 2015 and 2016 during fall migration (Jul 28 – Oct 18). We captured birds daily at two sites on the Schoodic Peninsula of Acadia National Park, Maine (44.367, -68.058) (Fig. 1). At the same time, we conducted weekly surveys of fruit abundance in ten 1m x 2m plots surrounding each net lane. We recorded the abundance of ripe fruit for each of the eight most common fruiting species during fall migration on the Schoodic Peninsula: Mountain Holly (*Ilex mucronata*), Black Huckleberry (*Gaylussacia baccata*), Wild-raisin (*Viburnum nudum*), Mountain-ash (*Sorbus americana*), Winterberry (*Ilex verticillata*), Northern Bayberry (*Morella caroliniensis*), Smooth Shadbush (*Amelanchier laevis*), and Blackberries and Raspberries (*Rubus* spp). We analyzed the fecal samples by carefully scanning for and removing seeds. To identify the seeds, we compared our samples to seeds we collected in the field and by using the USDA Forest Service Woody Seed Plant Manual. **The Blake-Nuttall award funded directly the salary of the assistant that carried out the seed analysis work.**

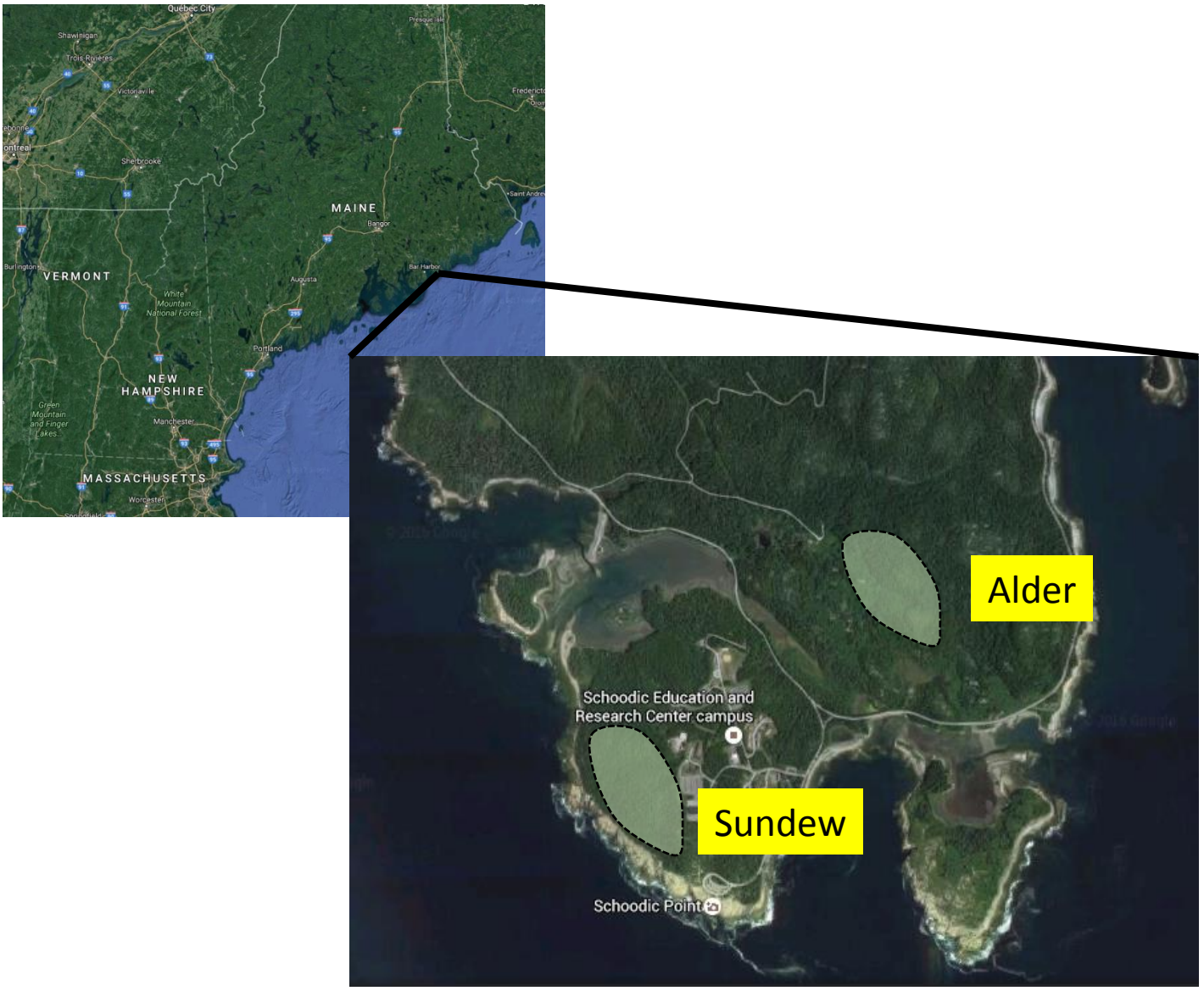

Figure 1: Location of the Schoodic Peninsula of Acadia National Park and the two study sites.

Preliminary results:

General patterns of bird migration, arthropod biomass, and the phenology of fruit production:

Overall, we banded 44 species in 2015 and 99 species in 2016. Species richness and bird abundance (indexed by capture rate, i.e. number of bird caught for each hour each net was open) varied between the two sites and across the fall migration season (Figs. 2, 3). In general, there was a slight decline in species richness through the fall though in 2016 there was a slight bump late September (Fig. 2). Bird abundance tended to decline from mid-August to mid-September but then peak again in late September and early October (Fig. 3). The late season peak was more evident in the Sundew site and, interestingly, abundance peaked on October 1st in both 2015 and 2016.

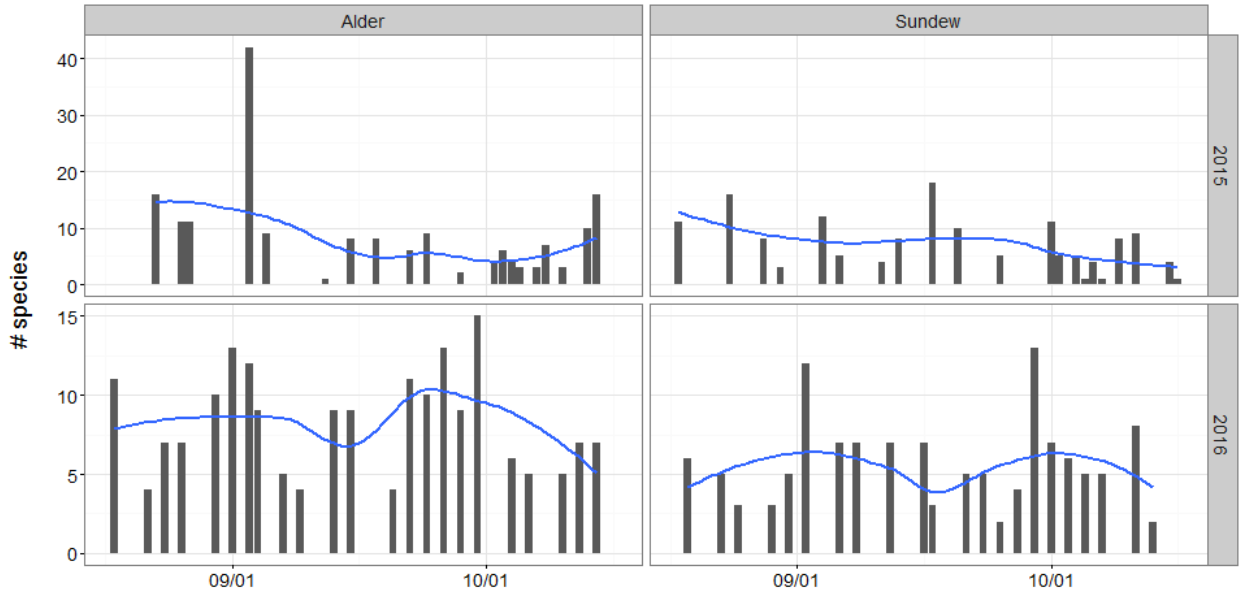

Figure 2: Daily bird diversity (# bird species) for the Alder and Sundew sites in 2015 and 2016. The bars are the species richness values while the lines are smoothed curves illustrating the main temporal pattern

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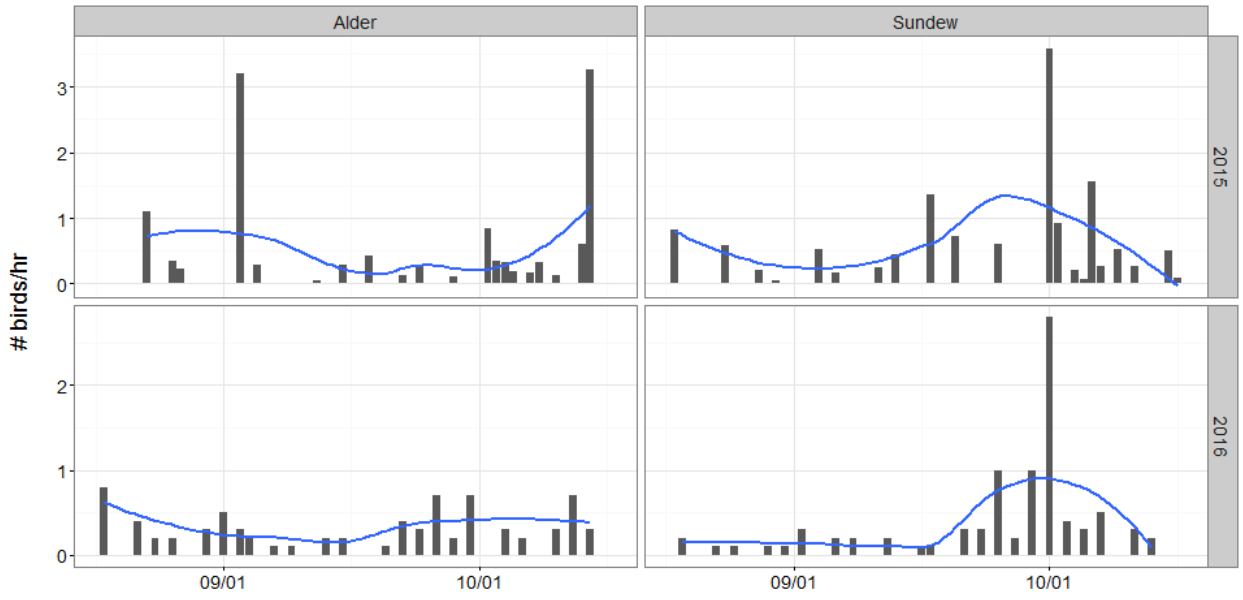

Figure 3: Daily bird capture rate (# bird captured per net hour) for the Alder and Sundew sites in 2015 and 2016. The bars are the capture rate while the lines are smoothed curves illustrating the main temporal pattern.

In 2015, the most common bird species in both sites were Yellow-rumped (Myrtle) Warbler (*Dendroica coronata coronata*) and Golden-crowned Kinglet (*Regulus satrapa*) (Fig. 4). Magnolia Warbler (*Setophaga magnolia*) was also common at the Alder site. In 2016, the kinglet was absent from both sites and White-throated Sparrow (*Zonotrichia albicollis*) was more abundant (Fig. 4). Common Yellowthroat (*Geothlypis trichas*) and Blackpoll Warbler (*Setophaga striata*) were also common at the Alder and Sundew sites, respectively (Fig. 4). Overall the Alder site was more diverse than the Sundew

site and 2016 was more diverse than 2015 but for Alder, only (Fig. 5). The diversity of the Sundew site in 2015 and 2016 was nearly equal.

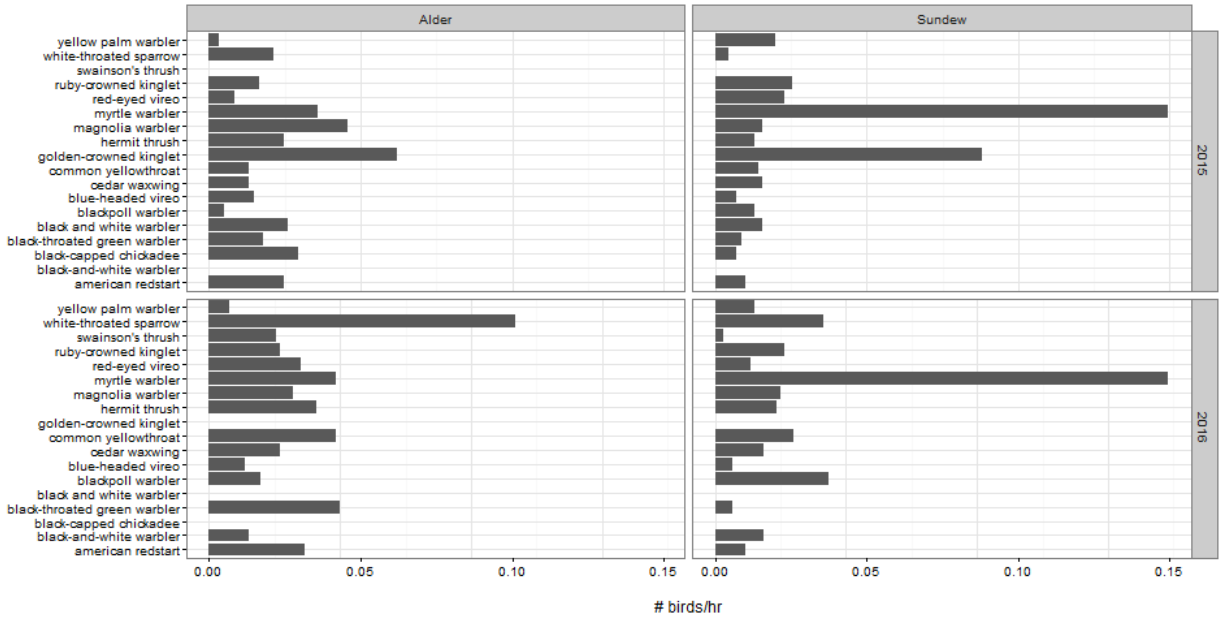

Figure 4: The most common bird species in the Alder and Sundew sites in 2015 and 2016. The list includes only those species captured on at least six different days in one of the sites in both years. Abundance is the yearly capture rate (total number of birds caught in the year per net-hour).

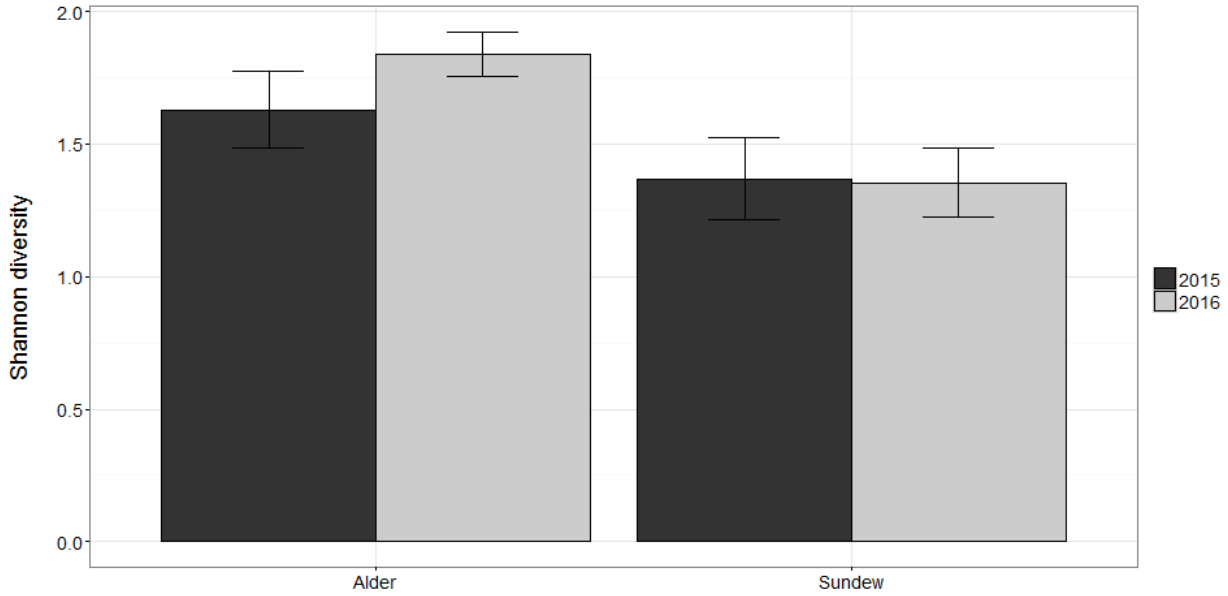

Figure 5: The Shannon diversity index for the Alder and Sundew sites in 2015 and 2016. The thick bars are the average diversity for each day birds were caught in the year. The error bars are the standard error of the mean.

In 2015, Mountain Holly dominated the fruiting community at both sites, though Black Huckleberry and Bayberry were also abundant at Sundew (Fig. 6). The fruiting community at Alder in 2016 was more

diverse than in 2015: Mountain-ash and Winterberry produced large number of fruits alongside Mountain Holly (Fig. 5). Meanwhile, in Sundew the composition of the fruiting community was similar in 2016 though the species produced more fruit (Fig. 6).

Of the four common fruiting species, Mountain Holly tended to produce fruit the earliest, followed by Black Huckleberry, Mountain-ash, and Winterberry (Fig. 7). Fruiting phenology was similar in both sites and fruit tended to peak earlier in 2016 than 2015 (Fig. 7).

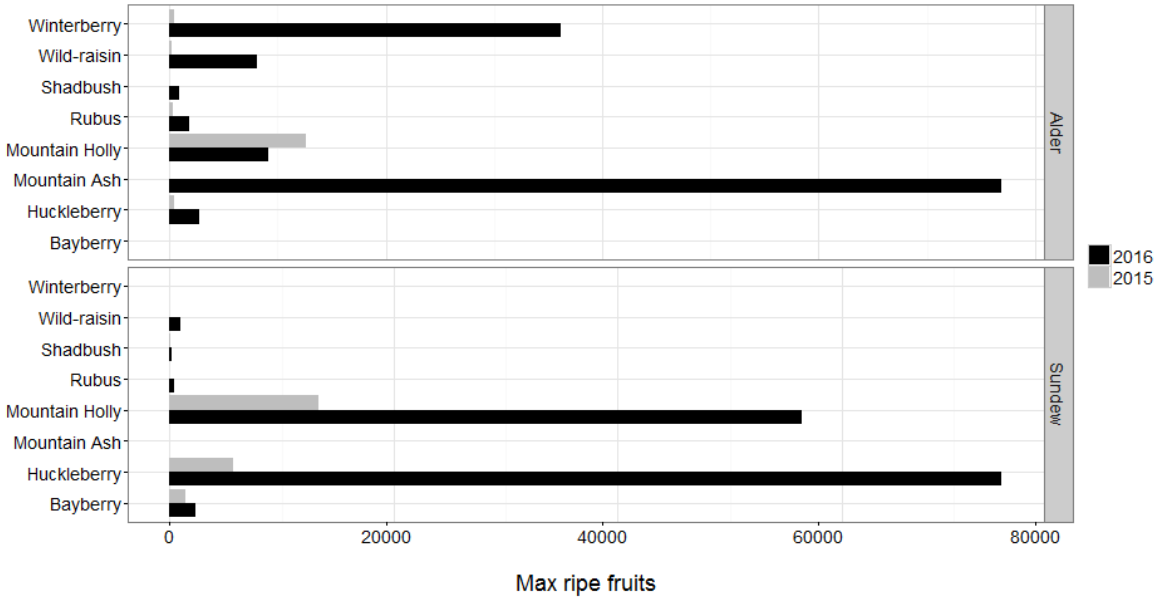

Figure 6: Species producing the most fruit in the Alder and Sundew sites in 2015 and 2016. The maximum daily number of fruits for each species at each site is shown.

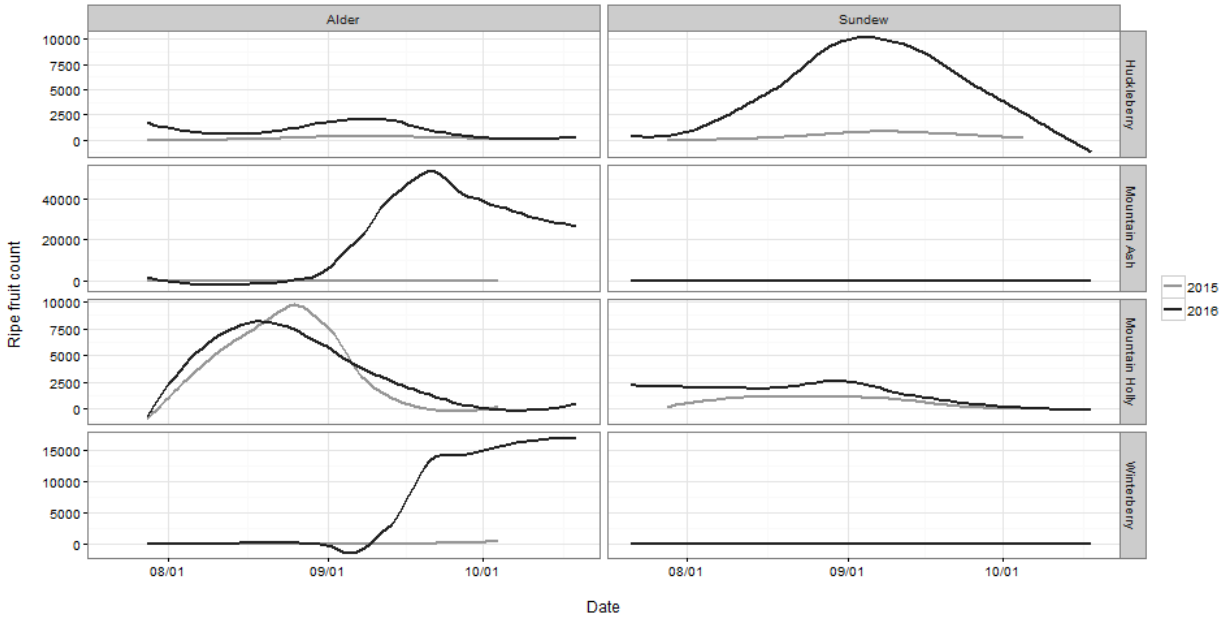

Figure 7: Fruiting phenology of the four most common species at the Alder and Sundew sites in 2015 and 2016. Smoothed daily fruit production is shown. Mountain Ash did not produce fruit in 2015 and it and Winterberry were not found at the Sundew site.

Arthropod biomass declined slightly during the fall migration season except at Sundew in 2015 when the decline was more severe (Fig. 8). Arthropod biomass was higher in 2015 than 2016 in both sites (Fig. 8).

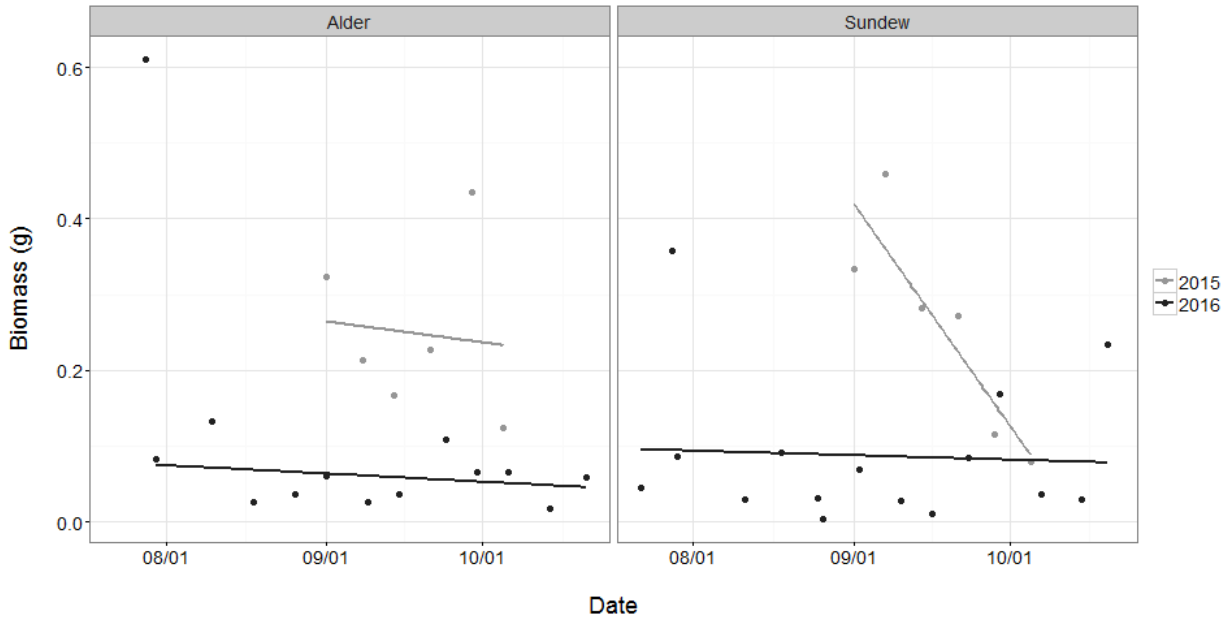

Figure 8: The phenology of arthropod biomass at the Alder and Sundew sites in 2015 and 2016. The lines are linear best fits to the recorded biomass values (points).

Fruit consumption by birds

Overall, we collected 95 fecal samples in 2015 and 645 fecal samples in 2016. Of those samples, 15 had seeds in 2015 and 85 had seeds in 2016. Many samples had seeds of more than one species. The fecal samples were spread across 22 bird species in 2015 and 37 bird species in 2016. The most commonly consumed fruit species – present in more than 10% of the fecal samples – were Mountain Holly, Black Huckleberry, Common Juniper (*Juniperus communis*), Smooth Shadbush, and Bayberry (Fig. 9). The birds with the most fruit in their feces – seeds present in more than 40% of each species' fecal samples – were Cedar Waxwing (*Bombycilla cedrorum*), Swainson's Thrush (*Juniperus communis*), Hermit Thrush (*Catharus guttatus*), and Yellow-rumped (Myrtle) Warbler (Fig. 10). (While it is well known that Myrtle Warbler consumes Bayberry, we found that it also consumed Common Juniper. Meanwhile, we found Bayberry seeds in White-throated Sparrow and Red-eyed Vireo). Another eight species had at least ten fecal samples but with <15% of those samples containing fruit (Fig. 10). Meanwhile four species had at least ten fecal samples but with none containing fruit (Fig. 10).

On average, bird species with fruit in their diet consumed 3.28 ± 0.75 different fruit species (mean ± standard error of the mean). Cedar Waxwing and Hermit Thrush had the most diverse diets, consuming 11 and 10 different fruit species, respectively (Fig. 11).

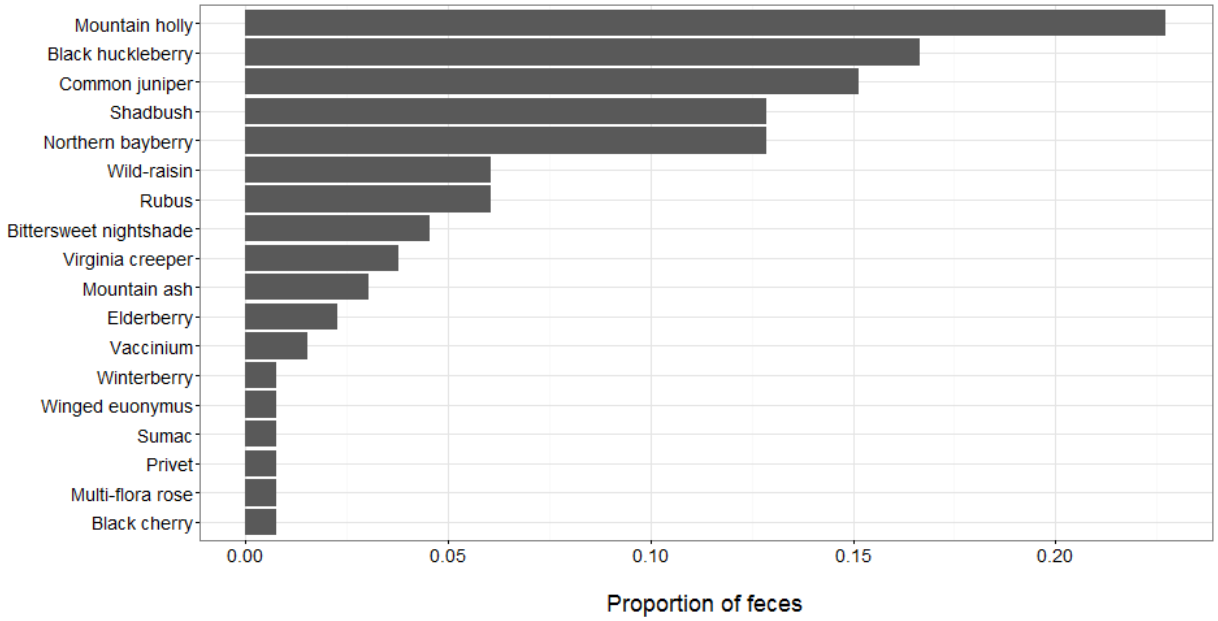

Figure 9: The proportion of total fecal samples collected in both sites and both years containing at least one seed of each plant species. Not all species were recorded on our phenology surveys.

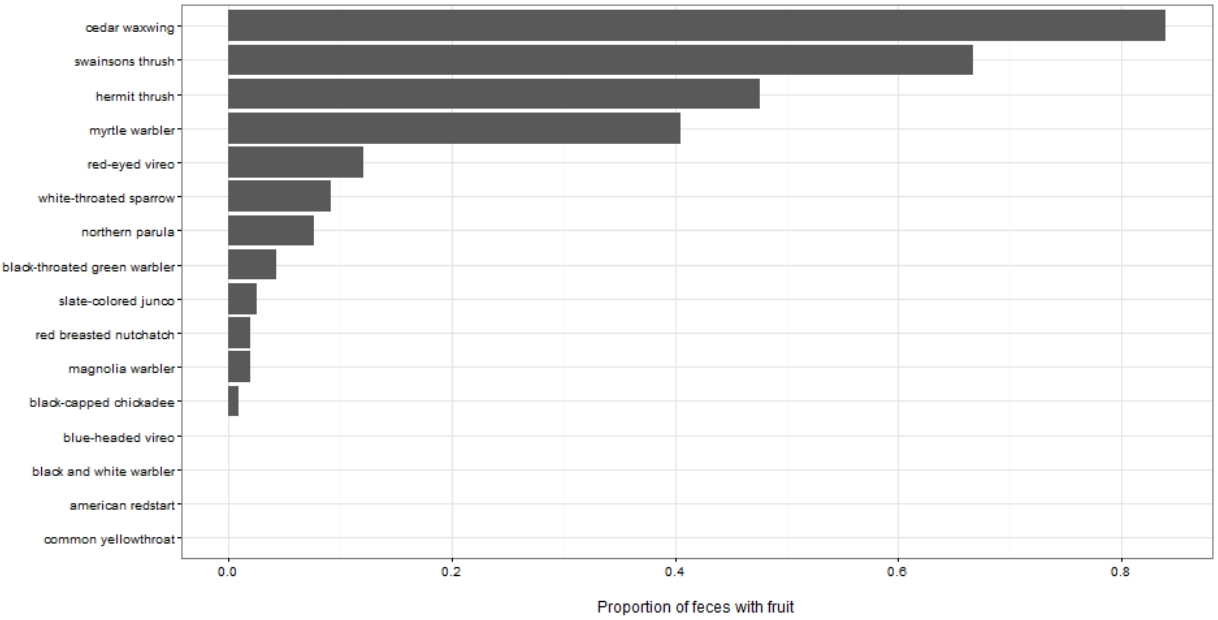

Figure 10: The proportion of fecal samples collected in both sites and both years containing at least one seed from any plant species. Only bird species with at least 10 total fecal samples are shown. Four bird species never had seeds in their feces.

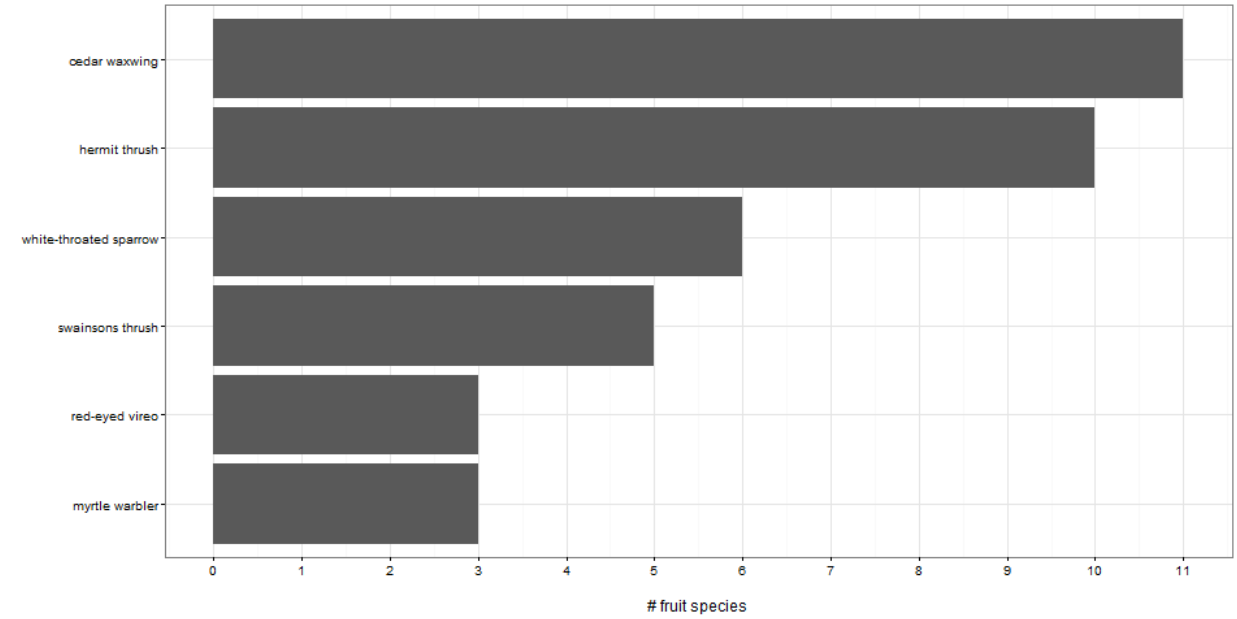

Figure 11: The number of different fruit species found in bird feces across the Alder and Sundew sites and 2015 and 2016. Only bird species with at least four fecal samples are shown.

The phenology of fruit consumption

The two most common fruits in feces – Mountain Holly and Black Huckleberry – were consumed primarily early in the fall migration season; they were nearly absent from feces after late September (Fig. 12). The other fruit species were consumed in consistent quantities through the fall migration season and were consumed daily in October (Fig. 12).

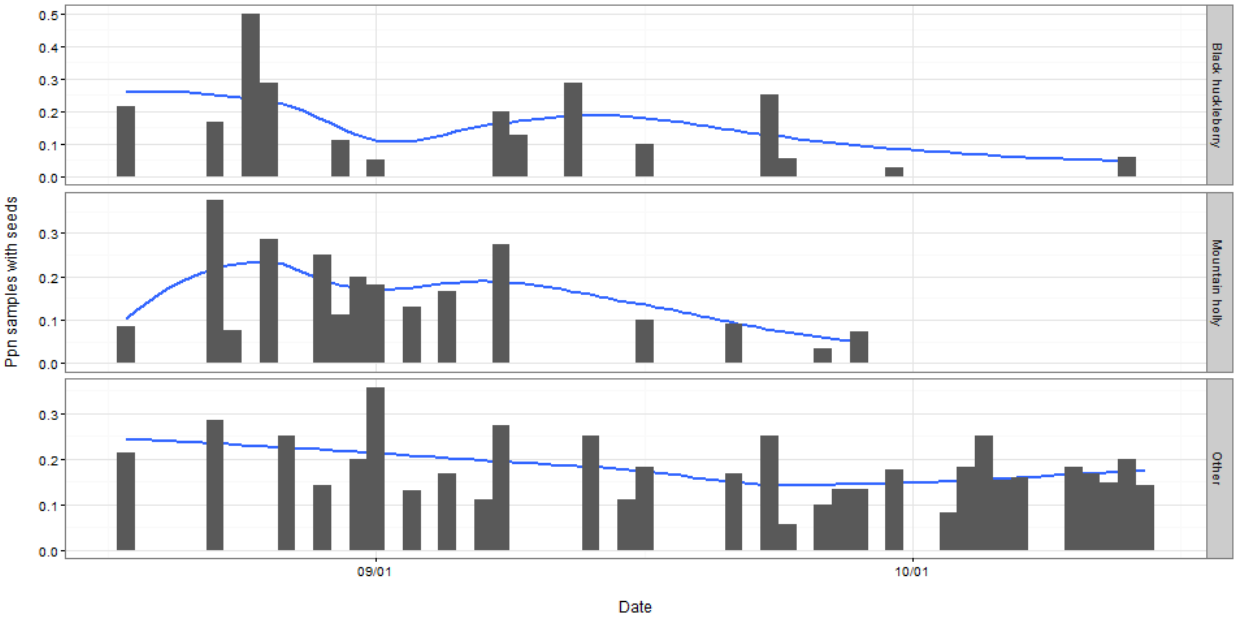

Figure 12: The proportion of fecal samples containing fruit belonging to Black huckleberry, Mountain holly, or all other species combined. Only days with at least four fecal samples collected are shown.

Summary: Returning to our original questions:

What species of fruit do birds consume?

- Overall, we discovered 19 species of fruit in the bird diet. Black Huckleberry, Mountain Holly, Common Juniper, Smooth Shadbush, and Northern Bayberry were the most common, found in over 10% of the fecal samples we collected.

What species of birds consume fruit?

- Overall, we found seeds from fruit in 18 bird species. Cedar Waxwing, Hermit Thrush, Swainson's Thrush, and Myrtle Warbler were the primary frugivores; over 40% of their fecal samples contained fruit.

Do both resident and migratory bird species consume fruit?

- The primary frugivores were migratory. However, we also discovered fruit in some fecal samples from common residents: White-throated Sparrow, Red-breasted Nuthatch, Slate-colored Junco, and Black-capped Chickadee.

Do birds consume the most commonly available fruit species or do they specialize on certain species, regardless of their availability?

- Black Huckleberry and Mountain Holly were the most common fruit in bird diets and these species were also the most plentiful in our sites during the first two-thirds of the migration season. Smooth Shadbush and Northern Bayberry were present in smaller amounts on our sites but they were relatively common in bird diet. Common Juniper was very common in bird diet but we did not observe it in our sample plots. Likewise, we found eight other fruit species in bird feces that we did not observe in our sample plots.