

**WSP Scientific Research Permit # 180403**

**Autumn 2018 Interim Report**

*Presence of formerly common wildlife species in St. Edward State Park, as determined by non-invasive methods.*

**SECOND INTERIM REPORT ON CAMERA TRAP STUDY OF WILDLIFE PRESENCE  
IN SAINT EDWARD STATE PARK: AUTUMN 2018<sup>1</sup>**

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*Note: This document reports on the results of the initial six months of an ongoing camera trap pilot study in Saint Edward State Park. It supersedes an earlier interim report (Stokes and Burns 2018), and presents the results (with minor corrections) from that earlier report (data collection period: May 18 – June 6, 2018) combined with the results of study since that report (June 13 – Nov. 9, 2018). Additional data will be collected in fall 2018 and winter and spring 2019. A final report will be submitted in 2019 based on the combined data collected from the entire pilot study (May 2018 – April 2019).*

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## ABSTRACT

*St. Edward State Park is the site of one of the largest and most intact remaining areas of mature (> 120 years old) native forest in the greater Seattle metropolitan area. Although the vegetation of the park is well described and documented, there is little information about the wildlife that is present. In May 2018 we initiated a camera trap pilot study to begin to characterize the wildlife species in the park, as well as to determine the feasibility of a camera trap methodology at this site. We deployed three cameras in a core area of the park for a total of 90 days in the months of May, June, September, October, and November of 2018. Two cameras were positioned in the bed of a small creek and one was on a log crossing the creek. All cameras functioned for the entire time they were deployed, recording a total of 488 images of animals. Modifications in camera positioning and settings resulted in improved image quality over the course of the study. No cameras were disturbed by humans. We recorded a total of 135 different animal occurrences (images taken more than 30 minutes before or after another image of the same species) of 12 different species that could be reliably identified, and 4 additional possible species that could not be reliably identified. Most notably, we demonstrated the significant presence of several native predator species, including bobcat (not previously known to be present; 7 occurrences, at 2 of the 3 camera sites), raccoon (28 occurrences, 3 sites), and coyote (3 occurrences, 2 sites). We also detected the non-native Virginia opossum (11 occurrences, 3 sites). These predators were mostly detected at night, as were mountain beaver and deer mouse. The other species detected with certainty--Douglas squirrel, eastern gray squirrel, eastern cottontail, American robin, varied thrush, and hairy woodpecker--were mostly detected in the daytime. No domestic cats were detected. We conclude that a camera trap study is a workable approach for characterizing forest-dwelling mammals and birds in St. Edward State Park, and that diverse species, including at least three native predators, make substantial use of forested habitats in the park. It is unlikely that the park is large enough by itself to support viable populations of some of these species. The data collected thus far indicate the need for further research related to wildlife species presence and activity patterns, habitat connectivity, and ecological impacts of invasive species in St. Edward Park and similar urban wildlands. Additional data collection will be pursued through spring of 2019. The findings of the completed study may provide results that can inform management for conservation of wildlife in the park.*

## INTRODUCTION

St. Edward State Park includes approximately 300 acres of maturing native Pacific Northwest forest, perhaps the most intact remaining example of native forest habitat in the Seattle metropolitan area (Smith 2006, Stokes et al. 2014). Nonetheless, widespread reduction and alteration of native habitat throughout the Seattle area has reduced the native biodiversity of the region, and some of the animal species that formerly inhabited undeveloped habitats such as the forest at St. Edward Park may be reduced in number or no longer present, a phenomenon known as defaunation (Dirzo et al. 2014). For example, bobcat (*Lynx rufus*), long-tailed weasel (*Mustela frenata*), Townsend's chipmunk (*Tamias townsendii*), flying squirrel (*Glaucomys spp.*), and northern red legged frog (*Rana aurora*) are all formerly widespread and relatively common species in the region that are not known to be present in the park (ESA 2017). An analogous loss of plant species may also be occurring in the park, with widespread species such as grand fir (*Abies grandis*) and Sitka spruce (*Picea sitchensis*) apparently absent (pers. obs), although this remains to be confirmed.

Loss or reduction of species has the potential to degrade the ecological integrity of the park's forest ecosystem. Furthermore, as one of the most heavily visited of all the Washington state parks (DeMay 2017), and with its close proximity to an urban center, reduction of the park's biodiversity would represent a lost experience (Pyle 1993, Miller 2005, Stokes 2006) for many people, a large proportion of whom may not have opportunities to experience this biodiversity elsewhere.

Restoring and/or managing for species that have been extirpated or reduced may be an appropriate strategy for addressing declining biodiversity and defaunation in St. Edward State Park. By restoring species that have declined or have been extirpated from the park, native diversity, ecological function, ecosystem services, and visitor experience may be protected and enhanced. However, a restoration effort of this scale and complexity requires a great deal of information, and little of that information currently exists. What native animal species are present in the park, and in what numbers? How are they using the habitat? What species are missing (i.e., formerly, but no longer, present)? What native species can the existing habitat support? What non-native species are present? What restoration efforts are needed to provide high value habitat to support populations of the missing species?

This pilot study is a first step in developing the information needed to determine if a faunal restoration effort would be appropriate in St. Edward Park, and if so, how it could be successfully pursued. As a starting point, we used camera traps to survey a core area of the park for presence of animal species to find out what species currently exist in the park and what species may be missing. We were particularly interested in predators, as they are cryptic and rarely observed (and thus their presence or absence is poorly known), and they often exert disproportionately strong influence on ecological community structure and ecosystem function (e.g., Beschta and Ripple 2016). Native predators can be important for maintaining biodiversity in an area (Crooks and Soulé 1999), while non-native predators, particularly domestic cats (*Felis catus*), can be a serious threat to native species (Loss et al. 2013). Thus, we deployed camera traps along hypothesized predator travel routes and positioned cameras in ways designed to detect predators.

In addition to the information we hoped it could produce, this study is also a test of the viability of camera trap study methods in St. Edward Park. Camera traps have the potential to produce reliable data on diverse aspects of animal ecology (Trolliet et al. 2014). However, they are also subject to limitations, and in addition to the usual limitations of all camera trap studies, in an urban setting such as St. Edward Park, disruption of cameras by people is a possible problem that could make this approach unworkable (Meek 2017). We used the pilot study to assess the magnitude of this potential problem at St. Edward, as well as to refine our camera trap methodology for future expansion of the research if the method proves workable.

## **STUDY AREA: SAINT EDWARD STATE PARK**

Saint Edward State Park is located on the northeast shore of Lake Washington in the city of Kenmore WA. At 326 acres, nearly all of which is forested, it is the site of one of the few substantial areas of largely native forest in the Seattle metropolitan area (Fig. 1). The site was logged in the late 1800s (NPS 2006), following which the forest has undergone largely natural

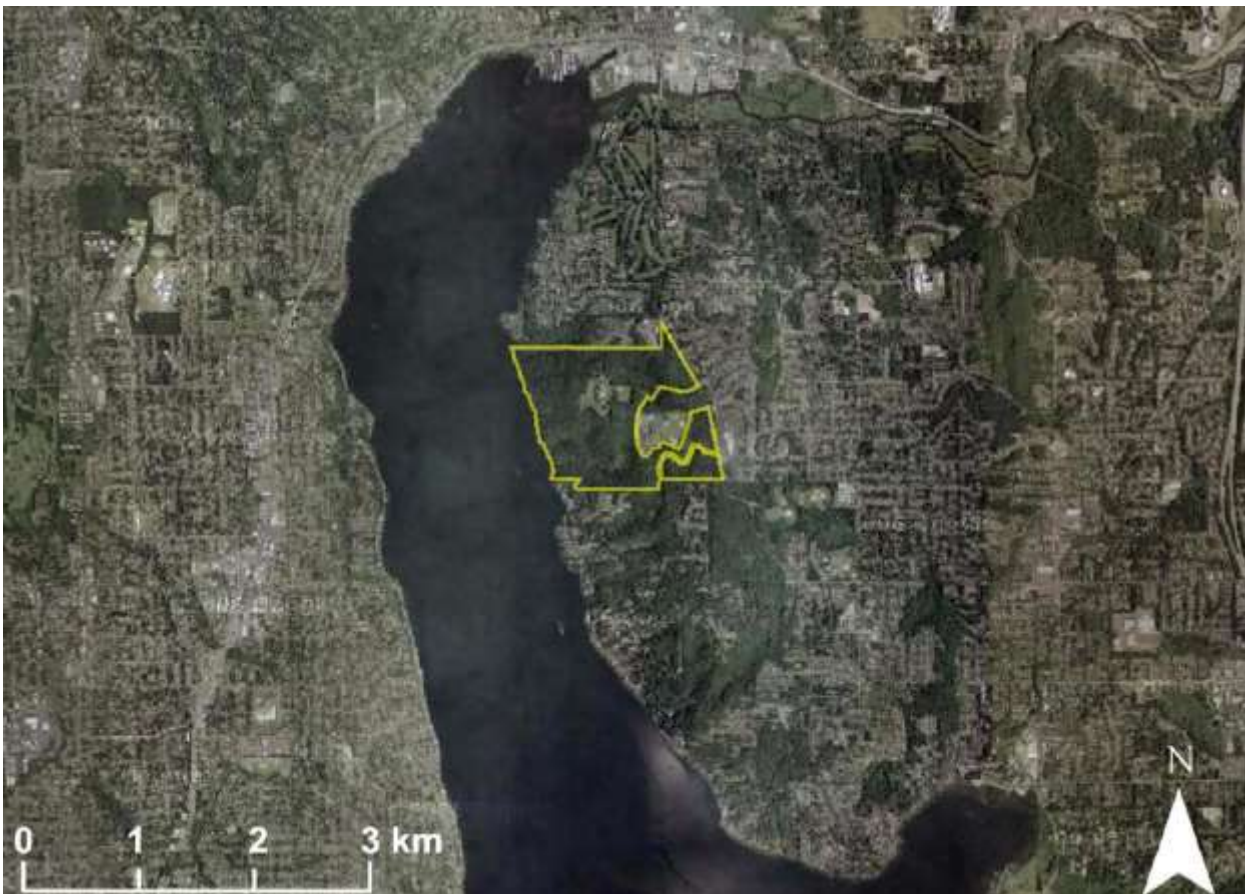
succession with little human disturbance. A vegetation inventory conducted for Washington State Parks (Smith 2006) indicated that the park is unusual in the Seattle area in having a diversity of native plant associations that are relatively intact, including substantial areas of forest that are nearing mature stages.

The forest at St. Edward Park consists of various native forest types typical of the western hemlock zone (Franklin and Dyrness 1988) of western Washington, ranging from nearly pure coniferous stands dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*), to mixed canopy forests of Douglas fir, bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*), to mostly deciduous forest dominated by red alder and bigleaf maple (Smith 2006). Other common canopy tree species include black cottonwood (*Populus trichocarpa*), Pacific madrone (*Arbutus menziesii*), and Oregon ash (*Fraxinus latifolia*). The shrub layer is generally substantial, commonly consisting mainly of one or more of the following: salal (*Gaultheria shallon*), trailing blackberry (*Rubus ursinus*), Oregon grape (*Mahonia nervosa*), sword fern (*Polystichum munitum*), Indian plum (*Oemleria cerasiformis*), salmonberry (*R. spectabilis*), red huckleberry (*Vaccinium parvifolium*), and red elderberry (*Sambucus racemosa*). Small but increasing amounts of non-native invasive woody species, including English holly (*Ilex aquifolium*), English ivy (*Hedera spp.*), cherry laurel (*Prunus laurocerasus*), and Portuguese laurel (*P. lusitanica*) (Green et al. 2013; Stokes et al. 2014, 2017; Lopez and Stokes 2016) are also invading the forest, with potentially negative impacts on native species (Church et al. in review).

Several small watercourses are present in the park, including two perennial incised streams that flow through steep ravines from wetlands in the upper elevations of the park to Lake Washington (Fig. 2, ESA 2017). The shrub vegetation along these streams is dense, dominated by salmonberry, with substantial amounts of devils club, sword fern, native blackberry, and other native woody and herbaceous species. Large trees have fallen across the streams, forming occasional log “bridges” 0 to 10 m above the streambed.


The forest at Saint Edward Park is mostly surrounded by residential development and is bordered by a heavily trafficked two-lane road (Juanita Drive) on the east, and Lake Washington on the west (Figs. 1 & 2). However, the isolation of the forest is not complete; substantial areas of forest, some of which is formally protected, adjoin the park on the south and north. Bordering the southeast corner of St. Edward Park is Big Finn Hill Park, a 220 acre King County park which consists mostly of early- to mid-successional Douglas fir forest and includes a stream and wetlands. O. O. Denny Park, a mostly forested 46 acre park that includes old-growth remnants and a salmon-bearing stream, extends from the west end of Finn Hill Park to Lake Washington. Juanita Woodlands, a forested 40-acre King County park, is also nearby. In addition to these protected areas, substantial areas of forest occur in residential areas to the north and south of St. Edward Park, and on the adjoining 51-acre Bastyr University property, approximately half of which is forest similar in type and condition to that of St. Edward Park (Figs. 1 & 2). Patterns of use of these protected and unprotected forest lands by St. Edward wildlife is unknown. Two potential movement corridors, the shoreline of Lake Washington and the Inglewood Golf Course to the north, may provide connections to large areas of natural habitat along the Sammamish Slough (Fig. 1), although wildlife use of these potential corridors has yet to be investigated.

St. Edward Park receives heavy human use, with approximately 500,000 visitors per year (DeMay 2017). Among common activities at the park are hiking, mountain biking, wildlife watching, picnicking, orienteering, and organized sports on the playfields (ESA 2017). Weekends are especially busy, and sometimes include special events that attract large numbers of visitors to the developed portion of the park (the seminary building and surrounding lawn area). The park's extensive network of trails (Fig. 2), receives substantial use by hikers, particularly in the summer and on weekends (pers. obs.). Many park visitors bring dogs, which are required to be on leash. Park visitors mostly use the official trails, although a significant number of social trails have developed and appear to be increasing in number and degree of establishment, particularly those connecting surrounding neighborhoods with the official park trail system (pers. obs., L. Kunze pers. comm.). The park is closed to visitors between sunset and sunrise.



**Figure 1.** St. Edward State Park and environs. Dominated by primarily native semi-mature forest, the park (border indicated by yellow line) is largely surrounded by suburban residential development, but is connected to forested habitats in Big Finn Hill and O. O. Denny parks, as well as unprotected areas of forest to the north and south. Other habitat connections include the shoreline of Lake Washington to the west, and the semi-forested Inglewood Golf Course and the Sammamish River to the north. Aerial photo modified from Smith (2006) to include 2018 McDonald property addition.

*Figure 2 redacted*

**Figure 2.** St. Edward State Park and locations (numbered 1, 2, and 3 in red) of 3 camera traps deployed in May, June, Sept., Oct., and Nov. 2018. 

 Map  
sources: King County (streams) and Washington State Parks, modified to include 2018 McDonald property addition.

## **METHODS**

In May 2018 we deployed three wildlife camera traps in a forested area of St. Edward State Park (Fig. 2, Table 1). This location was selected for study because it appears to be relatively undisturbed by humans (D. Kline, pers. comm.; pers. obs.), and is in an interior or core area of the park's forested habitat, and thus we expected it could be an area frequently used by native forest wildlife.

The cameras we used were Bushnell Trophy Cam Trophy HD model # 119537 (Fig. 3), manufactured by Bushnell Outdoor Products (Bushnell 2013). These cameras have a shutter that

is triggered by a passive infra-red motion sensor that detects movement of a warm object (e.g., mammal or bird) in the field of view. The cameras take color pictures under high light conditions, and black and white photos in low lights, using a “low-glow” infra-red flash to avoid disturbing the subject. They have a recovery time of 0.6 seconds (Bushnell 2013).

We deployed the devices in continuously active (24 hr) “camera” mode and set them to capture 5 megapixel still photos. For the initial deployments (May 18 – June 29) camera settings were as follows: Camera #1 was set to take a burst of three successive photos per trigger. The other two cameras were set to take one photo per trigger. LED control (for night illumination) was set at “High” to maximize the distance (60 feet; Bushnell 2013) from which an identifiable image of an animal could be captured at night. The cameras were set to wait 10 seconds after a trigger to respond to a new trigger. Sensor level was set to “auto.” Night vision shutter speed was set to “low.” We activated the time feature so that all images were stamped with time and date. The “Field Scan” feature was not activated.

Based on the initial photographs we obtained, we changed some of the camera settings in September as follows: All cameras were set to take a burst of three photos per trigger and the wait period was reduced from 10 to 5 seconds to capture more images of individual wildlife occurrences. The LED control and night shutter speed were both set to “medium” to improve image quality, reduce blurring, and avoid overexposures. We also added additional property labeling to the camera cases to dissuade theft or disturbance in case of discovery by a member of the public.

We attached the cameras to limbs or bush stems with straps or duct tape at various heights (0.05 – 1.5 m) above the target view area. Cameras were deployed for increasingly long durations over the period from May to November (Table 1). We did not deploy cameras in July and August, the period of highest numbers of park visitors, to avoid possible disturbance of cameras by people.



**Figure 3.** A Bushnell Trophy Cam Trophy HD camera trap used in the St. Edward Park study, attached to tree. The camera uses a passive infra-red sensor to detect motion, and a “low glow” infra-red flash to take pictures at night without disturbing the subject. Photo by Nik Burns.

**Table 1.** Camera placements and days deployed. Three camera traps set at St. Edward State Park, 2018. See Fig. 2 for site locations. All times Pacific Daylight Savings Time.

Camera #	Site	Deployment			Recovery			Days	Location	Camera Ht (m)	Direction	Notes
		Date	Day	Time	Date	Day	Time					
1	1	5/18/18	Fri	15:30	5/23/18	Wed	08:05	5	on log across ck., 0.96 m diam. 2.6 m above ck.	0.05 m above log	SW; down log	Substantial veg. on log Log not visible from trail
2	2	5/18/18	Fri	15:50	5/23/18	Wed	08:15	5	on log across ck., 0.75 m diam. 10 m above ck.	0.15 m above log	SW; down log	Little vegetation on log; some moss; Log barely visible from trail
3	3	5/18/18	Fri	16:30	5/23/18	Wed	08:25	5	on log across ck., 1.0 m diam. 5.5 m above ck.	0.4 m above log	S; down log	Substantial veg. on log Log not visible from trail
1	1	5/25/18	Fri	09:10	5/31/18	Thu	07:10	6	creek bed 2 m SE of log	1.5 m above ck.	NW; downstream	Ck. bed rock, sand, CWD Ck. flowing
2	2	5/25/18	Fri	09:25	5/31/18	Thu	07:15	6	on log across ck., 0.75 m diam. 10 m above ck.	0.4 m above log	SW; down log	Same as 5/18/18.
3	3	5/25/18	Fri	09:45	5/31/18	Thu	07:20	6	creek bed 2 m W of log	1.4 m above ck.	E; upstream	Ck. bed rock, CWD Ck. flowing
1	1	6/2/18	Sat	08:00	6/6/18	Wed	08:00	4	creek bed 2 m SE of log	0.80 m above ck.	NW; downstream	Ck. flowing Salmonberries ripe
2	2	6/2/18	Sat	08:15	6/6/18	Wed	08:20	4	on log across ck., 0.75 m diam. 10 m above ck.	0.4 m above log	SW; down log	Salmonberries ripe
3	3	6/2/18	Sat	08:40	6/6/18	Wed	08:30	4	creek bed 2 m W of log	0.95 m above ck.	E; upstream	Ck. flowing Salmonberries not ripe
1	1	6/13/18	Wed	09:05	6/21/18	Thu	08:20	8	creek bed 2 m SE of log	1.0 m above ck.	NW; downstream	Ck. flowing Salmonberries ripe
2	2	6/13/18	Wed	09:20	6/21/18	Thu	08:35	8	on log across ck., 0.75 m diam. 10 m above ck.	0.6 m above log	SW; down log	Salmonberries ripe
3	3	6/13/18	Wed	09:35	6/21/18	Thu	08:45	8	creek bed 2 m W of log	0.8 m above ck.	E; upstream	Ck. flowing Salmonberries ripe
1	1	6/22/18	Fri	08:30	6/29/18	Fri	07:50	7	creek bed 2 m SE of log	0.9 m above ck.	NW; downstream	Ck. Flowing, no salmonberries
2	2	6/22/18	Fri	08:50	6/29/18	Fri	08:00	7	on log across ck., 0.75 m diam. 10 m above ck.	0.6 m above log	SW; down log	No salmonberries
3	3	6/22/18	Fri	09:00	6/29/18	Fri	08:10	7	creek bed 2 m W of log	0.8 m above ck.	E; upstream	Ck. flowing No salmonberries; fresh human tracks in stream
1	1	9/7/18	Fri	08:35	10/9/18	Tue	07:10	32	creek bed 2 m SE of log	0.95 m above ck.	NW; downstream	Ck. flowing
2	2	9/7/18	Fri	09:05	10/9/18	Tue	07:20	32	on log across ck., 0.75 m diam. 10 m above ck.	0.8 m above log	SW; down log	
3	3	9/7/18	Fri	09:30	10/9/18	Tue	07:30	32	creek bed 2 m W of log	1.0 m above ck.	E; upstream	Ck. flowing
1	1	10/12/18	Fri	08:15	11/9/18	Fri	08:00	28	creek bed 2 m SE of log	1.4 m above ck.	NW; downstream	Ck. flowing
2	2	10/12/18	Fri	08:30	11/9/18	Fri	08:15	28	on log across ck., 0.75 m diam. 10 m above ck.	0.9 m above log	SW; down log	New camera placement on large limb projecting to side of main log.
3	3	10/12/18	Fri	08:40	11/9/18	Fri	08:30	28	creek bed 2 m W of log	1.2 m above ck.	E; upstream	Ck. flowing



We deployed the camera traps at three sites [REDACTED]

[REDACTED] The area around all three sites was characterized by thick brush primarily consisting of salmonberry, along with sword fern and native blackberry, under an upper canopy of mostly large bigleaf maple, with lesser amounts of red alder, western redcedar, western hemlock, and Douglas fir.

In the initial deployment (May 18 – 23), all cameras were positioned on top of the large logs that were across the creek, and were aimed to capture images of wildlife on those logs. Substantial herbaceous and shrubby vegetation was present on the crossing logs at sites 1 and 3; the log at site 2 was largely free of vegetation except for moss. Because no images of wildlife were captured in the initial deployment at sites 1 and 3, we moved the cameras at those sites to the creek bed below the crossing logs and aimed them to capture wildlife travelling on the creek bed. Camera 1 was aimed in a downstream direction, and camera 3 was aimed upstream. Camera 2 (on a log bridge approximately 10 m above the creek) was aimed southwest along the length of the log.

At the location of the camera traps, the creek bed was 1 – 2 m wide, with a shallow (generally < 5 cm deep) water flow ranging from 0.3 – 1 m in width in May, June and Sept. The creek bed was characterized by a mostly rocky surface with some sand and gravel, and substantial amounts of coarse woody debris. Live shrubs, primarily salmonberry, were growing in and along the creek bed.

Except for the first deployment, we deployed and collected cameras in the morning, when few park visitors were present, to avoid calling attention to the cameras. To get to the camera sites, [REDACTED] as close as possible to each site, and then travelled off trail to reach the site. We took care to avoid leaving evidence of our route by stepping on coarse woody debris and bare ground where possible, avoiding stepping on herbaceous vegetation, and scattering woody debris on the ground at the location [REDACTED].

After collection of the cameras following each deployment, we downloaded the recorded images to a computer and deleted the images stored on the cameras' memory cards. Two researchers (Stokes and Burns, May 18 – June 6; Stokes and Samuelson June 13 – Nov. 9) independently visually inspected each image to determine if wildlife was present and, if possible, identify the wildlife to species. We assigned reliability ratings to species identification as follows:

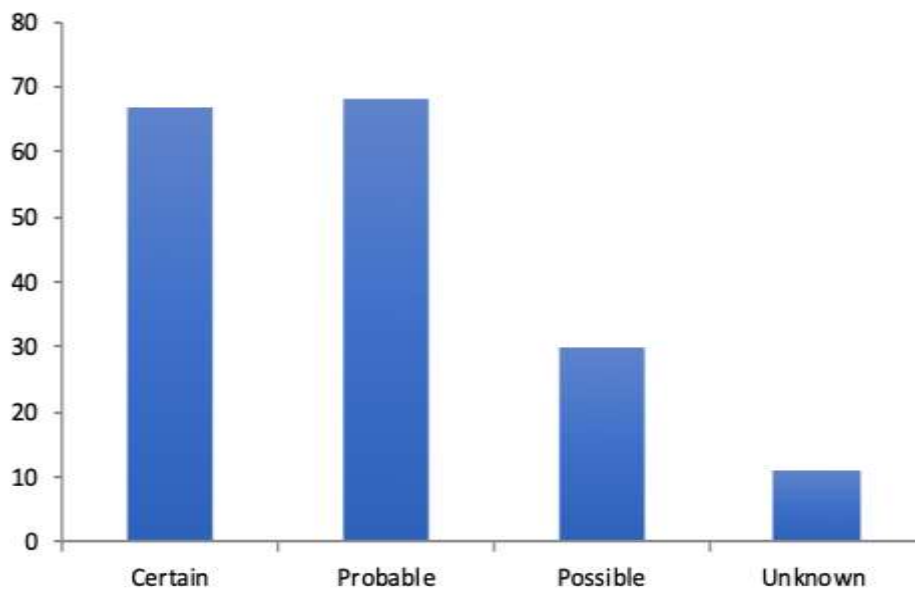
- “Certain” image is clearly identifiable to species; there is no other reasonable possibility
- “Probable” image is highly likely to be the species but there is some (minor) ambiguity
- “Possible” image appears to be the species, but could reasonably be a different species
- “Unknown” an animal is present, but the image provides no reliable indication as to species

As the cameras took pictures in rapid succession, many individual animals were photographed multiple times. We defined a single occurrence or detection of an animal as encompassing all images that could be reliably identified to species (“certain” or “probable”) that occurred within 30 minutes of another reliable image of the same species at the same site.

## RESULTS

### *Camera trap methodology*

All cameras recorded images over the entire period of deployment (Appendix 1). A total of 488 images and 176 occurrences of discernable non-human animals were recorded, 402 images (82%) and 135 occurrences (77%) of which could be identified to species with substantial reliability (certainty level = “certain” or “probable;” see Methods; Fig. 4). The remainder (n = 86 images, 41 occurrences) were not considered reliably identifiable (“possible” or “unknown”). A substantial proportion of the less reliably identified images (n = 24) and occurrences (n = 11) were of squirrels for which the only uncertainty was whether the animal was an eastern gray or Douglas squirrel.



**Figure 4.** Reliability of species identification for all wildlife occurrences recorded between May 19, 2018 and November 7, 2018. Four categories of reliability (see text): “certain” (n = 67), “probable” (n = 68), “possible” (n = 30), and “unknown” (n = 11).

The majority of “unknown” occurrences (n = 11) could not be identified due to poor-quality images (overexposed or blurred) or because the animal subject was only partially visible (behind vegetation or partly out of the frame). In addition, images of animals in rapid motion such as flying birds, and smaller species at distance also resulted in “unknown” occurrences. Deer mice were reliably identified to genus, but the two species native to the area (*P. maniculatus* and *P. keeni*) could not be distinguished.

Occurrences of predators were particularly identifiable to species. Ninety-two percent (49 of 53) of all occurrences that appeared to be of larger animals (opossum-size or larger) were reliably identifiable (“certain” or “probable”). Of all animal occurrences that were not reliably identifiable, (“possible” or “unknown;” n = 41) only four (10%) could possibly have been opossum-size or larger (i.e., one of the predator species).

Identifiable images were recorded both in the daytime and at night. Daylight (ambient lighting, color) images were generally clearer, with subjects more identifiable, than nighttime (infra-red flash, black & white) images. We recorded many fewer wildlife occurrences with cameras in daylight mode in the Sept – Nov. deployment period (4%; 3 of 82 occurrences) than in May – June (57%; 54 of 94 occurrences). The reduced proportion of daylight images in Sept - Nov. is likely due in part to the faster shutter speed (as of the Sept. deployment) and lower ambient light levels for a greater portion of the day during this period; however seasonal changes in species presence and/or activity patterns may also contribute to this difference.

Overall reliability of identification of species improved over the course of the study. Among all occurrences, 72% of 94 animal occurrences had a reliability of “certain” or “probable” in the May – June deployments, versus 82% of 82 occurrences in Sept. – Nov.

Quality of images was influenced by camera height. Initial placements of cameras at very low heights (0.05 – 0.4 m above the substrate) resulted in some nighttime images that were “blown out” and difficult to interpret. We surmise that these overexposed images resulted from a large animal (e.g., bobcat or other large mammal) passing very close to the camera (e.g., bobcat occurrence at site 2 on May 22); Appendix 1). By raising the camera height to 0.8 – 1.5 m in later deployments, we were able to get clearer images and less overexposure.

The changes to camera settings (faster shutter speed, lower flash level, bursts of three pictures rather than just one) that we instituted beginning with the September deployments also appeared to improve the reliability of low-light (infra-red flash, black & white) detections; we recorded fewer overexposed and blurry images, and the subjects of the photos were more identifiable. Over the 60 days the cameras were deployed with the modified settings (i.e., from Sept. 7 – Nov. 9), 84% (n = 66) of 79 low-light animal detections were identifiable to species with “certain” or “probable” reliability, compared to 63% (n = 25) of the 40 low-light detections in the 30 days of deployment at the original settings (May 18 – June 29).

None of the cameras were visible from the trails in the park, and over the course of the 90 days of camera deployment, no cameras were damaged, disturbed, or stolen. [REDACTED]

[REDACTED] The camera produced 38 images of the

children as they looked closely at it, and then left the creek bed via the north bank. Later, a WAS counselor confirmed that they had seen the camera, but had known what it was and did not disturb it.

Other than this incident, we saw no evidence that the cameras were observed or visited by humans, and no other images of humans were recorded by the cameras. The thick brush—mostly salmonberry, sword fern, and native blackberry—around the camera sites make it likely that if humans had traveled near the cameras, indications of their passing (e.g., broken stems, crushed leaves, disturbed ground, footprints) would be visible. Except for the trail left by the WAS group, we did not observe such indications.

We made seven round trips [REDACTED] to each camera site (deployment and collection for seven periods of deployment totaling 90 days; Table 1). As of the last visit (Nov. 9), we had created no visible trails, and our routes to the camera sites were not visible from the [REDACTED].

#### *Wildlife in St. Edward Park*

We recorded a total of 135 different occurrences of 12 (non-human) animal species that could be identified with certainty or high probability (Table 2), doubling the number reported in the first interim report. Species observed included three native predator species: bobcat (detected on 7 of the 90 days at 2 of the 3 locations; Figs. 5 & 6), raccoon (detected on 17 days at all 3 locations; Figs. 7 & 8), and coyote (detected on 2 days at 2 locations; Fig. 9). We also detected a non-native predator, the Virginia opossum (detected on 10 days at all 3 locations; Fig. 10). The remaining eight species detected with certainty were Douglas squirrel, eastern gray squirrel, eastern cottontail, mountain beaver, deer mouse, American robin, varied thrush, and hairy woodpecker. (Table 2 and Appendix 1). In addition to the 12 species we could identify with relative certainty, we recorded images of four less reliably identified species (certainty level = “possible”): spotted towhee, Swainson’s thrush, house finch, and flying squirrel, as well as unidentified small mammals (Appendix 1). We recorded no occurrences of domestic cat.

Bird and mammal species were detected at similar rates at sites 1 and 2, while mammal species accounted for the majority of occurrences at site 3. No single image recorded more than one species, although several occurrences included more than one individual of the same species (four occurrences of more than one raccoon, two occurrences of two varied thrushes). We found no evidence of any wildlife occurrence on logs covered with substantial woody and herbaceous vegetation (i.e., the initial deployment on logs at sites 1 and 3).

Animal occurrences were more frequent in May-June than in Sept.-Nov, with more than twice the detection rate in May - June (2.3 detections/day) than in Sept. - Nov. (1.1 detections/day). This may be due to higher animal activity levels with greater availability of plant material in spring and early summer, or simply because diurnal species (e.g. squirrels and birds) were active for more of the time when days are longer. It is also possible that lower ambient light levels in fall reduced the likelihood of triggering the cameras. Predator species, however, were detected at similar rates in spring (0.58/day) and fall (0.50/day).

Nearly all detections of predators (92%), as well as deer mice and mountain beaver (95%), occurred in low-light conditions (black and white images). While more detailed analysis of the

timing of occurrence is needed, it appears that these species are highly nocturnal, possibly a consequence of the strong presence of humans and human activity in the park. Douglas squirrel, eastern gray squirrel, eastern cottontail, and all bird species were mostly detected in the daytime (Appendix 1).

Animals photographed were engaged in a variety of activities. The larger mammalian predators mostly appeared to be travelling (walking or running), crossing the log in either direction at site 2 or travelling upstream or downstream in the creek bed. The use of the creek bed as a travel corridor for raccoons, coyote, and opossum is further suggested by occurrences of each of these species a few minutes apart at cameras 1 and 3, consistent with travel of an individual over the approximately 300 m distance between the two sites. Bobcat, raccoon, and opossum were observed travelling both on the log crossing and in the creek bed, while coyote were only observed in the creek bed.

Smaller animals, such as mountain beaver, the two squirrel species, rabbit, and deer mouse, as well as a variety of bird species, appeared to engage in activities such as foraging, drinking, and searching in the immediate vicinity of the camera. These species frequently appeared in the same precise location in several separate occurrences and on different days. At the time of year when the forest was probably the driest (September), both Douglas squirrel and varied thrush were observed drinking from the creek. In June, when salmonberries were ripe, robins were twice seen in the creek bed with berries in their beaks.

Douglas squirrel was reliably detected at two sites (2 and 3), and possibly detected at the third (a “possible” occurrence at site 1), while the eastern gray squirrel was only detected at site 2 (on the crossing log above the creek; Appendix 1). Both squirrel species were frequently seen on the log at site 2, where they appeared to forage on seeds and/or transport seeds.

In the course of conducting our research, we opportunistically observed wildlife species that were not detected by our cameras. These included deer *Odocoileus hemionus columbianus*, barred owl *Strix varia*, and pileated woodpecker *Dryocopus pileatus*; pers. obs). These species may not make frequent use of the specific sites and/or habitat types where our cameras are located.

**Table 2.** Summary table of “certain” or “probable” species occurrences<sup>1</sup> as detected by camera traps in St. Edward State Park, over 90 days, May 18 – November 7, 2018.

Species	No. of occurrences <sup>2</sup>	No. of days detected	No. of locations detected	Detections per day of camera deployment (No. detections/90 d)	Days detected per day of camera deployment (Days detected/90 d)
Eastern cottontail <i>Sylvilagus floridanus</i> (SYFL)	4	3	1	0.04	0.03
Douglas squirrel <i>Tamiasciurus douglasii</i> (TADO)	17	15	2	0.19	0.17
Mountain beaver <i>Aplodontia rufa</i> (APRU)	8	8	2	0.09	0.09
Deer mouse <sup>3</sup> <i>Peromyscus spp</i> (PESP)	5	5	1	0.06	0.06
Eastern gray squirrel <i>Sciurus carolinensis</i> (SCCA)	18	12	1	0.20	0.13
Raccoon <i>Procyon lotor</i> (PRLO)	28	17	3	0.31	0.19
Bobcat <i>Lynx rufus</i> (LYRU)	7	7	2	0.08	0.08
Coyote <i>Canis latrans</i> (CALA)	3	2	2	0.03	0.02
Virginia opossum <i>Didelphis virginiana</i> (DIVI)	11	10	3	0.12	0.11
American robin <i>Turdus migratorius</i> (TUMI)	18	11	2	0.20	0.12
Varied thrush <i>Ixoreus naevius</i> (IXNA)	15	11	1	0.17	0.12
Hairy woodpecker <i>Leuconotopicus villosus</i> (LEVI)	1	1	1	0.01	0.01

<sup>1</sup> Including “certain” and “probable” detections; “possible” detections, which included possible flying squirrel, house finch, Swainson’s thrush, spotted towhee not included.

<sup>2</sup> images of species (certain or probable) more than 30 minutes apart.

<sup>3</sup> *Peromyscus maniculatus* or *P. keeni*.



**Figure 5.** Bobcat on log 10 m above creek at 23:57 on September 7, 2018 at site 2.



**Figure 6.** Probable bobcat moving downstream in creek bed at 00:52 on May 31, 2018 at site 3.



**Figure 7.** Raccoon on log 10 m above creek, at 01:18 on May 30, 2018 at site 2.



**Figure 8.** Raccoon traveling downstream in creek bed at 09:12 on June 5, 2018 at site 1.





**Figure 9.** Coyote moving downstream at 16:55 on June 16, 2018 at site 1.



**Figure 10.** Virginia opossum on log at 1:38 on October 27, 2018 at site 2.

## CONCLUSIONS

### *Feasibility of camera trap methodology in St. Edward Park*

Our results to this point suggest that camera trap studies are feasible in St. Edward State Park. Our three cameras functioned well and were not stolen, vandalized, or otherwise disturbed by humans over the course of the 90 days they were deployed. We detected only one instance in which a camera was observed (but not disturbed) by humans—during an off-trail exploration of the creek by a group of elementary school-age children with their camp counselor.

We attribute the absence of human disturbance of cameras in this heavily visited park to 1) placement of cameras in brushy areas not often visited by humans and not readily observed from trails, 2) deployment and collection of cameras in the early morning hours (usually before 9:00 AM, when few people were on the trails), and 3) care taken to avoid creating visible user trails to the camera sites. Whether cameras would be undisturbed in areas of the park that are more heavily frequented by humans is not known.

Over the time they were deployed, the cameras recorded multiple nighttime and daytime images of 12 non-human, reliably identifiable, mammal and bird species (in addition to four more possible species), including six new identifiable species that had not been recorded as of the time of the initial interim report (Stokes and Burns 2018). The cameras were particularly effective at detecting the predator species that are the main focus of the study; there were very few images of possible predators that could not be reliably identified to species. We also recorded numerous detections of smaller species (e.g., squirrels, birds), and in most cases, the images of detected animals were identifiable to species with high reliability. Even very small mammals—deer mice—were detected and identifiable to genus. However further research, perhaps including live trapping, is needed to determine which of two possible deer mouse species is present in the park, and to more completely survey for other small mammals that might be present.

Identification of images to species improved significantly with the modifications we made in camera positioning and settings beginning with the September deployments. Following the modifications, we obtained fewer nighttime images that were blurred or overexposed, and by recording bursts of three images (instead of one) with each trigger, we were better able to detect and identify the species in the images. With further refinements of technique and equipment, we may be able to improve our ability to identify images to species and perhaps, in some cases, to individual.

### *Wildlife in St. Edward Park*

At present, our results concerning wildlife presence in the park are preliminary. Nonetheless, some initial conclusions may be drawn from our results to this point.

The data produced by our camera traps indicate that there is a diversity of wildlife present in St. Edward Park. To date, our cameras, sampling only three sites in one habitat type within a small area of the park, have detected 12 reliably identified mammal and bird species. Additional study continues to detect new species; with a doubling of species detected since our initial report. With further study, we expect to detect additional species and to identify with greater certainty some or all of the species detected that could not be reliably identified. Of particular interest is the

flying squirrel, a species not known to exist in the park. Although our cameras were not positioned to capture arboreal species, we recorded one possible image of a flying squirrel.

Our data also suggest that diversity of native mammalian predators in the park is high, and includes bobcat, coyote, and raccoon, all of which appear to be present, active, and wide-ranging. Predators used the crossing log (site 2) as well as the creek bed as travel ways. The relatively frequent occurrence of these native predators suggests that this key element of the ecological community may be contributing to ecological functionality of the park. It is likely that the park does not encompass enough area to support viable populations of these predators; thus the continued existence of these species in the park depends on maintenance of connectivity between the park and additional habitat. The level and nature of such connectivity for these predator species has not been evaluated, and should be the subject of further research.

While most of the animals we detected were native species, three of the 12 species were non-native. The impacts of these non-natives on native species and the ecosystem are unknown. Multiple occurrences of opossum, with detections at all three camera sites, suggest that this non-native predator has a substantial presence in the park. The opossum is a generalist predator, with possible ecological impacts such as predation on small bird and mammal species, and competition with native predators. The extent of these potential impacts in St. Edward Park is unknown. The lack of detections of domestic cat, suggests that this potential threat to native mammal and bird diversity is not present in core areas of the park, however, its presence in edge areas of the park cannot be ruled out.

The non-native eastern gray squirrel was detected at a frequency (18 occurrences) similar to that of the native Douglas squirrel (17 occurrences), and in many cases the two species appeared to be engaged in similar behaviors at the same location (site 2), suggesting a possible competitive interaction. Similarly, the eastern cottontail rabbit may feed on herbaceous plants used by other mammalian herbivores (e.g., mountain beaver, deer) in the park. The extent and effects of these possible competitive interactions, and the degree to which these non-native species provide a food source for predators are not known.

The mammalian predators we detected, both native and non-native, appear to be strongly nocturnal. The high level of daytime human activity and consequent disturbance in the park may cause predators to concentrate their activity at night to a greater degree than in less disturbed areas (Gaynor et al. 2018). Such a shift in circadian activity patterns could have potentially important, but as yet unidentified ecological effects (Gaynor et al. 2018, Smith et al. 2018).

It should be noted that determination of species presence with camera traps is limited to the species that use the specific habitats sampled by the cameras. Numerous wildlife species known to occur in the park (ESA 2017), some of them observed by us elsewhere in the park during this study (e.g., deer, barred owl, and pileated woodpecker) were not detected by our cameras. Our results primarily reflect the subset of the park's mammalian and avian species that use terrestrial portions of brushy, forested, riparian habitats.

The detection of diverse wildlife species, including native predators, at our camera trap locations may indicate that special management attention to stream corridors is warranted to protect native biodiversity in the park, for example, by limiting human incursion into these areas. However,

additional data collection is necessary to draw robust conclusions about wildlife use of habitat at St. Edward and possible management recommendations. We expect to include management recommendations in our final report.

## **FURTHER RESEARCH**

Our preliminary results demonstrate the feasibility of a camera trap approach for detecting forest-dwelling animal species in St. Edward Park, and indicate that continuation and expansion of this study is worthwhile and has the potential to produce new and useful information, including documentation of species not previously or currently known to exist at the park (e.g., bobcat and flying squirrel). Future study should include greater numbers of camera sites, sampling different locations and habitat types, and longer data collection periods sampling all seasons. Deployments in areas of the park with greater human presence and potential habitats outside the park should be attempted, as wildlife use of such areas (e.g., edge habitats, potential wildlife travel routes, road crossing sites, etc.) may be critical to persistence of some species in the park.

Improvements in cameras (e.g., “no-glow,” as opposed to “low glow” cameras), camera settings, and deployments, along with greater sampling effort may offer the possibility of investigating questions beyond simply the presence or absence of species, including characterization of species abundance, activity patterns, behavior, and interactions. Of particular importance for conservation of wildlife at St. Edward are questions concerning habitat connectivity, effects of roads on wildlife, and impacts of invasive species on native species. Additional minimally invasive approaches to surveying wildlife and their activities, such as behavioral observation, live trapping (e.g., to determine presence of small mammal species), and hair sampling may be useful in conjunction with camera trapping. The authors plan to continue the camera study in winter and spring of 2019.

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APPENDICES

Appendix 1

**Animal occurrence detected by camera traps, St. Edward State Park, May-Nov, 2018.** Each row is one occurrence. All images of certain or probable reliability (see text) within 30 min. of previous image of same species defined as one occurrence.

Camera/Site	Date	Day	Time	<sup>1</sup> Species	Certainty of Identity	No. of photos	Activity of Animal	<sup>2</sup> Camera Mode	Direction of Movement/Other
2	5/19/2018	Sat	06:25- 49	TADO	Probable	2	Running on log	C	Moving SW and then NE
2	5/19/2018	Sat	7:33	TADO	Probable	1	Running on log	C	Moving SW, away from camera
2	5/19/2018	Sat	8:19-9:19	SCCA	Possible	5	Moving on log	C	Moving SW, close to cam., could be TADO
2	5/19/2018	Sat	9:57	Animal	Unknown	1	close to camera	C	Mammal or bird close to camera
2	5/19/2018	Sat	12:12 - 20	SCCA	Possible	2	Moving on log	C	Moving SW, then NE, could be TADO
2	5/19/2018	Sat	13:24 - 35	TADO	Possible	2	Running down log	C	Moving SW, away from cam, could be SCCA
2	5/19/2018	Sat	14:19	TADO	Possible	1	Walking on log	C	Moving NE toward camera, could be SCCA
2	5/19/2018	Sat	16:26 - 29	TADO	Probable	2	Walking down log	C	Moving away from camera
2	5/19/2018	Sat	17:48 - 57	TADO	Certain	3	Walk & climbing limb	C	Moving SW, away from camera
2	5/19/2018	Sat	18:49	SCCA	Probable	1	Walking on log	C	Moving WS, away from camera
2	5/20/2018	Sun	13:02	SCCA	Probable	1	Walking down log	C	Moving WS, away from camera
2	5/20/2018	Sun	16:08	SCCA	Probable	1	Running, jumping	C	Moving away from camera
2	5/21/2018	Mon	11:10	SCCA	Certain	1	Walking on log	C	Moving closer to camera
2	5/21/2018	Mon	23:28	GLSA	Possible	1	landing on limb?	B&W	Appears as blur in one frame
2	5/22/2018	Tue	01:01 - 05	LYRU	Certain	2	Looking from log, walking on log	B&W	Appears to have come across log from SW, then turned to head back SW after coming very close to camera (15 overexposed images)
2	5/22/2018	Tue	07:09 - 34	SCCA	Probable	4	Walking on log	C	Moving SW, away from camera; then back NE
2	5/23/2018	Wed	4:32	LYRU	Possible	1	Standing on log	B&W	On edge of frame, hardly visible, 4 overexposed images
3	5/25/2018	Fri	23:38 - 39	LYRU	Probable	2	Walking on ck bed	B&W	Moving upstream, away from camera
1	5/26/2018	Sat	13:06	TUMI	Certain	3	Standing in water in ckbed	C	Standing in water, facing left (south)
2	5/27/2018	Sun	04:49 - 50	PRLO	Certain	3	Walking on log	B&W	Moving NE, towards camera
3	5/27/2018	Sun	8:33	PRLO	Probable	1	Running on ck bed	B&W	Moving downstream, towards camera
1	5/27/2018	Sun	12:22	Bird?	Unknown	1	in air	C	Blur in air, probably a bird
3	5/28/2018	Mon	02:04 - 40	APRU	Possible	2	Walking on ck bed	B&W	Moving towards camera
3	5/28/2018	Mon	4:32	LYRU	Probable	1	Walking on ck bed	B&W	Moving upstream, away from camera
2	5/29/2018	Tue	6:32	SCCA	Certain	1	Walking on log	C	Moving NE, towards camera
2	5/29/2018	Tue	8:16	SCCA	Certain	1	Walking on log	C	Moving SW, away from camera
2	5/29/2018	Tue	10:07	SCCA	Probable	1	On log	C	Moving NE, past camera; tail only visible
2	5/29/2018	Tue	12:05	SCCA	Certain	2	Standing, sniffing log	C	Facing SW, away from camera
1	5/29/2018	Tue	16:25	SYFL	Certain	3	Stationary	C	Facing SW, on sand in creek bed
2	5/30/2018	Wed	01:14 -16	PRLO	Certain	3	Walking on log, looking	B&W	Moving towards camera
2	5/30/2018	Wed	10:29	SCCA	Certain	1	Running on log	C	Moving SW, away from camera
3	5/31/2018	Thu	0:52	LYRU	Probable	1	Jumping near ck bed	B&W	Jumping downstream, towards camera
1	6/2/2018	Sat	10:12	TUMI	Probable	1	Flying	C	Moving E, toward & to right (N) of camera
1	6/2/2018	Sat	12:51 - 53	TUMI	Certain	6	Perching in 2 locs.	C	Facing SW, in ck bed
1	6/2/2018	Sat	13:22 - 34	SYFL	Certain	9	3 locs; ck bed & on log	C	Moving SW across ck bed
2	6/2/2018	Sat	17:12	SCCA	Probable	1	running on log	C	Running on log away from camera
1	6/2/2018	Sat	18:10	SYFL	Certain	3	Eating herbaceous stem	B&W	In ck bed
1	6/3/2018	Sun	02:25-26	PRLO	Certain	12	Walking	B&W	Entered view from upstream; circled back to face camera, then continued downstream
2	6/3/2018	Sun	6:54	SCCA	Probable	1	Running on log	C	Running on log away from camera
1	6/3/2018	Sun	9:52	TUMI	Certain	3	Perched on dead limb	C	In ck bed, facing SW

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1	6/3/2018	Sun	21:35	PRLO	Certain	3	Standing in ck bed	B&W	Appeared to be looking toward camera, as if it had been moving in upstream direction
3	6/3/2018	Sun	22:36	APRU	Possible	1	In ck bed	B&W	Facing camera, middle of creek bed
3	6/3/2018	Sun	23:13	APRU	Possible	1	In ck bed	B&W	Downstream of prev, barely in photo
2	6/4/2018	Mon	8:19	SCCA	Probable	1	running on log	C	Running on log away from camera
3	6/5/2018	Tue	6:08	PRLO	Certain	2	Walking in ck bed	B&W	Moving downstream, toward camera
1	6/5/2018	Tue	9:12	PRLO	Certain	3	Walking in ck bed	C	Moving in downstream direction
3	6/5/2018	Tue	10:16	PRLO	Certain	1	Walking in ck bed	B&W	Moving upstream, away from camera
3	6/5/2018	Tue	21:59	APRU	Possible	1	In ck bed	B&W	This & next: same sequence as prev APRU
3	6/6/2018	Wed	0:18	APRU	Possible	1	In ck bed	B&W	See previous record.
2	6/6/2018	Wed	6:22	SCCA	Possible	1	running on log	B&W	Running on log away from camera
2	6/6/2018	Wed	7:41-7:56	SCCA	Probable	2	running on log	C	Running on log away from camera; we collected camera 12 minutes after last photo of SCCA
1	6/13/2018	Wed	13:57	TUMI	Certain	2	Landed on log	C	Facing to right of camera, eating salmonberry, only wing in one image
3	6/13/2018	Wed	22:12-46	APRU	Probable	3	Walking on ck bed	B&W	Walking and foraging in ck bed, seemingly returning to burrow or safe spot between forays into crk bed
1	6/14/2018	Thu	18:11	TUMI	Probable	1	Perched on log	B&W	Same log as above, Facing right
3	6/15/2018	Fri	1:48	APRU	Probable	1	Walking in ck bed	B&W	Bottom right of camera, walking in ck bed, same location as prev.
2	6/15/2018	Fri	5:48	TADO	Possible	1	Running on log	B&W	Running on log away from camera, blurry, could be SCCA
1	6/15/2018	Fri	7:19	TUMI	Certain	3	Standing in ck bed	B&W	Facing camera
1	6/15/2018	Fri	11:52	SYFL	Certain	3	Stationary, sniffing, feeding?	C	Facing to right of camera
3	6/15/2018	Fri	22:20	APRU	Possible	1	Walking on log on ck bed	B&W	Middle of camera on log in ck bed
3	6/16/2018	Sat	7:19	PRLO	Certain	1	Walking on log on ck bed	B&W	Bottom right of camera, moving along log. Walking downstream.
1	6/16/2018	Sat	7:43	PRLO	Certain	3	Looking from log	B&W	Moving down stream. Could be same individual 24 minutes ago at Camera 3.
1	6/16/2018	Sat	10:37	TUMI	Possible	1	Flying	C	Flying left across camera; image is a blur
1	6/16/2018	Sat	13:17	CAUS	Possible	3	Perched on wood	C	Possible Swainson's Thrush. Could be other spp., in creekbed
1	6/16/2018	Sat	16:55	CALA	Certain	3	walking	C	Coyote, walking downstream
1	6/16/2018	Sat	18:38	TUMI	Certain	3	Perched on log	B&W	Same log, Facing to right of camera
3	6/17/2018	Sun	2:53	DIVI	Possible	1	Walking on ck bed	B&W	Bottom right of camera, walking in ck bed; probably either DIVI or mustelid
2	6/17/2018	Sun	10:30	PIMA	Possible	1	Perched on log	C	Looks like spotted towhee. Could be robin or varied thrush. Facing upstream
1	6/17/2018	Sun	11:36-37	HAME	Possible	9	Perched on log	C	Looks like a house finch, but could be other finch or something else; On robin's log. Blurry. Maybe displaying. Facing to right of camera
1	6/17/2018	Sun	11:48	TUMI	Certain	3	Perched on log	C	Same log. Facing to right of camera
1	6/17/2018	Sun	14:08	TUMI	Certain	3	Perched on log	C	Same log. Facing to right of camera
1	6/17/2018	Sun	17:01	TUMI	Certain	3	Perched on log	C	Eating berry, Facing away from camera
2	6/18/2018	Mon	6:49	SCCA	Possible	1	Standing on log	B&W	Could be TADO, facing away
1	6/18/2018	Mon	11:05	TUMI	Certain	3	Stand in ck bed	C	Facing left (S); may be juvenile
2	6/18/2018	Mon	11:12	Bird	Unknown	1	Standing	C	Facing camera, looks like a sparrow or thrush
1	6/19/2018	Tue	11:37	TUMI	Certain	3	Perched on log	C	Same log, facing left
1	6/19/2018	Tue	12:11	TUMI	Certain	3	Standing on ck bed	C	Near same log, facing right; beak open (hot?)
1	6/19/2018	Tue	13:01	TUMI	Probable	3	Standing on ck bed	C	Near same log, facing right
2	6/19/2018	Tue	15:20-21	TADO	Certain	2	Walking along log	C	Middle camera, walking away along log. facing camera, then moving away (S)
3	6/19/2018	Tue	16:41	Animal	Unknown	1	?????	B&W	Mammal or bird in creek bed
3	6/19/2018	Tue	17:55	TUMI	Probable	1	Standing on ck bed	B&W	Left side of camera in ck bed
3	6/19/2018	Tue	20:28	TUMI	Possible	1	Standing on log	B&W	Middle, facing away from camera
2	6/20/2018	Wed	6:49	SCCA	Probable	1	Running on log	B&W	Middle camera running away
2	6/20/2018	Wed	7:40	SCCA	Certain	1	Running on log	C	Middle camera
2	6/20/2018	Wed	9:49	SCCA	Certain	1	Running on log	C	Running on log away from camera
3	6/20/2018	Wed	11:50	TUMI	Certain	1	Standing in ck bed	C	Middle camera, standing in ck bed
1	6/20/2018	Wed	20:23-25	TUMI	Probable	6	above, in crk bed	B&W	first on right bank, then in ck bed; possibly a second animal present. Bird images are 1 minute apart. Could be same individual or different.
1	6/21/2018	Thu	4:09	DIVI	Possible	1	Walking on ck bed	B&W	Moving upstream, mammal, unknown spp.; tail looks like DIVI
3	6/21/2018	Thu	4:30	DIVI	Probable	1	Walking on ck bed	B&W	Moving upstream and to left across camera. Could be same individual as 21 min earlier at camera 1.
3	6/23/2018	Sat	13:29	APRU	Probable	1	Walking on ck bed	C	Facing to right of camera



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3	6/24/2018	Sun	13:45	CALA	Certain	1	Walking on ck bed	C	Moving downstream. Walking right across camera
1	6/24/2018	Sun	13:59	CALA	Certain	3	Walking on ck bed	C	Moving downstream. Could be same individual seen 14 min earlier at camera 3.
3	6/24/2018	Sun	23:53	APRU	Probable	1	Standing on ck bed	B&W	In location where seen earlier. Facing to right of camera
2	6/27/2018	Wed	6:17	SCCA	Probable	1	Running	C	Running on smaller log that crosses main log, half out of picture.
3	6/27/2018	Wed	23:36	PRLO	Certain	1	Walking on ck bed	B&W	Walking upstream on ck bed away from camera
3	6/28/2018	Thu	12:04-14	HOSA	Certain	38	Walking in ck bed	C	Group of elementary school-age kids ( $\geq 9$ kids) from Wilderness Awareness School with counselor. Walking down stream in creekbed. Saw camera, spent time looking at it, but did not disturb it.
2	9/7/2018	Fri	23:57	LYRU	Certain	3	Walking on log	B&W	Walking south on log, Moving away from camera in middle. Good photos.
3	9/8/2018	Sat	1:29	DIVI	Certain	3	Moving (Foraging?) in ck bed	B&W	Moving upstram (away from camera) Right side to middle of camera
2	9/8/2018	Sat	1:41	LYRU	Probable	1	Running? on log	B&W	Moving fast towards camera
3	9/9/2018	Sat	4:06	DIVI	Probable	2	in ck bed	B&W	only tail visible, edge of frame
3	9/9/2018	Sat	4:21	PESP	Probable	3	leaping into ck bd	B&W	Possibl deer mouse (PESP); on left (S) bank, then leaping into ck bed
3	9/10/2018	Sun	0:27	Small mammal	Unknown	3	in ck bed	B&W	in ck bed in background on right side of camera
3	9/10/2018	Mon	18:18	TADO	Probable	1	Standing on log	B&W	Jumping left from log on left (N) bank, Facing to left of camera
3	9/11/2018	Tues	2:37	Small mammal	Unknown	3	in ck bed	B&W	no larger than a rabbit. Behind some vegetation, so only partially seen. Could be mouse, rat, mt beaver,
1	9/12/2018	Wed	1:44 - 1:50	DIVI	Probable	8	Walking on ck bed, foraging?	B&W	Bottom right side of camera, only tail visible
3	9/13/2018	Thu	12:26	TADO	Probable	3	Drinking in ck bed	B&W	Facing to left of camera
3	9/15/2018	Sat	16:26 -43	TADO	Probable	9	Moving along logs and ck bed	B&W	Moving from camera left to right then back again on ck bed
3	9/19/2018	Fri	23:45	DIVI	Certain	3	Moving on bank	B&W	Moving on logs on left (N) bank, moving downstream
3	9/20/2018	Thu	10:40	IXNA	Probable	3	Standing on logs	B&W	Varied thrush (IXNA) on left (N) bank; only ambiguity is because the black and white image makes it less certain.
3	9/20/2018	Thu	17:49	IXNA	Probable	3	Bathing or drinking, standing in water.	B&W	In ck bed; only ambiguity is because the black and white image makes it less certain.
3	9/20/2018	Thu	20:22	PRLO(3)	Certain	6	Walking on ck bed	B&W	3 individuals, Moving downstream (toward camera) Jumping from log in middle camera
1	9/20/2018	Thu	20:38-40	PRLO	Certain	9	Moving around on right bank	B&W	Moving around on right (North) bank of creek Middle camera to right side
3	9/21/2018	Fri	17:47	TADO	Probable	2	Walking on log	B&W	In creek bed, Jumping from log in middle camera
3	9/22/2018	Sat	15:20	TADO	Probable	1	On log	B&W	On same log on left (N) bank
3	9/24/2018	Mon	16:33-35	IXNA(2)	Probable	6	Standing on log, then foraging or drinking	B&W	Same log on left (N) bank; Flies off camera left to ck bed in middle camera; appears to be 2 individuals, but ambiguous
3	9/25/2018	Tue	16:08	IXNA	Probable	3	Standing on log	B&W	Same log on left (N) bank; Facing to left of camera
3	9/25/2018	Tue	17:55	IXNA	Probable	3	Standing in ck bed	B&W	Standing at water, then flying
1	9/26/2018	Wed	6:04-05	PRLO	Certain	6	Standing on log	B&W	Moving around on right (N) bank of ck. Middle of camera facing left
3	9/26/2018	Wed	10:16	IXNA	Probable	3	Standing on log	B&W	Same log on left (N) bank; Facing to left of camera
3	9/26/2018	Wed	18:13	TADO	Probable	3	Standing on ck bed	B&W	Next to water in crk bed; Middle camera facing right
3	9/27/2018	Thu	3:36	PRLO	Certain	2	Walking on ck bed	B&W	Moving downstream in creek bed; toward camera bottom left
3	9/27/2018	Thu	6:29	Mammal	Unknown	1	On ck bed	B&W	Probably PRLO, LYRU, or DIVI in creek bed; Bottom left camera
3	9/27/2018	Thu	14:41	TADO	Possible	2	Standing on log	B&W	Standing on log on left (N) bank; only tail visible
3	9/27/2018	Thu	16:00	TADO	Probable	3	Drinking in ck bed	B&W	Middle camera facing left
3	9/28/2018	Fri	9:17	IXNA	Probable	3	Standing on log	B&W	Same log on left (N) bank; Facing to left of camera
3	9/29/2018	Sat	10:04-5	LEVI	Probable	3	Pecking at dead log	B&W	Probably a Hairy woodpecker (LEVI), but could be Downy; On left side of ck bed, pecking at dead wood; Facing to left of camera
3	9/29/2018	Sat	12:11	IXNA	Probable	3	Standing on log	B&W	Same log on left (N) bank; Facing to left of camera
3	9/29/2018	Sat	15:56	TADO	Probable	1	Jumping in ck bed	B&W	Middle camera jumping right

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1	9/29/2018	Sat	20:49-50	DIVI	Certain	6	Foraging in ck bed	B&W	On right (N) bank; Moving left to camera middle
3	10/1/2018	Mon	5:39	PRLO	Certain	3	Walking on ck bed	B&W	Moving upstream; away from camera in middle
3	10/1/2018	Mon	13:02	TADO	Probable	2	Walking on ck bed	B&W	In middle of creekbed; Moving away from camera in middle
3	10/4/2018	Thu	22:25	Mouse?	Unknown	1	Walking on log	B&W	Possible PESP on same log as previous and following; Facing to left of camera
3	10/5/2018	Fri	1:08	PESP	Probable	3	Walking on log	B&W	PESP? Clearer than previous; on same log as previous and following; Facing to left of camera
1	10/5/2018	Fri	1:27-28	PRLO	Certain	4	Walking on ck bed	B&W	Moving upstream; towards camera in middle
3	10/5/2018	Fri	1:37	PRLO	Certain	3	Walking on ck bed	B&W	Moving upstream; away from camera in middle
3	10/8/2018	Mon	16:59	TADO	Probable	3	Standing on log	B&W	Same log on left (N) bank; Facing to left of camera
3	10/12/2018	Fri	13:42	TADO	Possible	3	Drinking from ck	B&W	Drinking from ck in middle of camera; ambiguity because it could be SCCA
3	10/12/2018	Fri	18:08	TADO	Possible	3	Drinking from ck	B&W	Drinking from ck in exactly the same position and location as previous occurrence; in middle of camera; ambiguity because it could be SCCA
1	10/12/2018	Fri	21:20	DIVI	Certain	3	Walking on ck bed	B&W	Walking upstream (east) on ck bed in middle of camera; looks like a small individual
2	10/12/2018	Fri	22:21	DIVI	Certain	3	Walking on log	B&W	Walking north on log; animal walks toward and out of camera view; unclear if DIVI crossed creek on log
3	10/14/2018	Sun	1:30	PESP	Possible	3	Walking on bank	B&W	Walking on bank on left of camera at bottom
3	10/15/2018	Mon	5:08	PESP	Probable	3	Walking on bank	B&W	Walking on bank on left of camera at bottom
3	10/15/2018	Mon	13:44-45	IXNA	Probable	4	Standing on ck bed	B&W	Standing on ck bed in middle of camera at bottom; then flew to left bank
3	10/15/2018	Mon	15:29	IXNA	Probable	3	Flying out of ck bed	B&W	Standing on bank on left side of camera and flying out of camera to the left
3	10/16/2018	Tue	7:46	IXNA	Probable	3	Standing on bank	B&W	Standing on bank on left side of camera at bottom
2	10/16/2018	Tue	8:38-41	TADO	Probable	9	Walking and eating on log	B&W	Walking South and eating on log in middle of camera; may be eating seed of bigleaf maple
3	10/16/2018	Tue	11:37	IXNA	Possible	3	Standing on ck bed	B&W	Standing on ck bed on right side of camera at bottom; animal may fly into ck bed; hard to see.
3	10/18/2018	Thu	17:02	IXNA	Probable	3	Standing on dead limb in ck bed	B&W	Standing on branch in ck bed in middle of camera
3	10/18/2018	Thu	17:38	IXNA	Probable	3	Standing on bank	B&W	Standing on bank on left side of camera
2	10/19/2018	Fri	9:32	TADO	Certain	3	Walking on log	C	Walking south in the middle of camera at bottom
3	10/19/2018	Fri	14:22	IXNA(2)	Probable	6	Standing on bank in ck bed	B&W	Looks like 2 individuals--a little hard to see them, but looks like 2. Both standing on branch in ck bed in middle of camera
3	10/20/2018	Sat	5:29	Small mammal	Unknown	1	in creek bed on left side	B&W	mouse or shrew, in creek bed, small and blurry
3	10/20/2018	Sat	19:21	PRLO	Certain	3	Walking on ck bed	B&W	Walking upstream (east) in creek away from camera on right side
2	10/21/2018	Sun	18:34-35	DIVI	Certain	6	Walking on log	B&W	Walking south on log, appears to be crossing creek on log
3	10/22/2018	Mon	5:35	PESP	Probable	3	Standing on bank	B&W	Walking on bank on left side of camera
3	10/22/2018	Mon	5:38	APRU	Probable	3	Standing on ck bed	B&W	Standing on ck bed on right side of camera
3	10/23/2018	Tue	5:19	PESP	Probable	3	Standing on bank	B&W	Standing on bank on left side of camera
1	10/23/2018	Tue	13:57	TADO	Possible	3	Walking on log in ck bed	C	Only tail visible; middle camera facing right
3	10/24/2018	Wed	17:12	IXNA	Probable	3	Standing in ck bed	B&W	Standing in ck bed; Foggy image (raining?),
3	10/24/2018	Wed	21:35	PRLO	Probable	3	Walking on ck bed	B&W	Walking downstream (west) on ck bed toward camera on right side
1	10/24/2018	Wed	21:49	PRLO	Certain	3	Walking on ck bed	B&W	Walking downstream (west) away from camera on right side; may be same individual as same date at 21:35.
1	10/25/2018	Thu	7:21	PRLO(2)	Certain	6	Walking on ck bed	B&W	Walking upstream (east) on ck bed toward camera on right side; probably two separate animals, but not certain of this.
3	10/25/2018	Thu	7:32	PRLO	Certain	3	Walking on ck bed	B&W	Walking upstream (east) on ck bed on right side of camera at top; could be one of the PRLOs seen at 7:32
1	10/25/2018	Thu	9:09	PRLO(2)	Certain	3	Walking on ck bed	B&W	Walking upstream (east) on ck bed toward camera on right side; two animals together in picture; could be same 2 seen at 7:32
2	10/27/2018	Sat	1:38	DIVI	Certain	3	Investigating surface of log	B&W	Standing on log in middle camera at bottom
3	10/29/2018	Mon	5:33	PRLO	Certain	3	Possibly foraging, Standing on ck bed	B&W	Standing, attention on something in ck bed; on ck bed in middle of camera
3	10/29/2018	Mon	22:10-13	APRU	Probable	6	Walking on ck bed	B&W	Standing on ck bed in middle, exactly where raccoon had been investigating 17 hrs earlier; then standing on log on

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									right bank
1	10/31/2018	Wed	0:14	PRLO(2)	Certain	3	Walking on ck bed	B&W	Facing downstream (west); Digging, sniffing in ck bed? Two animals on right side of camera
3	10/31/2018	Wed	5:03-18	APRU	Probable	6	May be foraging; Walking on ck bed	B&W	Walking west then east on ck bed on right side of camera
1	10/31/2018	Wed	5:26	PRLO	Certain	3	Walking on ck bed	B&W	Walking upstream (east) on ck bed toward camera on right side
1	11/1/2018	Thu	1:35	PRLO	Certain	3	Walking on ck bed	B&W	Walking upstream (east) on ck bed toward camera on right side
3	11/1/2018	Thu	3:59	APRU	Possible	3	Walking on log in ck bed	B&W	Walking east on ck bed on right side of camera at top; foggy image
1	11/2/2018	Fri	19:39	APRU	Possible	3	Standing on log in ck bed	B&W	Standing on log in middle of camera; animal appears to go under log in first picture and returns in next
2	11/3/2018	Sat	2:20	DIVI	Certain	3	Walking, investigating, on log	B&W	Walking on in log in middle of camera
2	11/5/2018	Mon	6:14	LYRU	Certain	3	Walking on log	B&W	Walking south on log away from camera; appears to be crossing creek on log
1	11/6/1/8	Tue	7:26	APRU	Probable	9	Walking on logs in ck bed	B&W	Walking on and under log in ck bed in middle of camera on left side
1	11/6/2018	Tue	16:14	Small mammal	Unknown	2	Climbing on log	B&W	Climbing on log in ck bed in middle of camera; could be APRU
1	11/7/2018	Wed	15:17-19	Small mammal	Unknown	9	Moving around in creek bed	C	Moving around in creek bed, never wholly visible, blurry; could be APRU

- <sup>1</sup> Species: APRU: Mountain beaver *Aplodontia rufa*  
 CALA: Coyote *Canis latrans*  
 CAUS: Swainson's thrush *Catharus ustulatus*  
 DIVI: Virginia opossum *Didelphis virginiana*  
 GLSA: Northern flying squirrel *Glaucomys sabrina* (or Humboldt's flying squirrel *G. oregonensis*)  
 HAME: House finch *Haemorhous mexicanus*  
 HOSA: Human *Homo sapiens*  
 IXNA: Varied thrush *Ixoreus naevius*  
 LEVI: Hairy woodpecker *Leuconotopicus villosus*  
 LYRU: Bobcat *Lynx rufus*  
 PESP: Deer mouse *Peromyscus* spp. (*P. maniculatus* or *P. keeni*)  
 PIMA: Spotted towhee *Pipilo maculatus*  
 PRLO: Raccoon *Procyon lotor*  
 SCCA: Eastern gray squirrel *Sciurus carolinensis*  
 SYFL: Eastern cottontail *Sylvilagus floridanus*  
 TADO: Douglas squirrel *Tamiasciurus douglasii*  
 TUMI: American robin *Turdus migratorius*

<sup>2</sup> C = color image with ambient lighting; B&W = black and white image with infrared flash

## **Appendix 2**

### **Field personnel:**

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Nikolaus Burns, Spring 2018  
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Nathan Samuelson, Fall 2018 – Spring 2019  
Undergraduate student  
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### Appendix 3

#### Sample images of detected species identifiable with relative certainty



**Figure A3-1.** Douglas squirrel (*Tamiasciurus douglasii*) at 17:57 on May 19, 2018, climbing a branch on log at site 2.



**Figure A3-2.** Eastern gray squirrel (*Sciurus carolinensis*) at 12:05 on May 29, 2018, on log at site 2.



**Figure A3-3.** Eastern cottontail rabbit (*Sylvilagus floridanus*) at 13:34 on June 2, 2018, on log in creek bed at site 1.



**Figure A3-4.** American robin (*Turdus migratorius*) at 12:53 on June 2, 2018, on log in creek bed at site 1.





**Figure A3-5.** Probable bobcat moving upstream in creek bed at 23:39 on May 25, 2018 at site 3.



**Figure A3-6.** Raccoon moving upstream in creek bed at 21:35 on June 3, 2018 at site 1.