Inspiration Ridge Preserve Protocols for Ecological Inventories and Management

A Project for the Center for Alaskan Coastal Studies

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I. Introduction and Executive Summary

A. Introduction

The 640-acre Inspiration Ridge Preserve (IRP) was created by Ed Bailey and Nina Faust to form a wildlife corridor in the face of increasing regional development. As the stewardship responsibilities of IRP transition to the Center for Alaskan Coastal Studies (CACS), a thorough ecological inventory and management plan is needed to ensure the long-term ecological integrity of IRP. A rich understanding of the wildlife behavior, soundscapes, and vegetation composition on the Preserve will provide opportunities for CACS to incorporate IRP into their existing educational programs, and for Homer residents and tourists to experience the natural beauty and learn about the ecological characteristics of the Preserve.

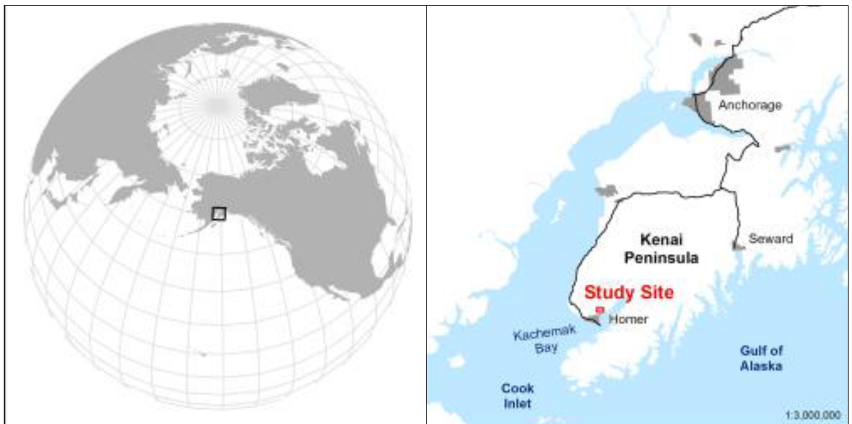

Figure 1.1. The study site was located on the Kenai Peninsula in south-central Alaska.

During the 2016 summer season, a team of Master's students from the University of Michigan's School for Environment and Sustainability (SEAS) began conducting baseline ecological assessments, which culminated in preliminary management recommendations for IRP (Carlson et al. 2017). Two summers later, a second team of SEAS Master's students worked with CACS to fill existing knowledge gaps, determine the long-term management goals for IRP, and create useable protocols for future data collection and use. Additionally, supplemental field studies were

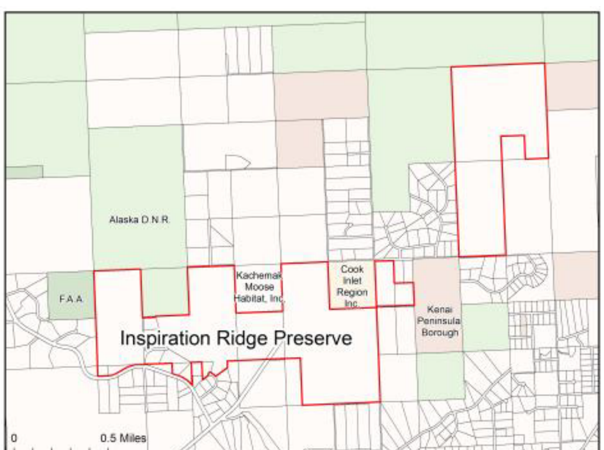

Figure 1.2. Inspiration Ridge Preserve (boundary outlined in red) and surrounding properties with owners indicated, unless privately owned.

conducted to complete the baseline against which future ecological assessments can be compared. This report is the culmination of that work. It introduces, provides the rationale for, and outlines standardized, replicable protocols for monitoring long-term changes in soundscapes, fish species, vegetation composition, wildlife activity, and sandhill crane populations. Furthermore, it reports the results from the 2018 field season and provides recommendations for future monitoring based on those results. A continuation of the photo monitoring started in 2016 was also conducted. Complete raw data tables, supplemental information, additional recommendations from the 2018 field season can be found in the appendices, as well as additional figures, graphs, and maps.

B. Executive Summary

1. Summary of Assessment

Sound Monitoring:

Development of monitoring protocols and analysis methodology was completed to assist CACS in advancing a long-term sound monitoring program on IRP. Protocols recommend sound data be collected on a "5on/55off" schedule for a year in the bog location. Analysis methods detail how to categorize each day by the geophony, biophony, and anthrophony components and create a representation demonstrating the amount of time dedicated to each component per day. Software options and recommendations are also given to aid in future analysis beyond the simple software used in the protocols.

Fish Monitoring:

After carrying out fish stream surveys, a total of 13 juvenile dolly varden (*Salvelinus malma*) were found during 10 trapping events across 8 locations in unnamed tributaries of Fritz Creek.

Long-Term Vegetation Monitoring:

After assessing the viability of conducting vegetation monitoring through transect surveys, a more holistic and efficient protocol was developed. This protocol leverages CACS' drones and remote sensing analysis techniques to assess long-term changes in the Preserve's vegetation compositions. Images are processed through georeferencing and heads up digitizing and quantified using a buffer and area analysis method. Technical recommendations for improved data collection and processing to improve the efficiency of this protocol are also provided.

Wildlife Camera Trap Monitoring:

A protocol was established for monitoring wildlife on IRP through the use of camera trapping. This protocol includes trap set-up, image processing, and various recommended data analyses, which will improve the knowledge of current and future wildlife activity on the Preserve and inform management decisions. This protocol was developed and tested during the 2018 field season. The 2018 camera trapping assessment indicates that, after accounting for differences in sampling efforts across camera traps, wildlife activity appears to be greater on the eastern portion of IRP and during the daytime. Moose was the species most likely to be observed, followed by snowshoe hare and black bear. Further analysis revealed that moose and black bear were more likely to be observed during the spring than during summer or fall. Lastly, the data indicate a positive correlation between distance to major road and occurrences of black bear, coyote, and Canadian lynx, suggesting that these species may be more sensitive to vehicle and/or human proximity than moose.

Sandhill Crane Monitoring:

An application "Kachemak Crane Watch" was developed to better facilitate study of the sandhill crane population through citizen science. The app records crane abundance and health parameters, as well as captures measurements of observation validity. Photographs, sound clips, or comments can also be attached to individual observation reports. For users who cannot or prefer not to download the app, a connected web map app through ArcGIS online was created from the app's feature service, enabling users to still record observations online. All data from the native and web map app will be uploaded to a database hosted by the online feature service and managed by CACS. Dashboards summarizing the reported data from the database can also be viewed through ArcGIS Online. Public versions of the dashboard and web app allow users to only view and edit their own observation points.

Photo Monitoring:

Photo monitoring was conducted during the 2018 field season as a continuation of protocols established in 2016. This season expanded upon that baseline to include additional points covering a wider area of the Preserve. Furthermore, the protocol was modified to use bearings in photo capture and recording, and a new naming convention was established.

2. Summary of Recommendations

Sound Monitoring Recommendations:

- Long-term sound monitoring programs should be run on a "5on/55off" schedule for a full year within the next year.

- The use of Dawn/Dusk recordings can be used to build species inventory every five years.

Fish Monitoring Recommendations:

- We recommend that CACS repeat fish trapping at the stream points we sampled and those sampled by the 2016 team, while also sampling new areas that are deep enough to submerge the traps.
- These stream surveys can be repeated every 3 years.
- Further analysis of stream health should be carried out by performing physical, chemical and biological water quality assessments.

Long-Term Vegetation Monitoring Recommendations:

- We recommend conducting vegetation monitoring through drone image capture every five years or following major disturbances to track long-term changes in vegetation composition.
- To alleviate limitations in time and objectivity, we recommend either employing more complex drone operation software which mosaic images or purchasing a drone or sensor attachment with a more sophisticated camera, which would facilitate a supervised image classification.

Wildlife Camera Trap Monitoring Recommendations:

- We recommend that CACS continue to monitor wildlife populations and habitat use on IRP annually by a) reinstalling camera traps in the same locations as the 2018 study period, as well as at additional sites, to monitor changes in wildlife activity at those locations over time and b) analyzing camera trap data for temporal (time of day), seasonal, and spatial differences in wildlife activity.
- The results of these analyses should be taken into consideration during the planning of visitor activity and access on IRP, particularly given the goals of CACS regarding maintaining IRP as a viable habitat corridor for certain wildlife species.

Sandhill Crane Monitoring Recommendations:

- To improve data collection and management, we recommend the use of the Kachemak Crane Application for all future crane observations. Historical records should be added to the online app database.
- In order to promote IRP's goal to create suitable crane habitat, we recommend the continuation of the annual mowing of the 18.3 acres between the Faust Residence and bluff. However, should the future goals of IRP shift or management resources grow limited, we recommend that an

assessment of crane use at that time occur in order to determine priority areas for continued selective mowing management.

- The impacts of the current supplemental feeding on the Homer crane population are unknown and therefore should be assessed to inform decisions on the frequency and quantity of future supplements.

Photo Monitoring Recommendations:

- We recommend CACS repeat photo monitoring annually at the designated points and compare annual photos with previous years to monitor any major changes that have occurred.
- Additional photo points can and should be added if they exhibit important characteristics of the Preserve. Addition points could be identified using drone imagery analysis.

3. Timeline of Recommendations

<table>
<tr><th></th><th>Spring</th><th colspan="2">Summer</th><th>Fall</th><th>Winter</th></tr>
<tr><td rowspan="6">Annual</td><td></td><td></td><td>Mow Field</td><td></td><td></td></tr>
<tr><td colspan="4">Crane Monitoring via Kachemak Crane Watch App</td><td></td></tr>
<tr><td colspan="4">Trail and Boundary Maintenance</td><td></td></tr>
<tr><td colspan="5">Sound Monitoring (first year study)</td></tr>
<tr><td colspan="5">Wildlife Camera Trapping</td></tr>
<tr><td colspan="5">Photo Monitoring</td></tr>
<tr><td>Every 3 Years</td><td></td><td colspan="2">Fish Trapping</td><td></td><td></td></tr>
<tr><td>Every 5 Years</td><td></td><td colspan="2">Vegetation Monitoring</td><td></td><td></td></tr>
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II. Sound Mapping

A. Introduction

Human activity has well-known impacts on wildlife, including habitat destruction, degradation, or pollution. A lesser-known anthropogenic influence on wildlife is the effect human activities can have on the auditory environment, often referred to as the soundscape. Airport and traffic noise increase wildlife stress levels resulting in reduced reproduction or increased potential for predation (Pepper et al. 2003). Noise levels at certain frequencies can mask bird vocalization, threatening their ability to communicate with each other and attract mates (Proppe et al. 2013). Noise can also mask predator movement, thus decreasing an animal's ability to detect danger (Pepper et al. 2003). As a result, the potential for decreased health among wildlife species is likely in the face of increasing human activities. Thus, comprehensive wildlife management plans should account for noise levels across the landscape.

Passive sound monitoring provides a rich picture of ecosystem health and wildlife use, and aids in building comprehensive management plans. Passive sound monitors are recording devices set up with monitoring strategies that may include: continuous sound monitoring, dawn/dusk cycles that record for an hour or two around sunrise and sunset, or programs to record a few minutes every hour during a 24-hour cycle. Recordings from these different sound monitoring programs can then be used to help analyze a landscape.

To measure the soundscape, sound ecologists differentiate between three primary components of a soundscape. Biophony – the biological or living sound component, which includes sounds such bird songs, frog croaks, or squirrel chatter. Geophony – the geophysical or non-living sounds of an environment, such as rainfall, wind blowing through trees, or a river rushing. The final component is the anthrophony – human sounds including not only people talking or making noise, but also cars driving past, planes overhead, or construction noise (Pijanowski et al. 2011).

B. Rationale

The IRP property is situated near the Homer airport and has a large ridgeline road bisecting the property. There is concern that noise pollution on the bluff could be disrupting wildlife, especially sandhill cranes, now or in the future (Mullet et al. 2015). The geographic locations, vocalization types, and frequency of birds and other wildlife can all be determined through the sound data. This information can then be used to inform CACS of wildlife habits and behaviors at key sites on the IRP property, as well as contributing to their knowledge of landscape characteristics and creating a catalog of bird songs. Analyzed sound recordings and soundscapes can also be used by CACS for their educational activities (for example, using selections of crane calls over IRP to supplement information on crane flock behavior) and for long-term sound monitoring programs.

Recordings taken in the Dawn/Dusk cycle can be used to identify bird species present on IRP, as birds are most active and vocal during dawn and dusk hours, and to build a baseline inventory of the bird species found on IRP. Dawn recordings are best for use in educational settings as bird songs during dawn hours are usually the full bird song rather than calls or truncated versions, making them the easiest to identify. Additionally, bird songs pulled from the Dawn/Dusk recordings are useful material for educational programs and they can help teach visitors how to identify bird calls they may hear on IRP.

Ultimately, sound monitoring should provide a comprehensive view of daily acoustic character. Recordings that follow a 5on/55off schedule are best used to accomplish such a goal. The first five minutes of every hour can be recorded giving five minutes for every hour of the day, which provides sufficient acoustic data to create a daily soundscape profile. The five minute schedule can also be a smaller amount data to manage.

C. Data Collection Protocol

1. Setting up the SongMeter4(SM4)

a. Load SD (preferably 64 GB) cards into slots A & B.
b. Start the device, enter the *Main Menu* and select *Quick Start* menu.
c. Choose the *Record 5on & 55off* pre-programmed option.
d. Select *Yes* to overwrite the existing schedule.
e. Press *Start Schedule* to begin recording with the selected schedule.
f. The screen should now display the current date and time with the message *Going to sleep until...* and the time it will begin recording.
g. The SM4 recorder should be mounted about four feet up on a tree or post that is well exposed (if necessary, clear branches and vines away from the microphones).
h. Securely tie the SM4 recorder into place.

i. Record the GPS location of the sound recorder and make note of area features to help keep track of habitat types nearby and time of day to indicate when first recording will be (e.g. if set up occurs at 2:38 PM, first recording will be at 3:00 PM).

    i. Sound recorder locations should be given names or numbers to identify the recording site. In the 2018 study, recording locations were labeled as Sound Point 1, Sound Point 2, and so on.

    ii. The map below (Figure 2.1) shows the sound monitoring locations used in the 2018 pilot studies done using both a 5on/55off schedule and a Dawn/Dusk cycle.

j. Check the next day to make sure the cycle ran correctly and that the SD card collected data.

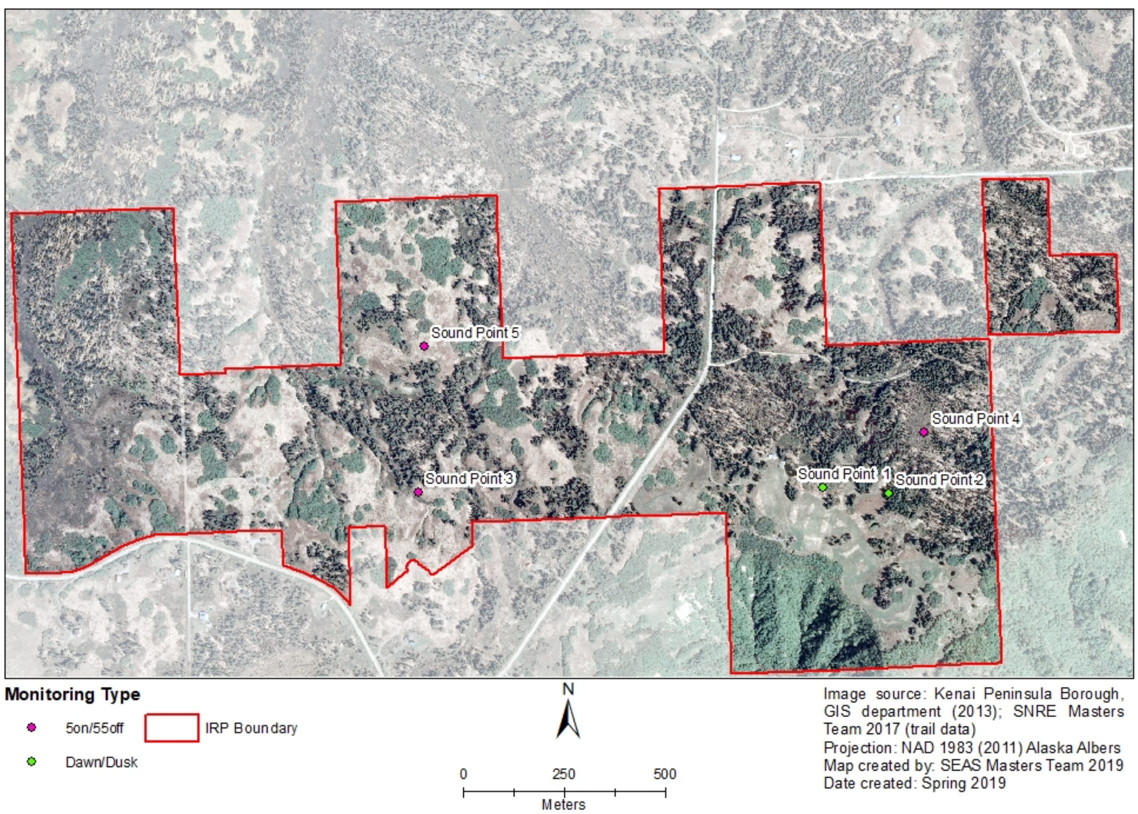


Figure 2.1: Sound Monitoring Points on IRP. Sound Points 1 and 2 were used in May 2018 and Sound Points 3, 4, and 5 were used in August. Monitoring strategy is denoted by the color of the point.

2. Retrieving Data from the SM4

a. Every other week, collect the SD cards and transfer the data onto external hard drives. Sound data are large files and may need to be stored externally from a computer to conserve storage space.

   i. External hard drives should be well organized so that each site is clearly labeled as its own folder or hard drive and the date and time of each recording on that site is readily determined from the file name.

b. All sound files will display the time and date for which they recorded and the SM4 ID code (e.g. S4A02006_20180814_050000 is the S4 Device A02006, recording on 08/14/2018 for the first five minutes after 5:00 AM).
c. It may also be helpful to create folders for each day of sound recordings and organize the 24 recordings for each day into its date folder (e.g. Folder 7/22/19 will have all files with "20190722" as the date portion of the file name and all times from "000000" through "230000").

D. Data Processing Protocol

1. Analyzing Sound Data

Note: This protocol uses RavenPro or RavenPro Lite. Video tutorials can be found at http://ravensoundsoftware.com/video-tutorials . Raven Lite is a free software that includes the basic sound analysis functions and can be used for this project. However, other tools are available (see Recommendations section).

Raven Lite software was used to analyze recordings. Raven is a sound analysis software designed by the Cornell Lab of Ornithology. Raven has two available versions: Raven Lite, the free version and Raven Pro, a more comprehensive version that requires a subscription. The software provides both spectrogram and waveform views for sound files. Raven Lite also auto-populates the selection table with the most common sound analysis metrics (Begin Time, End Time, High Frequency, Low Frequency, Delta Time, Delta Frequency, and Average Power Density), while allowing options for user annotation. The sound table calculated and compiled by Raven Lite can then be imported into an Excel spreadsheet for further analysis.

Overall, Raven Lite is an appropriate and cost-effective software option to begin sound monitoring on IRP. The management protocols are designed with this software in mind and no additional software purchases are necessary. If funds and expertise are available and there is a strong interest to expand sound monitoring on IRP, other options are available for consideration (see Recommendations section).

a. Import the desired sound file into Raven (*File | Open Sound File*).

b. From the *Open File* window, chose *Sound Page* for display type (keep defaults). This setting will display 60 seconds of the five minute recording at a time, allowing the sound shapes to be more easily viewed. The user can then 'page' through the recording with a 10 second overlap between pages (see Raven video tutorials "Paged sound windows part 1 & 2" from the above link).
c. On the left side of the screen, click to display the spectrogram and the Channel 1 sounds (spectrogram and waveform can be found in the *Views* section of the left column and the *Channel* section will display the two channels).
d. On the bottom of the screen, raise the *Selection Table* window to make viewing easier by clicking and dragging the dividing panel between the *Sound File* view panel and the *Table* view panel.
e. For soundscapes with a high density of sounds, zoom in to about 10 second windows may be helpful. To do so, use the axial zoom buttons in the bottom right corner of the sound file window and the scroll bar along the bottom to move through a sound page (the top scroll bar moves along the entire five minute recording, rather than within the current 60 second page).
f. Use the *Create Selection* button from the toolbar (crosshair icon) to select the identified sound as closely as possible (see Raven video tutorials).
g. Once the sound is highlighted, in the table, right-click on the selection and click *Commit Active Selection* and name the sound as accurately as possible (e.g. bird, dog, car, wind). The user can also play just that selected sound by hitting the play button on the top toolbar.
h. Save the sound table by clicking *File* | *Save Selection Table As* and assigning the table a name that would associate it with the recording it pairs with.

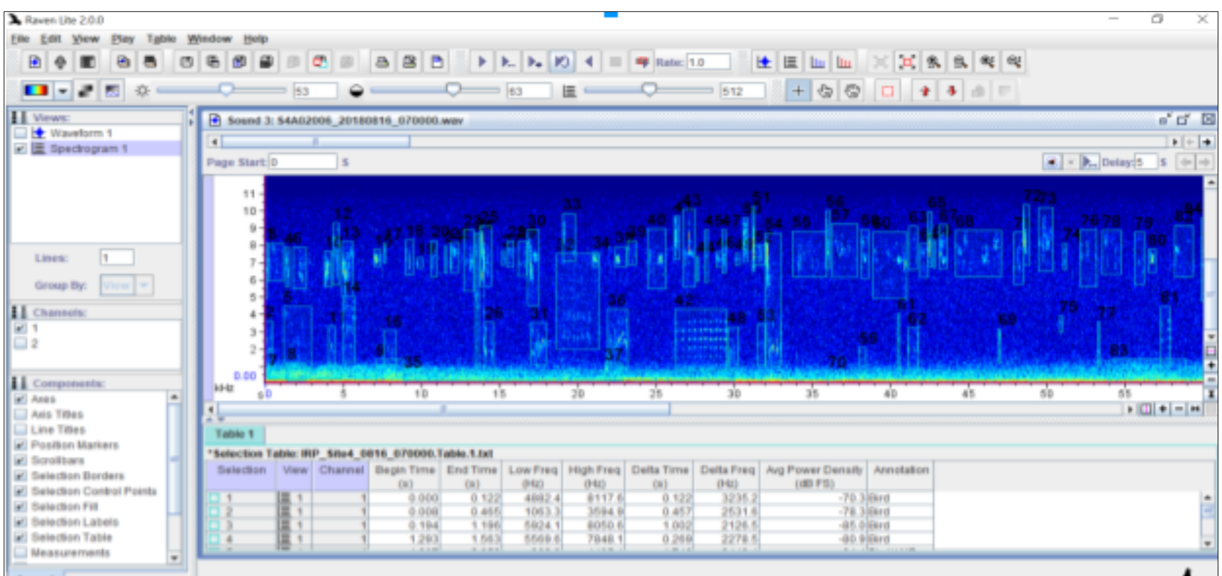


Figure 2.2. Screenshot of Raven Lite Desktop Application. Spectrogram view (selected on the left-hand column) with brightness and contrast (scroll bars found in toolbar below "table") set to help identify sound selections. Table view raised to view selections.

2. Exporting Selection Tables to Excel

Selection tables from Raven can be imported into an Excel spreadsheet (or other such program) for further analysis.

a. Open a new file in Excel and navigate to the desired selection table to open it.
    i. The user may need to adjust the file type to include all files for display as Raven tables are in ".txt" format.
b. Only one selection table (representing a five minute recording) can be opened in Excel at a time, but once a table is converted to Excel or other spreadsheet format, multiple hours can be combined into a single file for analysis between days, years, or sites.
c. Text wizards prompts from Excel will open the file using the default settings (click through *Next* three times and click *Finish*).
d. The data table created will show the selection table created from the five minute sound file.
e. Create a new column to denote *Hour* and enter the appropriate time code (e.g. 110000; see Figure 2.3).
f. Label the sheet (bottom left corner) with the site location identifier and date.
g. Continue to open other tables for the same site/location and copy and paste those tables into the original sheet making sure to add the hour code for each new table.
h. Once all the desired sound tables are in one sheet of the workbook, a new sheet can be added to complete the analysis.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Hour	Selection	View	Channel	Begin Tim	End Time	Low Freq (	High Freq	Delta Tim	Delta Frec	Avg Powe	Annotation
2	110000	1	Spectrogr	1	13.47393	14.71352	361.4	1373.5	1.24	1012.1	-51.8	Dog
3	110000	2	Spectrogr	1	20.94741	22.45648	216.9	1192.8	1.509	975.9	-50.5	Dog
4	110000	3	Spectrogr	1	26.19323	26.91183	142.6	1051.7	0.719	909.1	-46.2	Dog
5	110000	4	Spectrogr	1	33.57689	34.15177	178.3	1265.7	0.575	1087.4	-49.7	Dog
6	110000	5	Spectrogr	1	36.75671	37.29566	213.9	1283.5	0.539	1069.6	-46	Dog
7	110000	6	Spectrogr	1	41.03015	41.49724	142.6	1337	0.467	1194.4	-44.9	Dog
8	110000	7	Spectrogr	1	97.97701	98.18409	6662.4	7938	0.207	1275.6	-66.7	Bird
9	110000	8	Spectrogr	1	199.3735	199.8527	283.5	1582.7	0.479	1299.2	-52.6	Dog
10	110000	9	Spectrogr	1	214.7749	216.2809	94.5	1417.3	1.506	1322.8	-47.3	Car

Figure 2.3: Example screenshot of Excel Spreadsheet. Columns most used are *Hour* to denote time of recording, *Selection* is each selection's ID number per hour, *Delta Time* gives the duration of a selection in seconds, and *Annotation* identifies the sound.

3. Visualizing Soundscapes

a. Create a list in a new Excel sheet of all the sound annotations (identified sounds) from a day's recording. (*Sort & Filter* will give a list of all unique values in a column).

b. For each sound, sum both the number of occurrences of that sound (count) and the duration of the sound (measured in seconds from the *Delta Time (s)* column of the selection table).

e.g.	Sound	Component	Number	Duration(seconds)
	Car	A	5	3.688
	Bird	B	584	328.179

c. The *Component* column can also be added to denote what component of a soundscape a sound belongs to (for example: A = Anthrophony, B = Biophony, G = Geophony, U = Unknown/Other).

d. Finally, sum the total number of occurrences and total duration for each of the soundscape components.

e. Use the total duration in seconds for each soundscape component to create a pie chart (or other visual representation) for the total breakdown of soundscape for a site per day (or whatever metric the user may wish to choose to use).

<u>E. Results from 2018 Data Collection</u>

In May 2018, two sound points were set up on the east side of the IRP property, one near Goose Pond and the other along the southern portion of the Bog Loop Trail (see Figure 2.1 above for map locations). Maps of all sound monitoring points can be found in Appendix VII. These locations are along relatively well-traveled trails and fairly close to the Faust residence, making them easily accessible. SongMeter4 recording devices were placed on the ground at each location, set to record for two hours on a Dawn/Dusk cycle, and left for 48 hours.

Table 2.1. Coordinates of Sound Monitoring Points Summer 2018.		
	Latitude	Longitude
Sound Point 1	59.700520	-151.409131
Sound Point 2	59.700353	-151.406185
Sound Point 3	59.700770	-151.426949
Sound Point 4	59.701645	-151.404532
Sound Point 5	59.703993	-151.426425
Potential	59.699908	-151.425379

During August 2018, three additional sites were selected, two on the west side of the property and one on the east side (Figure 2.1), to measure overall soundscape composition, rather than focusing on bird vocalization. The same SM4 recording device was used, but set to record five minutes of every hour, on the hour using the programmed setting "5on/55off". This setting allows the daily range of sounds to be recorded. Rather than focusing on times when birds most frequently sing, intermittent recordings throughout the day capture a variety of sounds that may be heard during the course of the day such as: planes flying overhead, cars passing during morning and evening commutes, dogs barking, and scattered rainstorms. As this "5on/55off" program was selected to capture the range of sounds found on IRP, three locations were chosen that were likely to have diverse soundscapes – namely, locations from which road or house noises can be heard and locations that are known to be fairly quiet or remote. All monitored locations were suggested by N. Faust given her intimate knowledge of IRP. The recorders were tied to trees or snags set between four and five feet above the ground using woven straps. After three days of recording at a site, the SM4 was moved to another location. The first recording and last recording at each site was noted along with the GPS coordinates of the recorder. Once all sites had been tested, the SM4 was taken down.

Of the site locations tested in this study, Sound Point 4 provides a large diversity of soundscape components. The larger share of anthropogenic noise at this site in comparison with other sites will be a good point of study into the future as this location may be vulnerable to significant noise pollution. Located in the bog habitat, the location also would provide a potentially similar sound environment to the bog at Wynn Nature Center where plans for long term sound monitoring have been discussed.

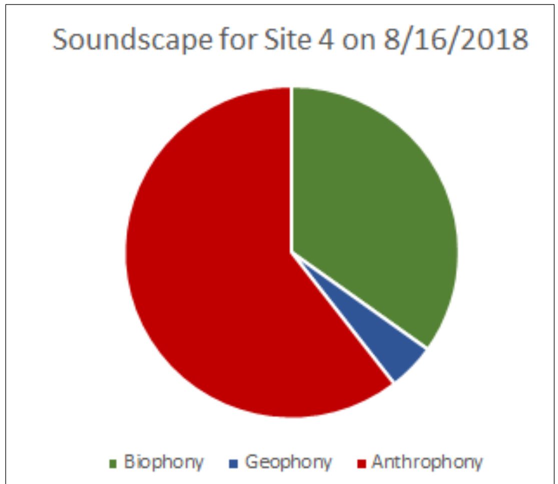


Figure 2.4. Example of a graphic to depict soundscape structure at a site and on a date showing the relative fraction of time each component contributed to the overall

F. Recommendations

1. Long-Term Sound Monitoring Using the 5on/55off Program

A long-term sound monitoring program that provides a full picture of the day's soundscape would be best supported by the protocols for the 5on/55off program. This program is not overly large so as to be difficult to manage like continuous recording programs. A year-long pilot study for sound monitoring should be undertaken. Sound will be recorded on this schedule for the full year at Sound Point 4 and analyzed as described above. This year-long study will form the basis for future sound monitoring analysis of trends over time in the soundscape on IRP.

2. Bird Surveys Using Dawn/Dusk Cycle

The use of Dawn/Dusk cycles to develop bird inventory or create a bird song library could be done in the future as a way to relate the bird species found on Wynn Nature Center with those on IRP. The two-hour recordings of dawn and dusk for the three days of testing are available on Basecamp. Dawn/Dusk monitoring could be run during the high migration days of early summer and for week-long intervals to collect songbird inventory recordings. This strategy of recording need only be completed once every five years as a way to confirm and update visual sightings.

3. Consider Other Software Options

Raven is a cost-effective and sufficient choice for baseline sound assessments, as outlined in the protocol here. Other software is available if more extensive future studies are planned or should funding arise. One such software option is Kaleidoscope, a program developed by Wildlife Acoustics, the same company that produces the SongMeter4 recording devices and therefore designed to work in conjunction with the developer's sound library. This feature makes sound identification simpler as the software can identify sounds from the sound library with the user selecting each sound themselves. Wildlife Acoustics makes note of this in the user's manual for the SM4 recorder:

> "The recordings are compatible with all popular third-party full-spectrum analysis programs available. Wildlife Acoustics recommends and supports our Kaleidoscope software, which allows you to easily view and classify your recordings. Kaleidoscope Viewer is a free download and Kaleidoscope Pro with bat Auto-ID is available for purchase at www.wildlifeacoustics.com" (SM4 Users Guide).

Subscriptions for this software are approximately $1,200.

New software is currently in development for use by the National Parks Service and has been used in Denali National Park. Sound monitoring efforts there are headed by David Betchkal (Betchkal 2015). The use of this software and analysis techniques piloted by Betchkal may prove beneficial for coordination with other sound monitoring programs conducted throughout Alaska.

III. Fish Trapping

A. Introduction

Along the coast of Homer, the Kachemak Bay fisheries are rich with pink (*Oncorhynchus gorbuscha*) and coho salmon (*Oncorhynchus kisutch*), and dolly varden (*Salvelinus malma*). These fish species are anadromous which means that they spend portions of their life cycle in both fresh and salt waters, feeding and growing in the sea and migrating into freshwater to spawn. These species are important because they serve as a keystone food resource, linking terrestrial and aquatic ecosystems (NOAA 2017; Willson & Halupka 1995). However, this thriving system remains vulnerable to the ever-increasing anthropogenic threats of climate change, changing land use, and habitat degradation. Human activities and land use change have had a direct impact on the abundance and viability of fish. Dolly varden populations in developed regions are disappearing and salmon populations are threatened by the use of forest chemicals and fertilizers (Armstrong & Hermans 2017; Armstrong 1979; Murphy 1995).

The loss of anadromous fish in Alaska presents a threat to aquatic and terrestrial ecosystems that rely on the predator-prey dynamics in which these fish participate. In response to this decline, the Alaska Department of Fish and Game (ADFG) determined that over 19,000 streams, rivers, or lakes surrounding Alaska are important for the spawning, rearing, or migration of anadromous fish and listed them in *The Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes*. However, based on further, thorough surveys conducted by the ADFG, it is believed that at least an additional 20,000 water bodies crucial to anadromous fish were not included in this analysis (Alaska Department of Fish and Game). These habitats will not be protected under the State of Alaska law (AS 16.05.871) until anadromous fish have been collected and identified by a qualified collector and then inventoried in the Catalog. Therefore, further aquatic research on properties such as IRP, whose fish populations are not well studied, should assess fish abundance and the potential for further protective management strategies.

B. Rationale

Fish surveys were conducted to collect baseline information on fish species composition and distribution in IRP waterways. Additionally, they were used to determine if anadromous fish are present in IRP's streams, which would merit additional legal protection of those streams under AS 16.05.871. Our fish surveys expand upon the 2016 baseline inventory to better understand fish abundance and distribution. A total of 10 fish trappings were conducted with hard and soft minnow traps in eight different locations on

Fritz Creek inside IRP, shown in Figure 3.1. These were carried out from July 2018 to August 2018, since by this time the streams have thawed and the conditions were ideal to place the traps.

C. Data Collection Protocol

1. Permitting and Reporting

Fish trapping methodology was developed in consultation with ADFG to ensure that procedures were in line with the standards of the state.

A catch permit needs to be secured from the ADFG for IRP a month before any trapping event. Fish found during the trapping have to be reported to ADFG using their supplied Excel template and with photographs.

Note: For more information and details on the regulations and stipulations of this permit, refer to: http://www.adfg.alaska.gov/index.cfm?adfg=otherlicense.aquatic_resource

2. Performing Trapping

Trap Locations

Select only streams with sufficient depth to submerge the entire entry hole of the trap at least a few inches below the water surface. Record the GPS location and flag nearby vegetation or shrubs to easily find the traps for collection.

Baiting and Trap Placement

Galvanized steel traps (GEE minnow traps) and collapsible fishing net traps are two trap types that are often utilized and are both available from the Kachemak Bay National Estuarine Research Reserve (KBNERR).

Fish trapping and baiting:

a. Use uncured salmon eggs (kept frozen until use) as bait. Prior to use, these eggs need to be soaked in 1% iodine or betadine solution for 30 minutes.
b. Place approximately 2-3 tablespoons of sterilized eggs in a perforated bag for the steel traps or a built-in pocket for the collapsible traps for each trapping event.
c. Completely submerge the hole of the trap underwater and, if possible, submerge the entire trap.

d. Secure the traps to the bank or nearby vegetation with twine or a chain and label them with the permit holder's name, phone number, and permit number.
e. Check traps approximately one hour after being set to ensure that they remained in place. Leave traps to soak overnight (approximately 24 hours) before retrieval.

Trap Retrieval and Analysis

a. Check the traps approximately 24 hours after they were placed and then pull the traps from the water, moving any fish from the trap into a bucket filled with water.
b. Place individual fish into a photarium (Figure 3.1.) to identify the species, measure the total length and 'fork length' (tip of the nose to the fork of the tail), and take several photographs.
c. If fish do not fit in the photarium, measure the total length and 'fork length' against a PVC measuring board. Identify the fish species with the help of ADFG and KBNERR species guides.

Figure 3.1. Example of a dolly varden being measured in a photarium

Replication

We recommend that CACS conduct replicate fish surveys in these same locations (Figure 3.2) and on other similar sites to get more accurate results. If possible, hard steel minnow traps should be used, as they proved more successful at capturing fish during our 2018 fish sampling. These surveys could be carried out once every three years during the summer, when the streams are running. Data obtained from these surveys can be represented graphically, such as the 2018 fish trapping abundance data in Figure 3.2

and Figure 3.3. If there is interest in conducting further stream health assessments, water quality assessments such as the ones describe in Appendix II, Part C could also be carried out every three years. We conclude, however, that given the size of the streams, all quite small, fish monitoring should not be considered a top priority.

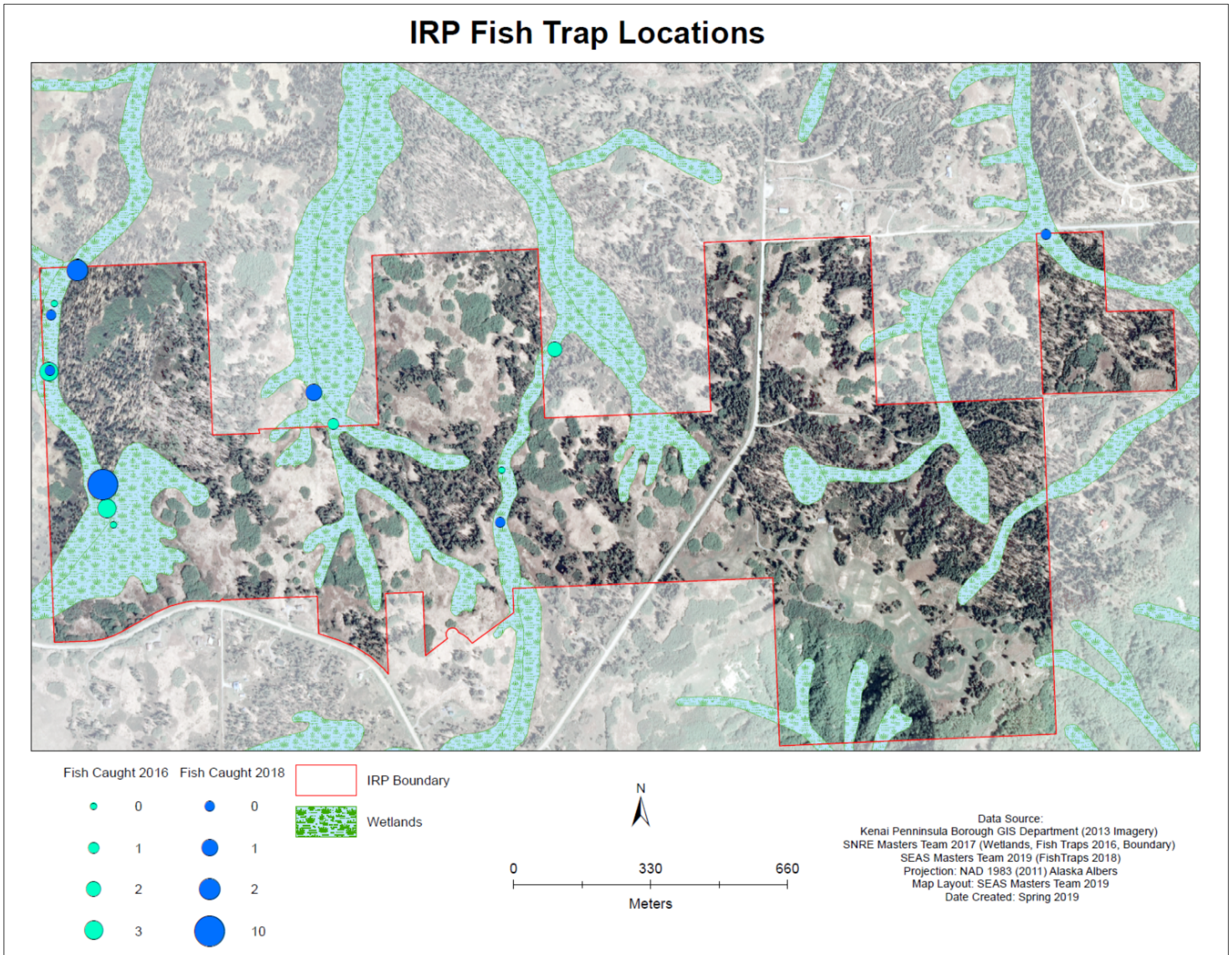


Figure 3.2. Fish Trap Locations within IRP Property

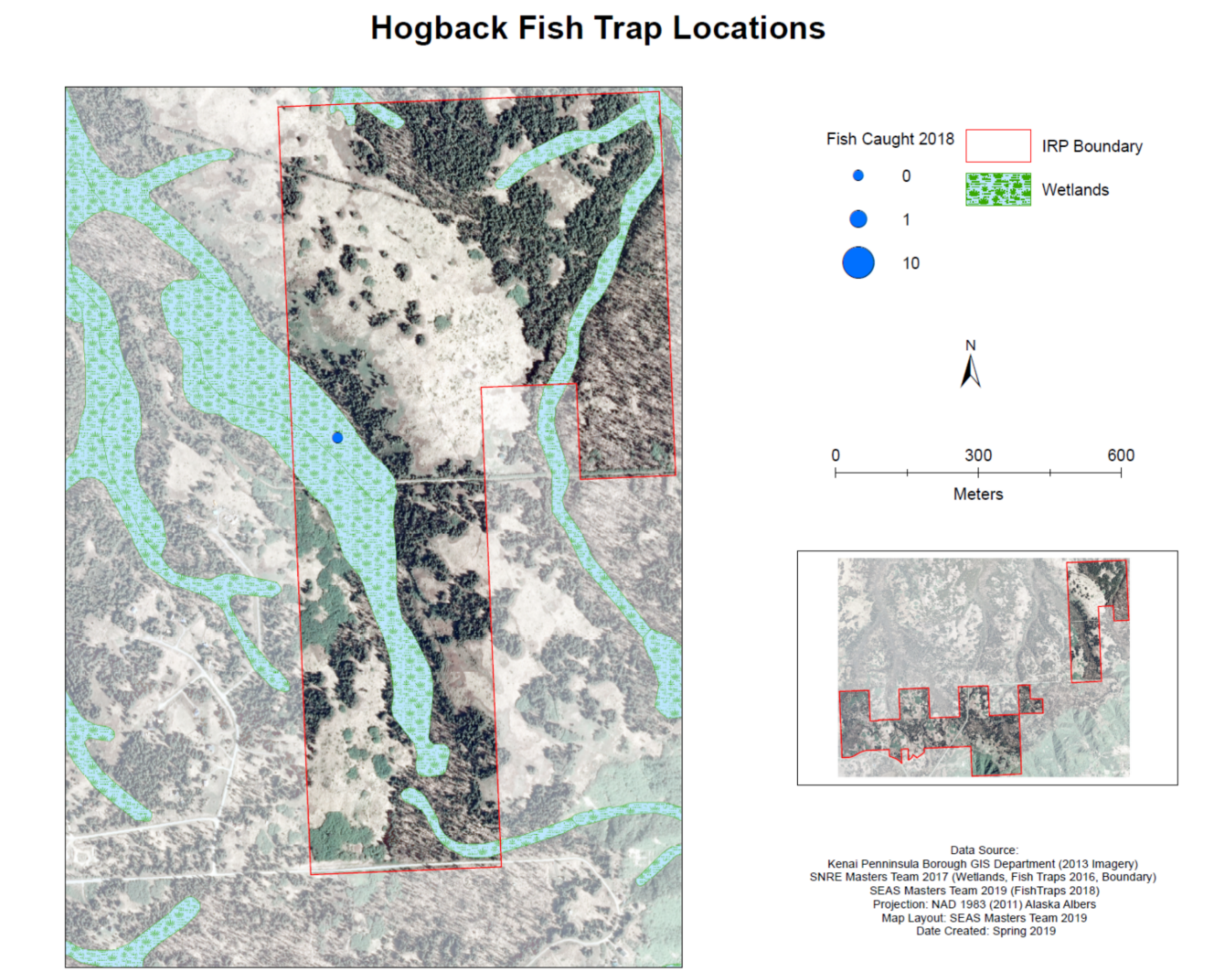


Figure 3.3. Fish Trap Locations within the IRP Hogback Property

D. Results from 2018 Data Collection

After conducting fish surveys during the summer of 2018, 13 juvenile dolly varden (*Salvelinus malma*) were found during 10 of trapping events across 8 sites (Figure 3.4.). However, dolly varden, are known to exhibit a variety of life history forms and can be anadromous or exclusively stream residents; therefore, their presence does not warrant anadromous protection from ADFG.

These results were expected due to the fact that IRP is located at a higher elevation than the Bay and a waterfall at the mouth of Fritz Creek acts as a natural barrier preventing anadromous fish movement from the Bay into the tributaries. In fact, it is surprising that fish reached these high elevation, first-order streams in the first place. Based on field observations and macroinvertebrate bioassessments (discussed in

Part C), this area does not appear to have any major pollution issues and is in good enough health to support these fish.

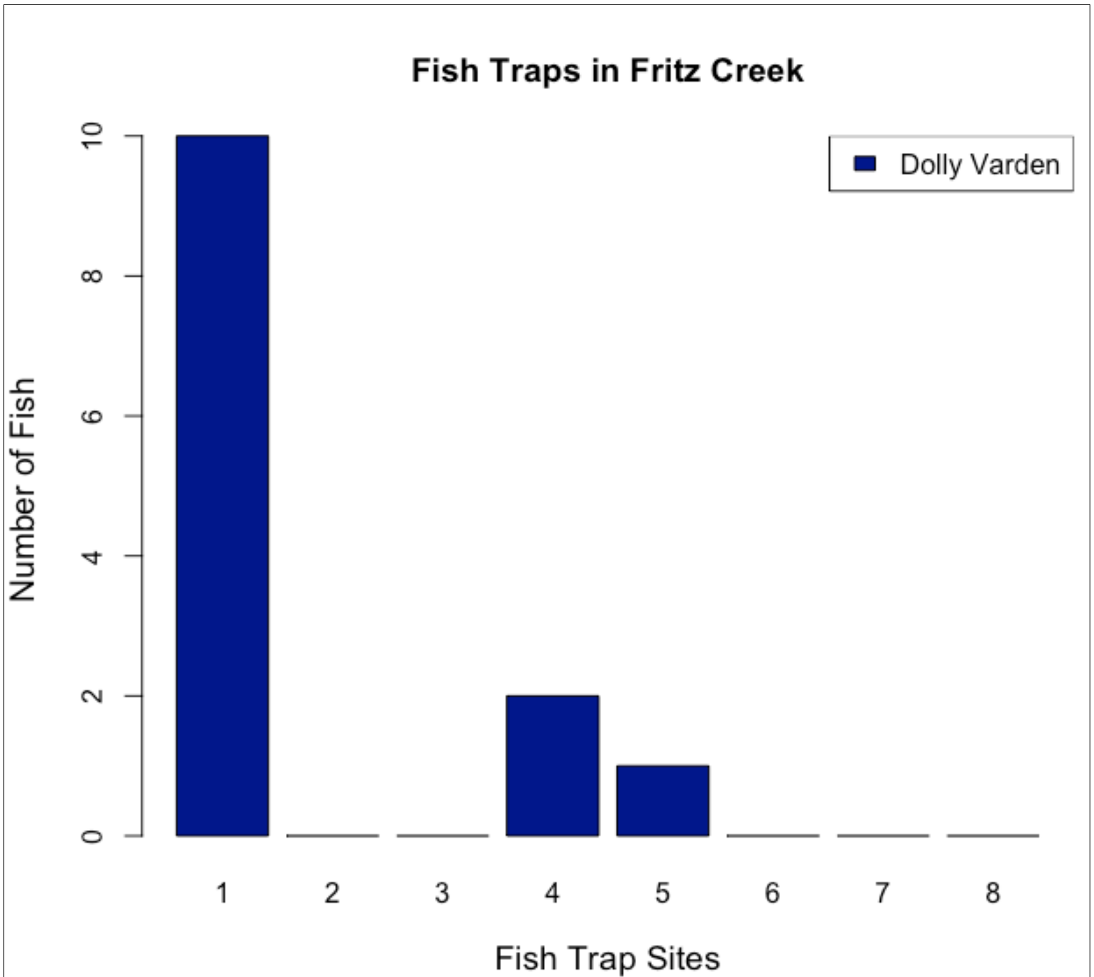


Figure 3.3. Graphic example of the number of fish found in the traps in each of the sampled sites.

E. Recommendations

We recommend that CACS:

a. Repeat the stream points we sampled (Table 9.1) and those sampled by the 2016 team (Figure 3.2), while also sampling new areas that are deep enough to submerge the traps.

b. Carry out stream samplings every 3 years.

c. Perform water quality assessments.

IV. Monitoring Long-Term Vegetation Changes

A. Introduction

Vegetation monitoring will be crucial to IRP for the assessment of natural stressors and anthropogenic impact on plant communities. It is anticipated that global warming will cause vegetation shifts in distributional ranges which could bring invasive species and lead to pest outbreaks (native and introduced), and increased herbivory pressure. Studies suggest that, across the Kenai Peninsula, climate change will force changes in vegetation composition such that deciduous, mountain hemlock, mixed conifer, and herbaceous species will increase while white, Lutz, and Sitka spruce species, alpine forests, and mixed forests will decrease. Specifically, in the southeastern Kenai Peninsula, a significant shift from coniferous and mixed forest communities to deciduous forest is anticipated (Magness and Morton 2018). Figure 4.1 illustrates vegetation changes anticipated across the Kenai Peninsula.

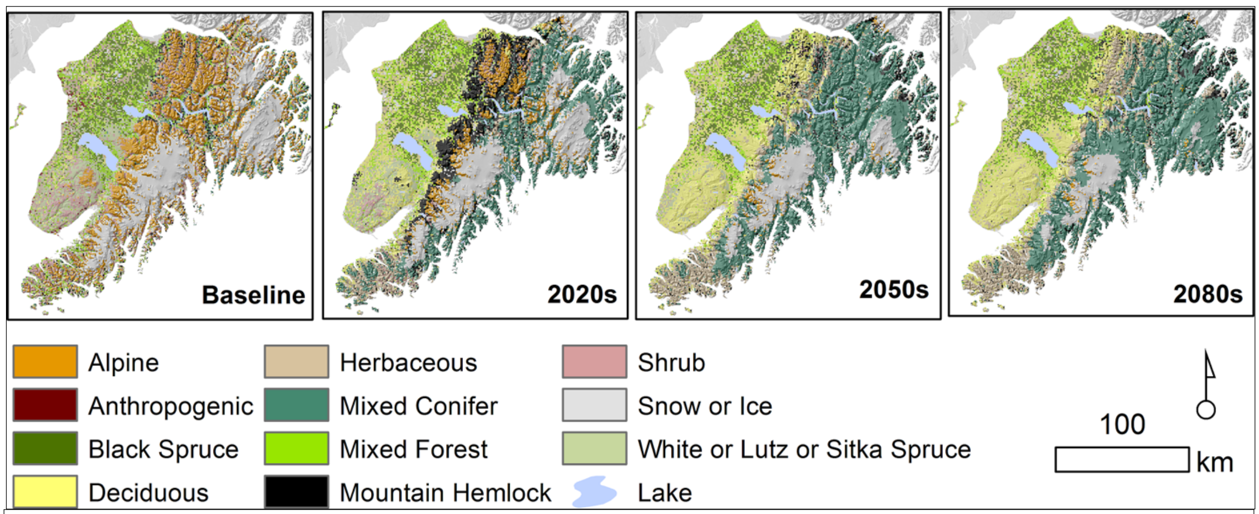


Figure 4.1. Anticipated changes in vegetation across the Kenai Peninsula (Magness and Morton 2018).

The methods outlined in this protocol can be used to collect baseline information and carry out future monitoring surveys against which comparisons over time can identify areas in IRP where vegetation is experiencing change or stress. Further research, along with the application of data from vegetation monitoring, can help identify threats to the vegetation in IRP so that they may be addressed. Long-term monitoring and data analysis will further CACS' understanding of vegetation trajectories and allow them to act accordingly.

We have developed a protocol for surveying vegetation using drone images. This approach avoids the difficulties of maintaining sampling transects in the field and the cost of using high resolution remote sensing data.

B. Rationale

The baseline inventory conducted in 2016 collected vegetation data through transect surveys. However, permanent transect markers are difficult to establish on the Preserve because of moose interference, moist soils, thick vegetation, and issues locating previous transects. Furthermore, we would need a large number of transects to account for the high degree of variability of vegetation on IRP and these surveys, which are time consuming, cannot cover the entirety of the Preserve. Alternative to transects, a technique commonly used to monitor vegetation at large spatial scales over time is remote sensing. Applying remote sensing analytical techniques to satellite imagery with consistent temporal and spatial resolutions offers a way to monitor areas of IRP that might otherwise be inaccessible and provides a holistic approach to monitoring vegetation trends. However, there is a trade-off between cost and spatial resolution; it can be prohibitively expensive to acquire data with a resolution sufficient enough for CACS' needs. Drone imagery capture is an increasingly common method for vegetation monitoring and analysis because of its versatility, spatial coverage, and timely data collection. Drones have the potential to meet the needs of CACS by providing a low-cost, on-demand alternative to satellite data. Access to drones affords CACS the ability to effectively and efficiently monitor IRP for long-term vegetation changes.

Having recently acquired the Phantom 3 Pro and Mavic 2 Pro drones, CACS can utilize aerial imagery to monitor long-term changes in vegetation composition at IRP. To ensure consistency in data collection the same coordinates should be photographed over time. We propose a sampling protocol based on the trail network system with easily identifiable intersections (see recommendations section for more thorough sampling possibilities). Key trailhead points should be photographed at regular intervals, every five years or after any major disturbance. Images can then be processed for vegetation changes and compared with previous records.

Image processing can be done using heads up digitizing, a common methodology for creating spatial data within GIS. This process utilizes static data – typically an aerial image, such as our drone images – that have spatial geolocation information but do not contain any attribute data. Digitizing an image is the process of manually drawing polygons based on user defined criteria. It is a substitute for an automated supervised or unsupervised classification (see Appendix III, Part C for more details).

For this project, we selected classification through heads up digitizing because:

1. It allows for user interpretation of an aerial image. Often, human interpretation is more accurate than a pixel-based computer classification. Procuring accurate and consistent results from the latter is heavily dependent on several factors:
    a. *Seasonality:* Leaf-on versus leaf-off vegetation will have different pixel signatures, as will flowers in a blooming stage versus budding. This variability would lead to inconsistent analysis by a computer-based classification method, but this is variability that the human eye can more readily detect.
    b. *Sunlight:* Similarly, the amount of sunlight in an image will change the brightness and pixel signature of vegetation classes. More importantly, the sun angle determines shadow amount and angle. Land cover that falls underneath shadow is virtually indistinguishable by a computer classification. Although it is sometimes difficult to distinguish with the human eye as well.
    c. *Similarity in Spectral Signature:* Many types of vegetation have similar spectral signatures – they are all varying hues of greens. Without a near-infrared band, a computer classification does not know how to interpret overlap between these signatures. Human interpretation, particularly when done by a local vegetation expert, can more readily distinguish types of vegetation based on context and texture. See Appendix III, Part C for more details about this.
2. It employs ArcMap, which is part of the ArcGIS software package. Other, more sophisticated software packages such as ERDAS Imagine, have more complex classification algorithms which might have improved supervised classification. However, for the purposes and scope of this analysis, such analytical power is unnecessary.
3. Heads up digitizing produces vector polygons, as opposed to some other classification methods which are raster-based. Although both represent spatial data, vector polygons are distinct entities for which multiple attributes can be stored. Raster data is pixel-based, can only hold one attribute, and has a coarser resolution. Given that the drone images will be used for vegetation classification and used in a buffer and clip method, it was determined that polygons would be necessary and more appropriate to store the information necessary and to be used in that form of analysis.

C. Data Collection Protocol

1. Sampling Locations

Key trailheads were selected based on their accessibility and easily identifiable landmarks for georeferencing purpose. Reference Figure 4.2 for point locations and see Appendix III, Part A for coordinates for each point.

Note: Camera trap aerial images are analyzed in a different way. Refer to the [Wildlife Camera Trap Protocol](#) for analysis details.

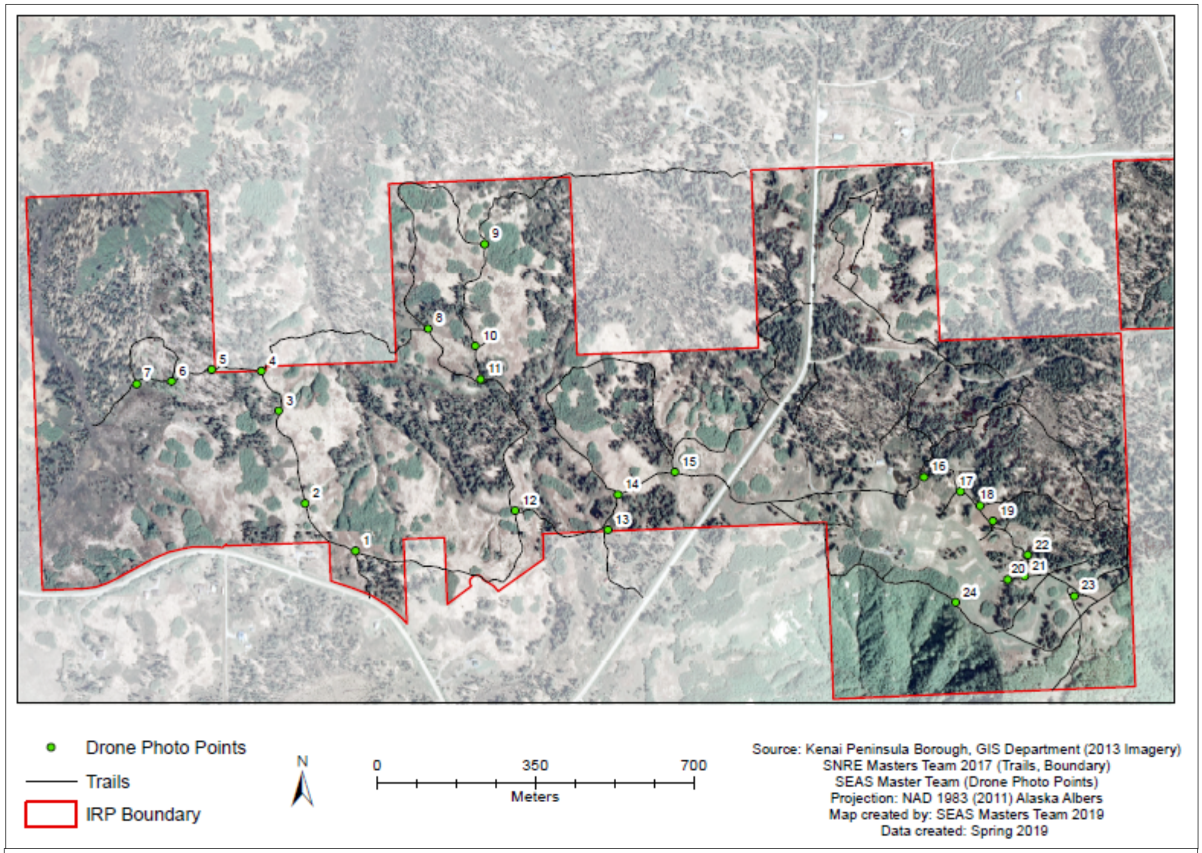


Figure 4.2. Locations of all drone photo points.

2. Sampling Frequency

Images can be taken once every 5 years or following a major disturbance. Intervals should be far apart for vegetation to change noticeably, but not too infrequent that intermediate vegetation stages are missed.

To match the 2018 data, drone images must be captured during the summer season when plants, specifically native fireweed, are in bloom. This is typically late July or early August. Native fireweed is easily identified by its bright purple color during bloom season. Without its unique color, it is not distinguishable from other small herbaceous vegetation in aerial images. Native fireweed is a crucial component of the quantification analysis, rendering classification useless without its proper identification. In addition, the distinctive height and color difference of most non-woody vegetation before and after bloom is stark. Images captured outside of the peak bloom time range will not be applicable to the constructed classification scheme provided in the management plan and will not be classifiable due to their seasonal differences. Thus, the ideal time for imagery capture is during peak blooming of native fireweed to allow for precise classification.

3. Licensing and Permissions

Prior to drone usage, a Federal Aviation Administration (FAA) drone pilot's license must be obtained by a group member operating the drone. The registration form can be found at the link through the Federal Drone Registration provided below:
https://federaldroneregistration.com/?gclid=EAIaIQobChMIleCSoYH43gIViLrACh1ViQNQEAAYASAAEgK52_D_BwE

In addition, the local Homer Airport (907-235-8588) must be informed of drone operation times and dates as well as specific flying locations. IRP is within a five mile range of the Homer Airport and therefore is limited in flying abilities due to potential collisions with low-flying planes.

4. Software Download and Operation

a. Download the DJI Go app for free through the Apple app store or Google Play for Androids.
b. Set the app to the specific drone being operated (Phantom 3 Pro or Mavic 2 Pro) before all flights. The software only allows continuous video to be taken during pre-programmed flight paths rather than the solitary images needed for vegetation data collection. In accordance with this and to stay within the scope of a beginner skill set to capture each image, the drone operator will have to physically walk to the trail intersection where images will be captured.

Note: For further details on how to operate a drone using the DJI Go App refer to the DJI Go App manual: https://store.dji.com/guides/dji-go-4-manual/.

5. Drone Operation Logistics

Federal regulations require the drone be within sight of the operator at all times or it is within sight of the drone operator's assistant. No images are to be taken that require the drone to leave the operator's or the assistant's field of view. To capture images efficiently, take all available spare batteries into the field when capturing images. Batteries typically only have a 15 minute lifespan. If the drone warns the operator of a low battery, it will automatically fly to the home point and land; the image will not be captured. Do not operate the drone even in light rain as it is not waterproof. Rain can destroy the drone and distort images. Avoid strong winds as well. They drain the battery very quickly and result in unprompted drifting of the drone, producing inconsistent photos.

6. Drone Imagery Capture

a. Using the DJI Go App, capture images at 120 feet (37 meters) and 393 feet (119 meters), the highest allowable flight height of the drone above the given photo point.

Note: the Mavic operates using the metric system while the Phantom drone collects data in the imperial system.

b. If needed, shutter speed can be adjusted to capture higher quality images in different light conditions. However, setting the DJI Go app to automatically adjust for shutter speed usually allows for acceptable automated adjustments. When adjusting shutter speed, capturing images that are as similar as possible in color scheme due to shutter speed settings is crucial for digitizing purposes.

c. When capturing images, limit the shading effect of trees as much as possible. This could mean taking images during a different period of the day when shadows are not as prominent, particularly during solar noon.

d. Take images in the direct center of all intersecting trailheads. This is where the GPS coordinates for each point were recorded. The operator being present in the photo is not an issue, but rather aides in the georeferencing process.

    i. When capturing wildlife camera aerial imagery: if a camera trap is located along a trail or at a trail intersection, the drone can be launched from a nearby open, flat area and navigated vertically (no horizontal movement required). However, if the camera is located off-trail launch from the closest open, flat area and navigate drone to the location of camera.

e. While capturing images, the drone camera should always be angled directly to the ground. This will have to be adjusted every time the drone is powered down.

f. The quality of each image should be checked before progressing on with imaging to ensure the image has no distortions, major shadows, or errors. Images with distortions around the edges of photos are common and must be retaken. Digitization with distorted images is inaccurate and correcting distorted imagery is beyond the skillset of a beginner GIS user.

7. Ground Truthing

Manually recording the vegetation types at each photo point is necessary for later classification. At each photo point draw a rudimentary sketch of the area identifying key vegetation patches similar to Figure 4.3. It is critical to include a north arrow and rough trails in each sketch for reference. Properly labelling vegetation is imperative because this will serve as a basis for digitization and classification later in analysis.

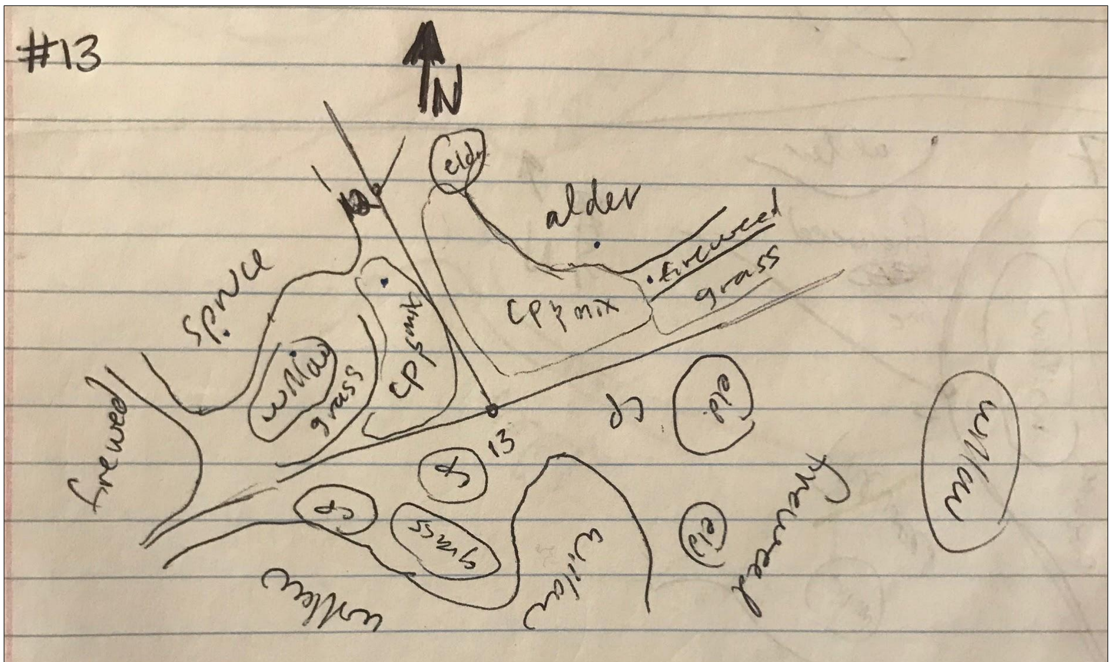


Figure 4.3. Example of a ground truthing sketch with point ID number, north arrow, approximation of the trails, and vegetation types observed.

8. Recording Metadata

Record the following metadata in a data table for each image:

Photo ID	Photo Point Number	Date	Time	Latitude	Longitude	Height	Notes

Photo IDs must be manually recorded in a field notebook and in a table after images are uploaded onto a computer. Photo ID refers to the name given to the image through the DJI Go app, *not* the photo point name assigned to the photo point in this protocol. Date, time, latitude, and longitude are all imprinted onto images as they are captured and can be accessed in image details. Although these are imprinted on photos, manually record this data in the field as a precaution. Height, referring to the actual height of the drone above the ground and not the altitude, is not imprinted on images and *will be lost* if not recorded in a field notebook. Write down any noteworthy or helpful observations. Include notes and a description of the area for future reference for any new images taken.

D. Data Processing Protocol

1. Georeferencing

Images captured through the DJI Go App are processed as JPEGs or TIFFs, not GeoTIFFs. This means that they cannot be directly imported into ArcMap and have to be georeferenced before they can be digitized. Georeferencing is a method of relating the coordinate system of a photo to the geographic coordinates on a map. Georeferencing images allows the images to be overlaid on a basemap on the Preserve, matching the features and coordinates of the basemap. A base layer map with known georeferenced coordinates is used to place an unreferenced image onto a coordinate system. Aerial images taken using the DJI Go app are not automatically georeferenced. However, images taken using Pix4D are automatically georeferenced images. Within ArcMap, the georeferencing process is outlined below.

a. Launch ArcMap and open a new map
   i. Name it appropriately e.g. Georeference_Images.
   ii. No spaces can be present in Shapefile names.
b. Connect to the folder with the drone and basemap data through ArcCatalog. The *Connect to Folder* is the button shown  (Figure 4.4). All documents within the folder are now easily accessible through ArcCatalog and can be dragged from catalog onto the map.
   i. These data are provided in Basecamp.
c. Upload drone images into ArcMap by clicking the add data button  at the top of the map or simply dragging images from ArcCatalog.
   i. The basemap is the "imagery2013sharp" shapefile provided in Basecamp. Add this to the map.

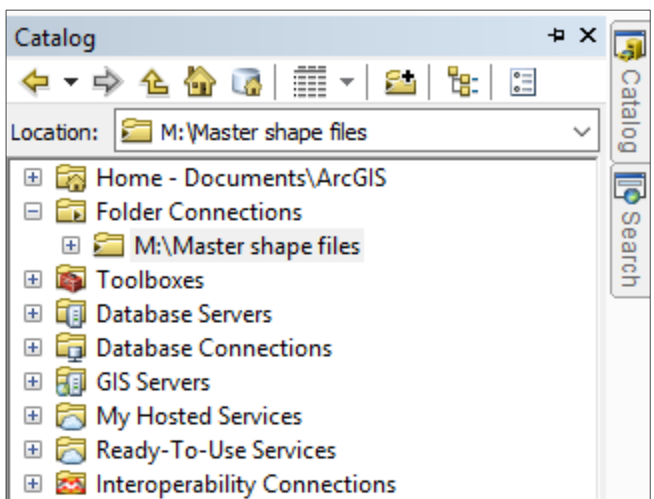


Figure 4.4. ArcCatalog Connection Folder in ArcMap.

ii. If more up-to-date-imagery is available, this can be substituted as a basemap.

d. Georeference an image by clicking *Customize* | *Toolbars* | *Georeferencing* at the top of the map. This will add the georeferencing toolbar.

e. On the *georeferencing toolbar*, choose the desired drone image to georeference from the scroll down selection.

f. Add control points to the image by selecting the first control point option . Control points are known common points between the two images that are aligned through manual selection, creating a georeference. Select identifiable features for the drone image that can be matched with the same point on the base layer. Be sure to select the drone image first. Click the image in the *Table of Contents*, right-click, and select *Zoom to Layer*. Pick the first control point on the drone image, zoom to the base layer, and select the same point in this layer. A total of four to seven control points are ideally used to ensure the accuracy of the georeferencing.

g. If the image becomes distorted or a mistake occurs with the control points, they can be erased. To do this, either delete all the links or simply delete the last control point. To only delete the last control point, select the last point using the *Select Links* button and then the button. To delete all links select *Delete Links* from the scroll down menu. Reload the image from the pull-down menu by selecting *Reload Georeferencin*g. This will reset the image to its state before the distortion.

h. Once the images are aligned, rectify the image by selecting the scroll down bar and clicking *Rectify*. Save the image in the format: PhotoID_Georef, for example (13_Georef). This will save the image with the georeferencing. When rectifying, be sure to save images in the appropriate file by selecting the *Output Location* and choosing a location within the connected folder.

i. When multiple images are georeferenced, they can be viewed all together over the basemap and compared to see if georeferencing is sufficient. Add the georeferenced images to the map and redo any that are not properly aligned with the basemap.

2. Building Attribute Domains and Topology

Before beginning digitization for the first time, attribute domains must be built. Attribute domains control the type and values of inputs for attribute fields. This ensures consistency and integrity throughout the data. Attribute domains can only be applied within geodatabases. Creating a geodatabase and feature dataset, as well as attribute domains is done within ArcCatalog.

a. Right-click on the working database and choose *New | File Geodatabase.* Once created, right-click on the geodatabase and choose *New | Feature Dataset.* Choose the appropriate XY projected coordinate system and keep all other options to the default (Figure 4.5).

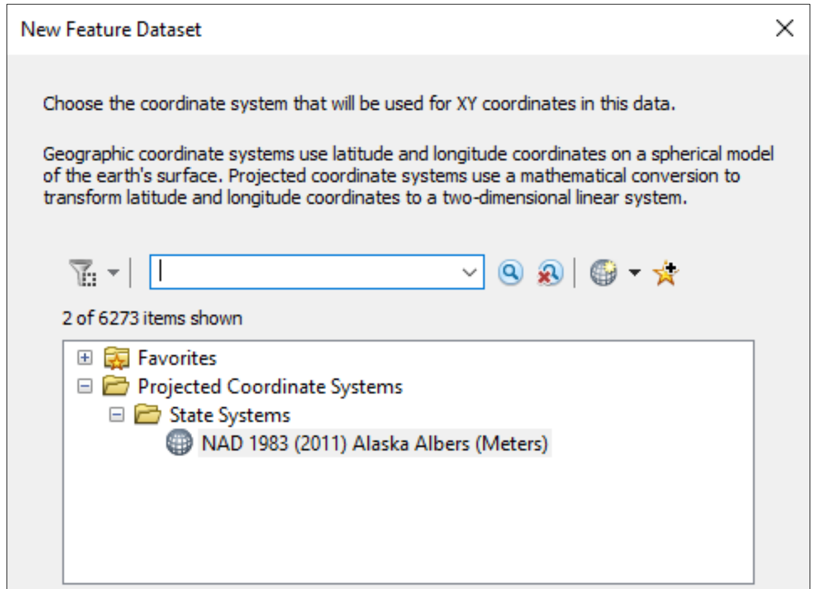


Figure 4.5. The NAD_1983_2011_Alaska_Albers projected coordinate system is located within the "State Systems" folder.

   i. All work in this project uses the NAD_1983_2011_Alaska_Albers coordinate system.

b. Define attributes within the *Properties* of the geodatabase. Within the *Domains* tab, enter the desired name and description.

c. Select the newly created domain and, under *Domain Properties*, change the *Field Type* to "Text" and the *Domain Type* to *Coded Values*.

d. Enter the classification scheme (Appendix III, Part B) within the *Coded Values* section (Figure 4.6).

e. Once the attribute domain is created, it can be applied to a feature class in which data will be created. Right-click on the feature dataset and select *New | Feature Class.* The *Feature Type* should be *Polygon Features*.

f. On the final page, define a new field and select *Text* as the *Data Type.* Under *Field Properties,* select the attribute domain from the pull-down menu (Figure 4.7).

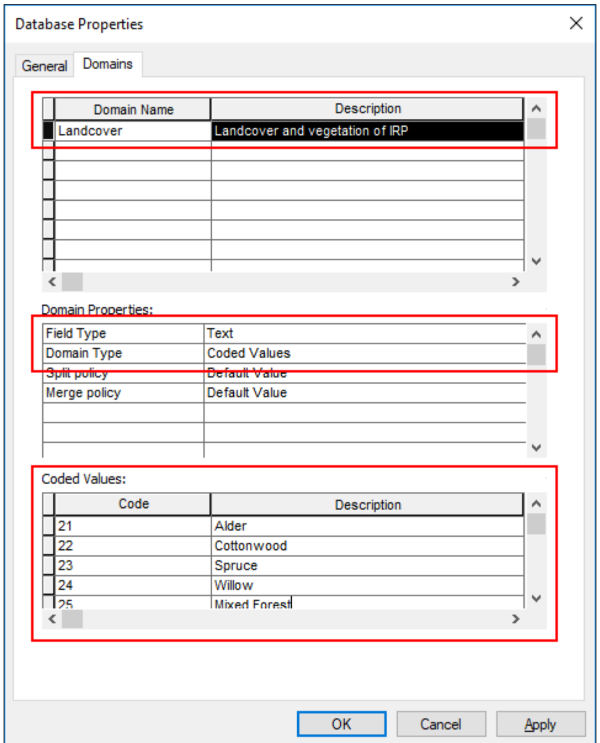


Figure 4.6 (left). Attribute domain properties and coded values for the geodatabase.

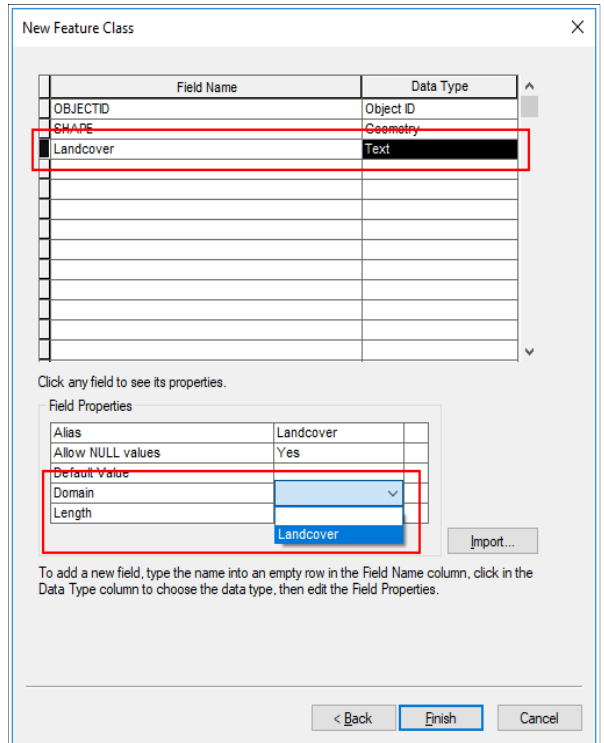


Figure 4.7 (right). Define a new text field and, with it selected, apply the land cover domain to it.

g. Define topology, as desired. For land cover, use the following topological rules:
    i. *Must not Overlap* – based on the assumption that a polygon can only be assigned one land cover type.
    ii. *Must not Contain Gaps* – based on the assumption that land cover is continuous and thus all drawn polygons should share borders.

h. New topology is created within the feature dataset by selecting *New* | *Topology* (Figure 4.8).
    i. For this project, the default cluster of 0.001 meters is used.

i. Add rules listed above, as well as any others deemed necessary or relevant.

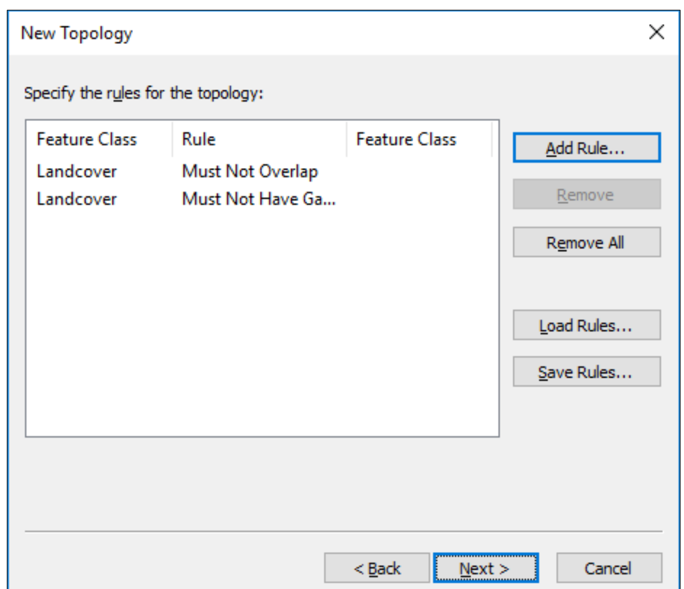


Figure 4.8. Recommended topological rules for land cover classification.

3. Digitizing

Heads up digitizing is the process of creating polygons using an aerial image as a reference. It is done in ArcMap, using the *Editor* (Figure 4.9 and *Topology* toolbars.

Figure 4.9. The *Editor* toolbar with *Editor* pull-down menu, *Edit Vertices, Cut Polygon, and Create Features* tools emphasized (left to right, respectively).

a. Add the topology, polygon feature class, and drone images to a new ArcMap session.

b. Within the *Editor* pull-down menu, select *Snapping* | *Snapping Toolbar* to ensure that snapping is enabled (icons will be shaded blue, as shown in Figure 4.10).

Figure 4.10. Snapping is enabled.

c. Also within the *Editor* pull-down menu, select *Options*. Within the *General* tab, set the sticky move tolerance to a value between 50-100. This sets a minimum number of pixels that a polygon must be moved to prevent accidentally moving polygons while editing.

d. For the polygon feature class, set symbology right-click on the layer, select *Properties* and navigate to the *Symbology* tab. Under *Categories* | *Unique Values,* uncheck *All Other Values* and click *Add All Values* to show all land cover classifications (Figure 4.11).

   i. When drawing polygons, it is useful to have a brightly colored outline but no fill for land cover classes.

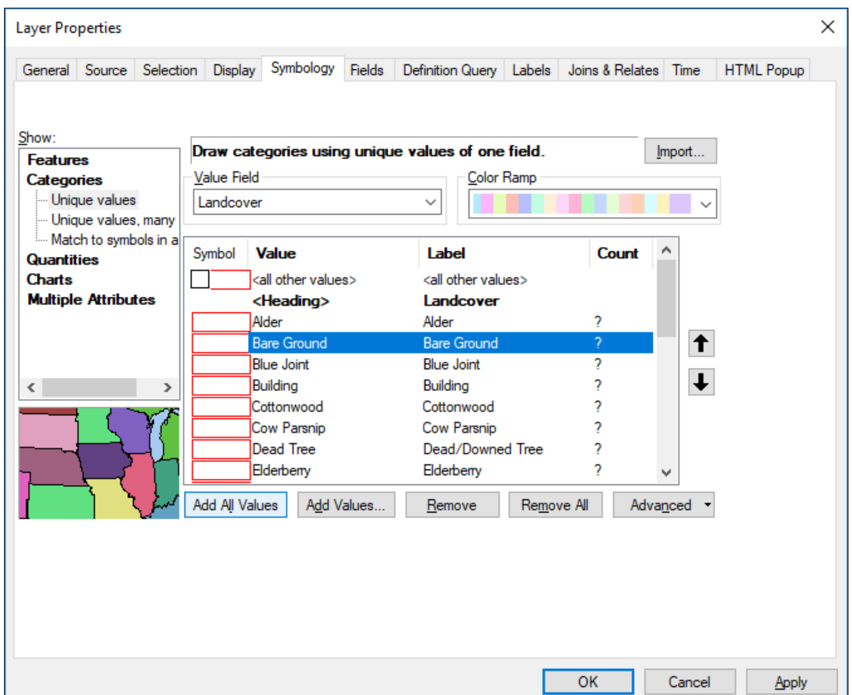


Figure 4.11. Add all land cover classes by selecting *Add All Values* within the *Categories* page of the *Symbology* tab. When digitizing, symbology should have no fill and a bright outline.

e. To begin digitizing, select *Start Editing* within the *Editor* pull-down menu. If the *Create Features* window does not automatically open, click on the *Create Features* icon in the *Editor* toolbar to display it (Figure 4.8). Ensure that all land cover classes are shown in the *Create Features* window.

i. If not, select the *Organize Templates* button (Figure 4.11) and, within the *Organize Feature Templates* dialog box, select *New Template* and check the appropriate template (polygon feature class) and, on the next page, check all classes.

f. Zoom in such that vegetation types are distinguishable. Image should not be at a smaller scale than with a representative fraction of 1:300; however, a larger scale is recommended. Between 1:100 and 1:50 is preferable.

g. From the *Create Features* window, select a class to digitize and then select the *Polygon* construction tool at the bottom of the pane (Figure 4.12).

h. Draw a polygon by placing points around the desired area and double-click when finished (Figure 4.14 and 4.15). Continue to draw polygons until the entire image has been digitized.

i. If drawing a polygon adjacent to another, the *Auto Complete Polygon* tool can be used (Figure 4.12). This tool necessitates only drawing the boundary of a new polygon that is not adjacent to an existing polygon (Figure 4.16) and will minimize topology errors.

ii. For each new polygon, ensure that the correct land cover class is selected from the *Create Features* window. To change the class of an already-drawn polygon, select the polygon, right-click and select *Properties.* Select the correct class from the drop-down list.

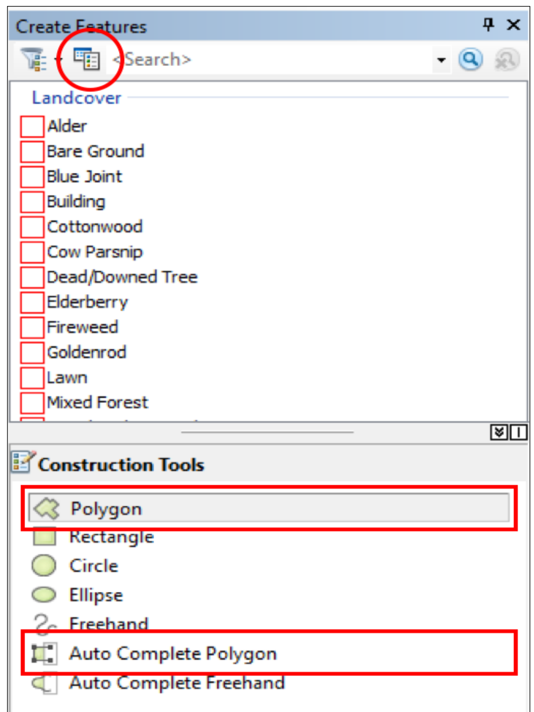


Figure 4.12. The *Create Features* window with the *Organize Template* icon, *Polygon* and *Auto Complete Polygon* tools emphasized (top to bottom, respectively).

iii. Delete a polygon by selecting it and pressing the delete key or right-clicking and selecting *Delete*.

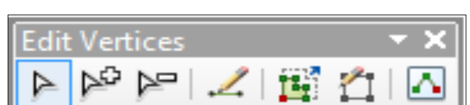


Figure 4.13. The *Edit Vertices* toolbar.

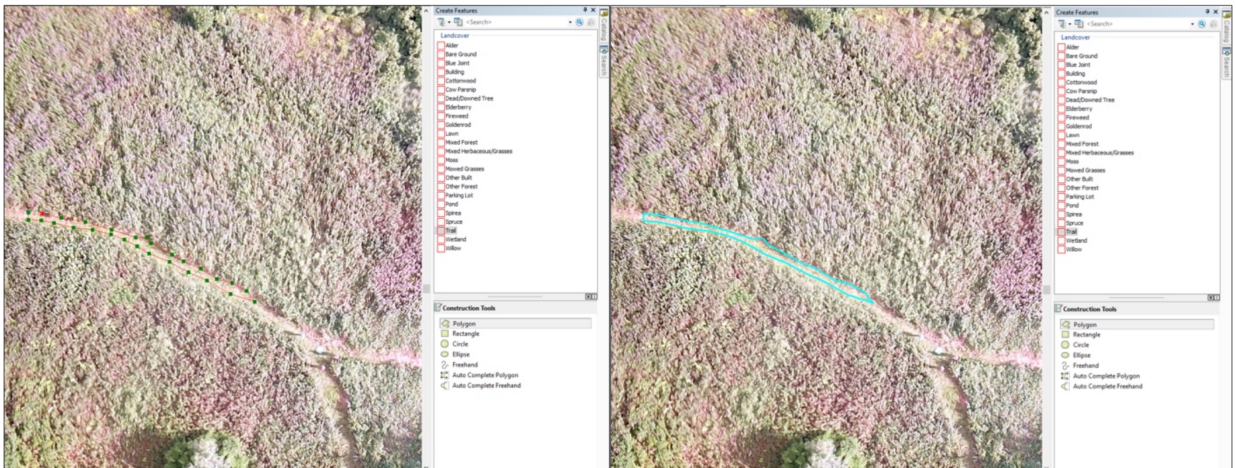
iv. To edit the vertices of a polygon, select the *Edit Vertices* tool from the *Editor* toolbar (as shown in Figure 4.13), which will open the *Edit*

Vertices toolbar. Use the *Modify Sketch Vertices*, *Add Vertex*, or *Delete Vertex* tools to modify the polygon. When done, click the *Finish Sketch* button.

v. To isolate a polygon within an existing polygon, select the inner polygon by clicking the arrow on the selection box and choosing the appropriate polygon (Figure 4.17). From the *Editor* pull-down menu, select *Clip.* Ensure that *Discard the area that intersects* is selected in the *Clip* dialog box.

vi. To merge adjacent polygons of the same land cover class, select the polygons and then, under the *Editor* pull-down menu, select *Merge.*

vii. Throughout digitization, frequently *Save Edits* under the *Editor* pull-down menu.



Figures 4.14 and 4.15. Drawing a trail polygon (left), which is highlighted once completed (right).

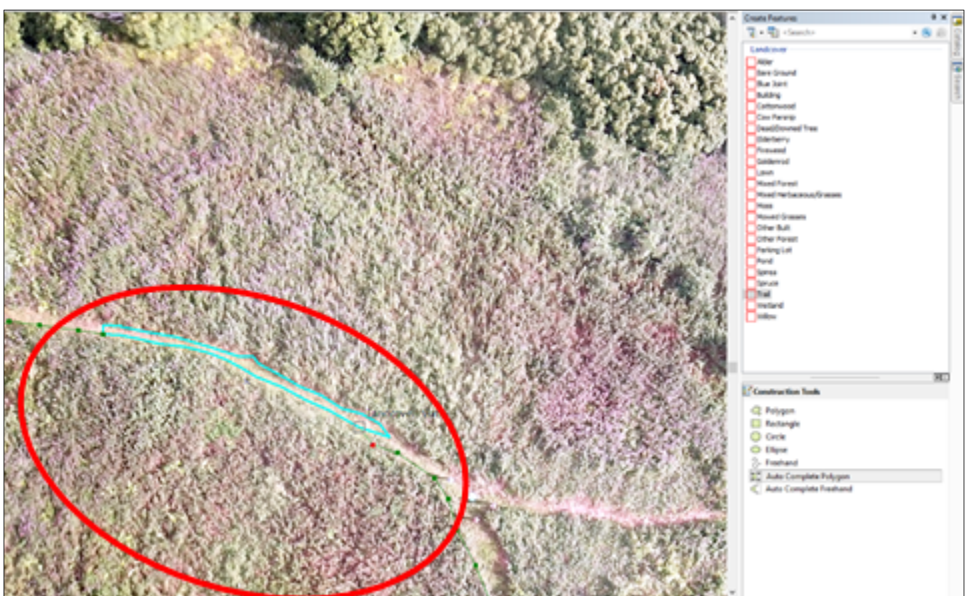


Figure 4.16. When drawing fireweed polygons adjacent to the previous drawn trail polygon, the *Auto Complete Polygon* tool can be used

4. Validating Topology

Topology rules, which were selected while building the feature dataset, ensure that there are no errors once polygons have been drawn. Topology can be validated periodically during the digitizing process but should be done at least once after all polygons have been drawn. Topological errors typically occur when the *Auto-Complete Polygon* tool is not used to draw adjoining polygons and vertices do not align perfectly (can create gaps or overlaps). Overlaps are also common when drawing small polygons within larger ones (e.g. a spruce tree in a field of fireweed) or if polygons are accidentally moved.

a. Use the *Select Topology* tool on the *Topology* toolbar to ensure that geodatabase topology is set correctly.

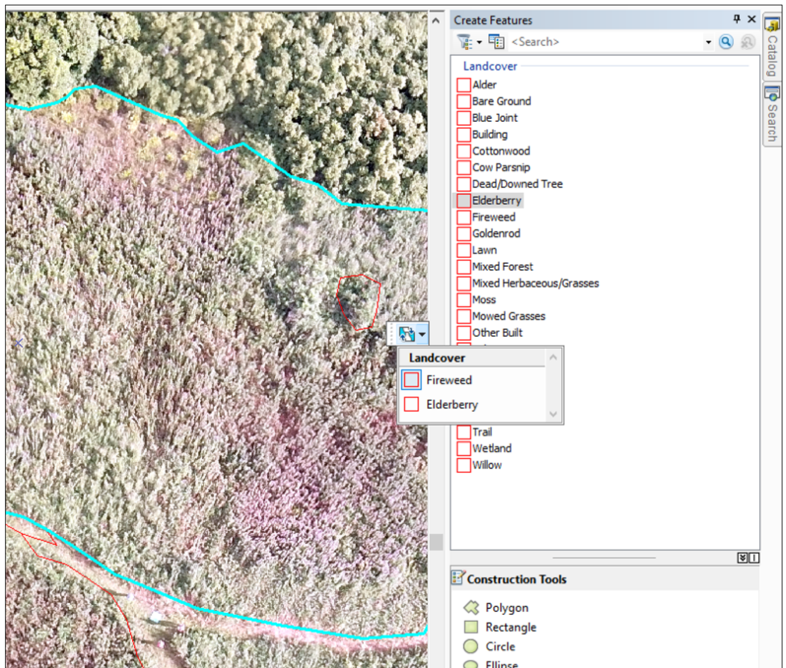


Figure 4.17. When isolating a polygon within a larger polygon, select the inner polygon (Elderberry) from the dropdown list before using the *Clip* tool.

b. Zoomed to the full extent of the aerial image, click *Validate Topology in Current Extent* on the *Topology* toolbar.

c. Pink lines or red-filled polygons that appear on the image represent topological errors (Figure 4.18).

   i. Select the *Fix Topology Error Tool* to fix legitimate errors. Right-click on an error to either *Subtract, Merge, (in the case of an overlap) or Create Feature (in the case of a gap)*. Note that any features created must be manually assigned an attribute. Alternatively, vertices of existing polygons may be edited to avoid overlap or gaps and new polygons can be drawn to fill gaps.

   ii. The boundary of the image will turn pink as a violation of the gaps rule because there are no adjacent polygons. However, because this is the extent of our image, there will never be adjacent polygons. Using the *Fix Topology Error Tool*, right-click to mark this as an exception, or simply disregard this error.

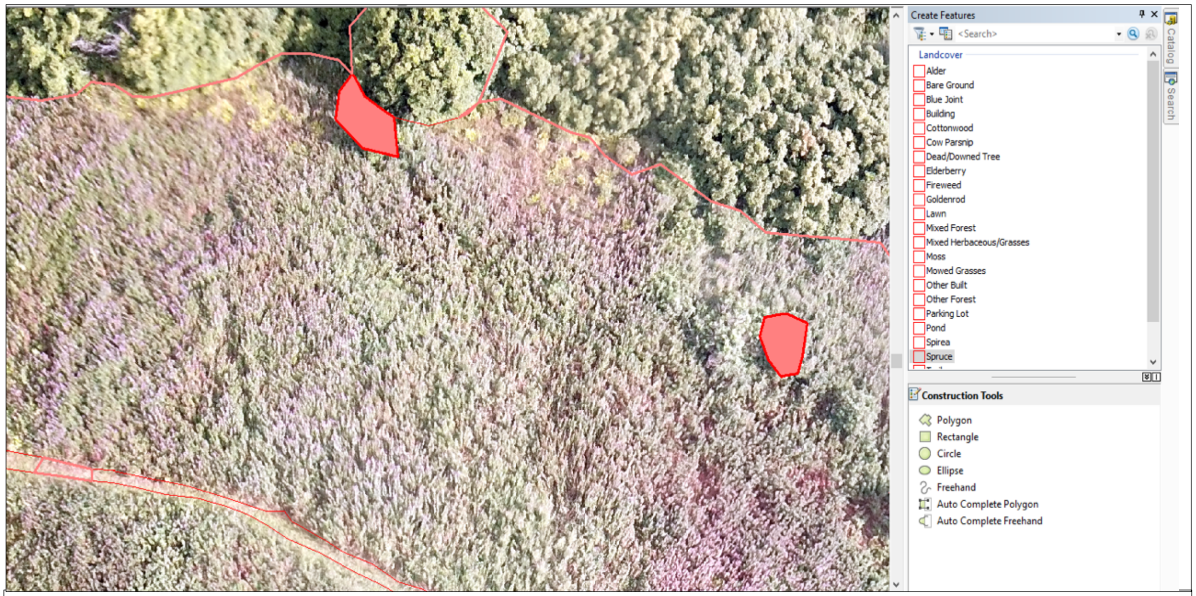
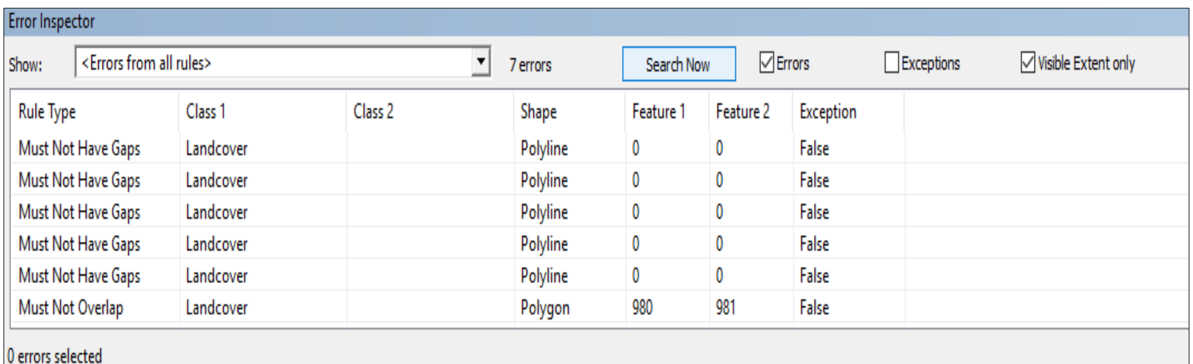


Figure 4.18. Topological errors are highlighted in pink and red. Pink lines indicate violations to the *Must Not Have Gaps* rule and red-filled areas indicate violations to the *Must Not Overlap* rule.


Error Inspector

Show: <Errors from all rules> 7 errors Search Now ☑ Errors ☐ Exceptions ☑ Visible Extent only

Rule Type	Class 1	Class 2	Shape	Feature 1	Feature 2	Exception
Must Not Have Gaps	Landcover		Polyline	0	0	False
Must Not Have Gaps	Landcover		Polyline	0	0	False
Must Not Have Gaps	Landcover		Polyline	0	0	False
Must Not Have Gaps	Landcover		Polyline	0	0	False
Must Not Have Gaps	Landcover		Polyline	0	0	False
Must Not Overlap	Landcover		Polygon	980	981	False

0 errors selected

Figure 4.19. Topological errors identified in the *Error Inspector* tool.

d. Once all noticeably highlighted errors have been fixed, open the *Error Inspector Tool* (Figure 4.19). Still zoomed to the full extent of the aerial image, run a search of all remaining errors, using the *Search* button. Either correct remaining legitimate errors or mark them as exceptions.

e. Save edits and *Stop Editing* from the pull-down menu on the toolbar.

5. Exporting Data

It is recommended that land cover data for each aerial image be saved as a unique shapefile (e.g. 1_Landcover for Point 1). Once each image is fully digitized and the editing session is ended, export all drawn polygons to a new shapefile.

a. Select all records within the attribute table and then, within the Table of Contents, right-click on the polygon feature class and select *Data | Export Data* (Figure 4.20).

   i. Make sure *All Features* and *This Layer's Source Data* are selected. For *Output Feature Class*, click the *Browse* icon and navigate to the desired output location. Name the file as desired. For *Save as type* select shapefile.

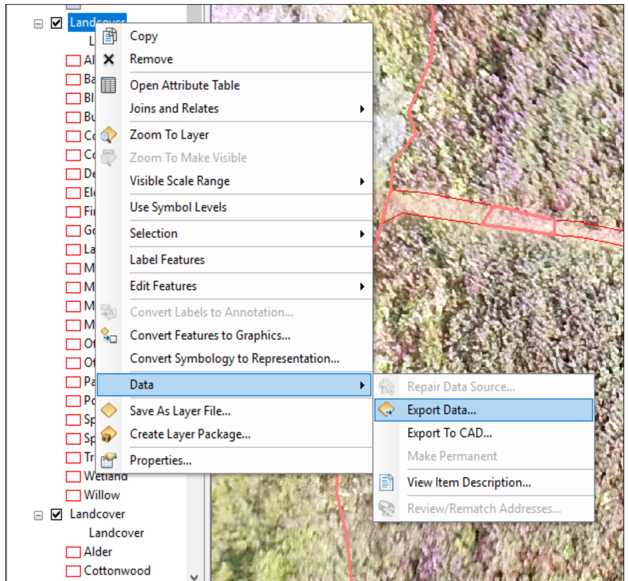


Figure 4.20. Right-click on the appropriate layer to export polygons to a new shapefile.

6. Vegetation Composition Analysis

Classified images are now ready for vegetation composition analysis. The vegetation composition of all images and each individual image is determined by quantifying the amount of each type of vegetation within the classification scheme. Vegetation quantification requires the following steps:

a. Add all the classified images to ArcMap.

b. Turn on the symbology for each land cover category based on the process outlined in the [Digitizing Protocol] above. This will show the classification scheme and display it on the images. The classification should now be displayed under the photo layer in the *Table of Contents* as well (Figure 4.21).

   i. Add the drone point shapefile. This shapefile contains all the aerial imagery GPS points needed to create a buffer.

   ii. If an aerial imagery point location is added and needs to be classified, this new point will have to be added to the drone point shapefile.

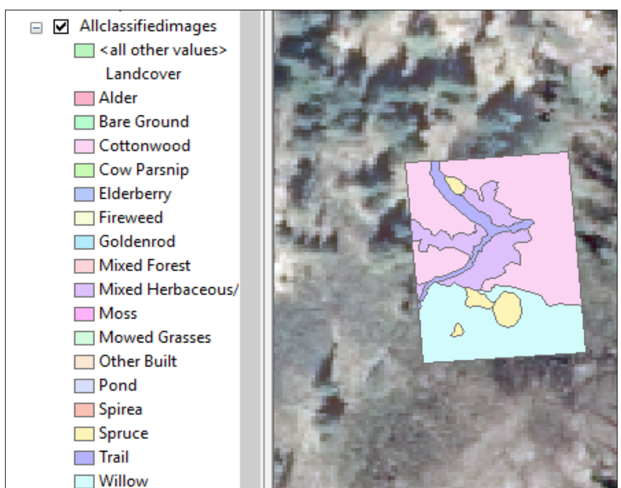


Figure 4.21. Example of the classification display under the layer and a classified image.

c. Create a buffer.

i. Click the *Geoprocessing* option on the toolbar at the top of the map and scroll to *Buffer* (Figure 4.22). Choose a single classified image in the *Table of Contents*.

ii. On the image above, the input feature is the layer to which the buffer will be applied (the drone shapefile).

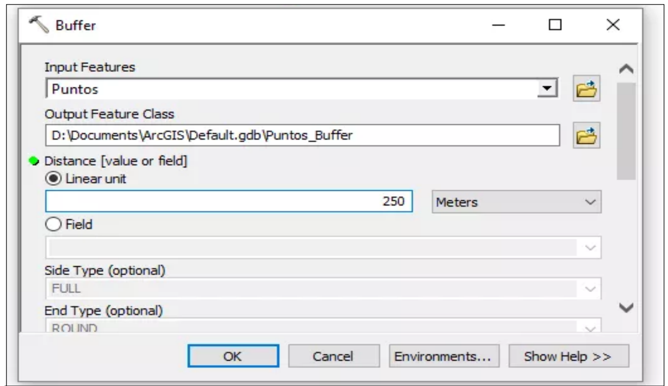


Figure 4.22. The *Buffer* tool display.

iii. For each classified photo choose the output name, location, and feature in the *Output Feature Class* box. Name the file the photo point name and buffer (9_buffer).

iv. Apply a 16 meter buffer to the file in the *linear unit* space. Be sure the units are set to meters. Press *OK*. A 16 meter buffer should now be visible around the drone point, similar to Figure 4.23.

Figure 4.23. Example of classified images with 16 meter buffers surrounding the drone photo point.

d. Clip the images.

i. In ArcToolbox click *Analysis Tool | 3D Analysis | Extract | Clip*. The *Clip* tool will be added to the map. The *Clip* tool will clip the 16 meter buffer from classified images.

ii. The *Input Features* is the image to be maintained in the output layer (the classified image layer). The *Clip Feature* is the feature that determines the clip shape and size (the buffer layer). The *Output Feature Class* is the file where the clip will be stored and

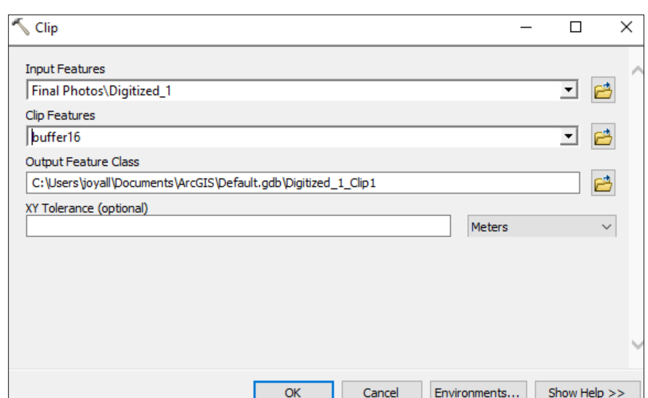


Figure 4.24. The *Clip* tool display.

the name (Figure 4.24). Clip individual photos first, inputting each photo (Classifed_1) and renaming it the clip name and clip (1_Clip).

e. Individual clips now have attribute tables detailing the specific shape areas and lengths for each vegetation type present within the clip (Figure 4.25). Right-click on the clip layer being analyzed, scroll to *Open Attribute Table* and all the data will be presented. This data is to be downloaded as a CSV (comma delimited) file and opened in Excel or copied and pasted into a master Excel sheet for analysis.

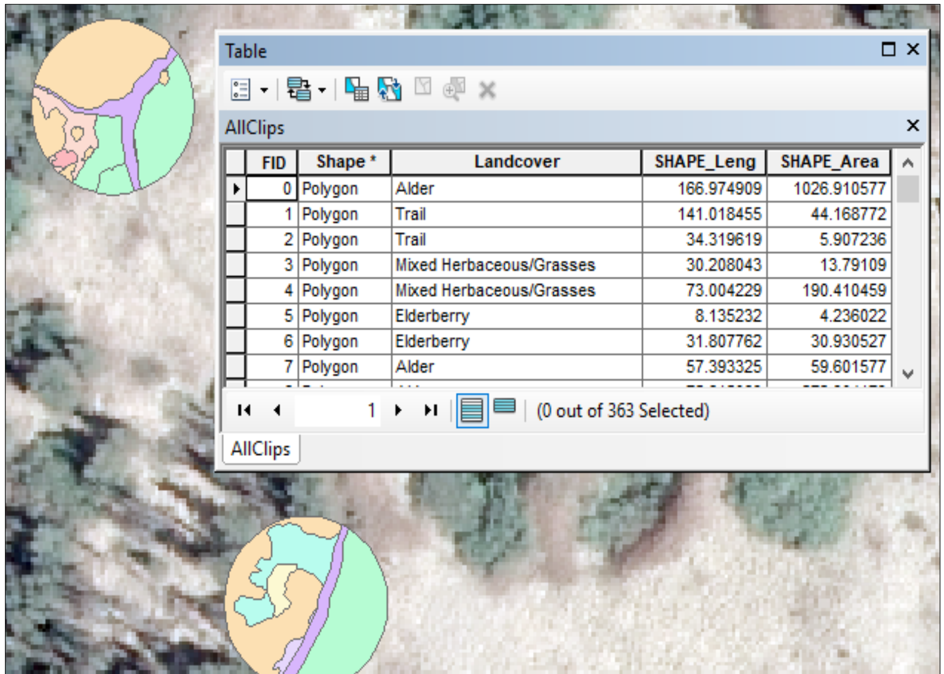


Figure 4.25. Example of clipped buffers with classification schemes and an attribute table.

i. Open the scroll down bar in the attribute table and select *Export Data*. Choose the output location and select an CSV file as the file type before saving.

f. Combine the data from all individual attribute tables in Excel.

i. Combine any replicate areas of the same classification (e.g. if one clip layer has two alder areas from two separate polygons, sum them).

ii. Create a master table with the overall area of each classification type. This can be visually represented in a table such as the one provided below (Figure 4.26).

E. Results from 2018 Data Collection

A complete version of drone and vegetation data can be found in Appendix III. An example of a bar graph that can be created from the vegetation data is shown below in Figure 4.25. Tables 11.2 and 11.3 are representative examples of how vegetation composition data is to be organized for each photo point. These tables also represent the contrast that can occur between two photo points. For example, Table 11.2 is primarily composed of fireweed while Table 11.3 is primarily composed of willow.

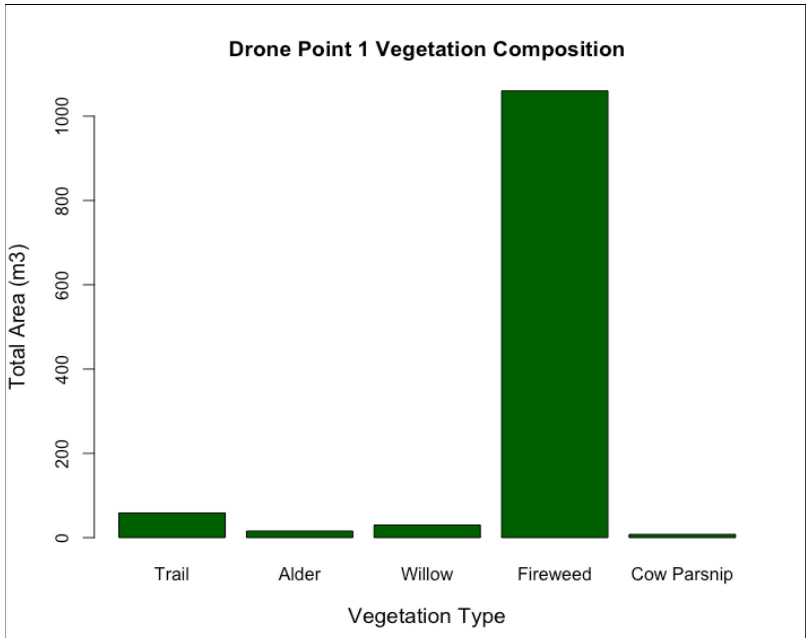


Figure 4.26. 2018 example of vegetation classification graph.

Table 11.2. Example of area of each vegetation type found at Point 1.

Classification Type Point 1	Vegetation Area (m^3)
Trail	58.31973274
Alder	15.66938617
Willow	29.86654719
Fireweed	1060.111748
Cow Parsnip	7.733256397
Total Area	1171.70067

Table 11.3. Contrasting example to Point 1 of vegetation types found at Point 4.

Classification Type Point 1	Vegetation Area (m^3)
Trail	137.3615842
Spruce	897.9660323
Fireweed	924.404037
Elderberry	11.94539794
Mixed Herbaceous/Grasses	70.55047807
Total Area	2042.22753

F. Recommendations

1. Utilize Pix4D During Drone Flights

In order to georeference and classify aerial imagery more efficiently CACS should use more strategic flight paths. Pix4D is a professional photogrammetry and drone-mapping software available for drone flight mapping and photo analysis. While the computer software is only available upon purchase, the app for iPhones or Androids is free. Pix4D would significantly reduce the workload of drone imagery analysis through the automated process of georeferencing images. Pix4D tags images with relevant coordinates as the images are taken, thus eliminating the need to georeference images manually. Pix4D is also an advanced software that allows the user to pre-program flight paths with grid pattern which later permit mosaicing analysis techniques described below.

Note: See the Pix4D manual below for further information on how to operate a drone in Pix4D.
https://support.pix4d.com/hc/en-us/articles/204010419--iOS-Pix4Dcapture-Manual

2. Employ Mosaicing Techniques

In addition to the benefits described in the classification recommendations, utilizing Pix4D to fly the drone would allow for mosaicing to analyze images. Mosaicing, or photo stitching, is the method of stitching images with overlapping fields of view together to produce higher-resolution, seamless panoramic images. Mosaicing images together results in more precise imagery due to the overlap. Mosaicing requires a process called orthorectification in which the distortion produced by topographical variations of the earth's surface are corrected within each image. Resulting images are 3D and lack terrain displacement present in non-orthorectified images. Orthorectified images are then stitched together to produce orthomosaics (images free from optical distortions). Orthomosaic images provide a precise look at the landscape, but more importantly can be input into analysis software (such as Pix4D) with algorithms provided to automatically classify and quantify vegetation types. This type of analysis is well-beyond a beginner skill set and could provide an excellent internship opportunity for an enthusiastic GIS student.

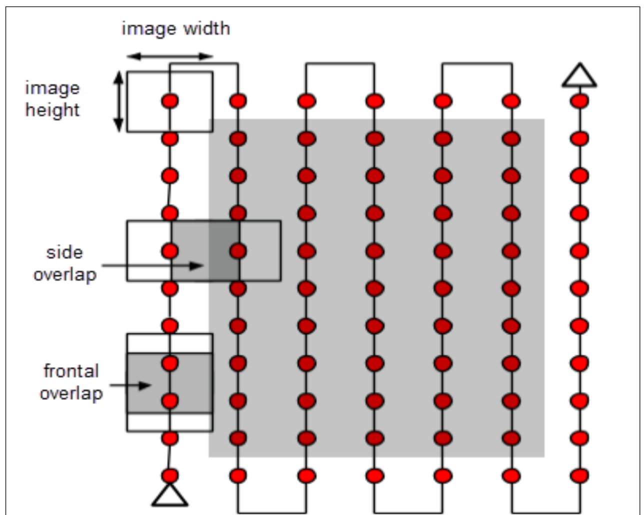


Figure 11.4 Grid Flight Pattern Outline (Pix4D Support).

A Phantom 3 Pro or Mavic 2 Pro can be programmed to fly a grid pattern with ease, allowing for mosaicing to be used later in analysis. A grid pattern, displayed in Figure 11.4, is a flight path in which the drone autonomously flies along rows over the area of interest. The proximity of each row is set to allow for each row to capture imagery in the two adjacent rows. Typically, the overlap is 60% or higher. For densely vegetated areas with complex geometric shapes such as the IRP, overlay is more effective with 85% or higher. If a more sophisticated drone is purchased, a grid pattern can be used to capture imagery of the entire preserve rather than small photo points. See Appendix III-D-1 for more detail.

3. More Sophisticated Drone

To alleviate the limitations outlined above, a more sophisticated and technically advanced drone could be purchased. Based on conversations with researchers using drones at the University of Michigan, a Parrot Bluegrass Fields quadcopter drone is recommended (https://www.parrot.com/business-solutions-us/parrot-professional/parrot-bluegrass#parrot-bluegrass-fields). See Appendix III-D-2 for more detail.

4. Multispectral Sensor Attachments

As an alternative to purchasing a new quadcopter drone system, CACS could purchase a multispectral camera (including blue, green, red, and near-infrared) to attach to their existing DJI Phantom and Mavic drones. See Appendix III-D-3 for more detail.

5. Supervised Classification

If CACS acquires the ability to capture images with at least four spectral bands, it is recommended that they do not follow the digitizing protocol outlined above. As already discussed, the time and objectivity limitations of that method are prohibitive. A supervised classification should be performed instead, which would alleviate those concerns and streamline the process. This would improve the feasibility of conducting long-term vegetation monitoring on IRP. See Appendix III-D-4 for more detail.

V. Wildlife Assessment through Camera Trapping

A. Introduction

Terrestrial wildlife populations in the Homer region will face countless challenges as changes to the landscape become more widespread. Anthropogenic land use change and shifting vegetation due to climate change or natural disturbances, such as pest outbreaks, have the potential to reduce landscape connectivity and habitat availability for many wildlife species. Along with direct disturbances caused by humans, these changes may alter the behavior, movement, and abundance of wildlife. Monitoring wildlife abundances and distribution, as well as changing environmental conditions through time, allows managers to understand how to best manage a preservation area for the purpose of maintaining wildlife diversity on the landscape. Camera trapping is one method increasingly used to monitor wildlife populations. Camera trapping is a non-intrusive, low-labor means of gathering information about the presence and behavior of wildlife at a particular locale (Kays et al. 2011). Continued utilization of camera trapping in a preservation area assists managers with assessing wildlife populations through time, thus informing management decisions. Camera trapping is more commonly employed to monitor large mammal species but can nonetheless be useful for many other species. Moose (*Alces alces*), black bear (*Ursus americanus*), coyote (*Canis latrans*), and Canadian lynx (*Lynx canadensis*) are examples of large mammal species present on IRP that could be monitored through camera trapping.

B. Rationale

We have developed a protocol for the assessment of wildlife on IRP, through the collection of camera trap data and other observations of animal evidence (such as scat, fur, and tracks). This protocol will allow CACS to gain and maintain an understanding of wildlife presence, distribution, and habitat use throughout the Preserve, and to assess changes over time. The ability to assess changes in wildlife activity in the future will be particularly important as IRP transitions to new management and as human activity on the Preserve subsequently increases due to newly available public access. This assessment will also be important in analyzing changes in wildlife in response to land use changes or any shifts in vegetation. We present the results from the 2018 data collection that was carried out using this protocol.

C. Data Collection Protocol

1. Documenting Wildlife Evidence

a. Document the locations of animal evidence observations while on-site by collecting GPS coordinates of the location and the date and time of the observations.
   i. Wildlife evidence that may be of interest include: scat, tracks, trails, beds/dens, fur, tree scratchings/markings, or other animal-made structures.

2. Setting up Motion-Triggered Camera Traps

a. Establish desired camera trap locations.
   i. Locations monitored during the 2018 sampling period should be repeated to increase sample size at those locations and to assess for change over time. (Table 5.1; Figure 5.1). Camera traps should be left in place for the full-year, if possible. If winter weather prevents this duration, then sample as much as possible across different times of year to allow for seasonal comparison of wildlife activity.
   ii. Additional locations may also be chosen based on observations of areas experiencing high wildlife use or areas not previously sampled. New locations for camera trap placement are suggested in the *Recommendations* section following this protocol (see Figure 5.14).
   iii. Camera trapping and the outlined analyses should be repeated every year (except vegetation analysis described in *Additional Analyses*, which can be done every 5 years).

Table 5.1. Coordinates and names of camera traps from period of observation (May-November 2018).

Trap Number	Camera Trap Location/Name	Latitude	Longitude
Camera Trap 1	Ridge Trail	59.69895354	-151.41332611
Camera Trap 2	Goose Pond	59.70089806	-151.40702066
Camera Trap 3	Gozzie Trail	59.70054635	-151.40501915
Camera Trap 4	Knoll Loop	59.70637538	-151.41192617
Camera Trap 5	Greenhouse Trail	59.70237143	-151.41000948
Camera Trap 6	Moose Pond	59.70058981	-151.42236524
Camera Trap 7	Cottonwood Loop	59.70351874	-151.44028801
Camera Trap 8	Hummingbird Cam/ 103 Trail	59.70324755	-151.42664387
Camera Trap 9	Moose Valley	59.70106247	-151.42723857

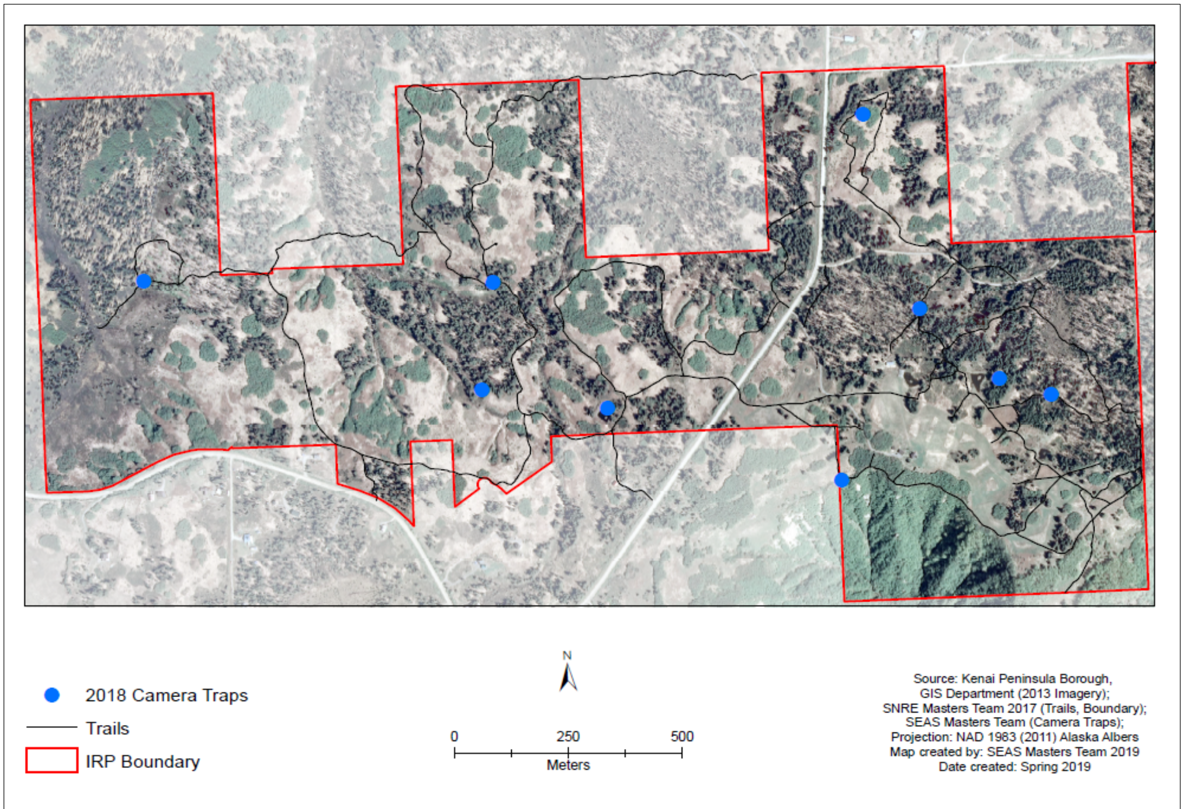


Figure 5.1. Camera trap locations for period of observation. (May-November 2018). Full-sized map available in Appendix VII.

b. Strap camera traps onto trees or wooden stakes and position in such a way so as to maximize the potential of wildlife detection, such as facing the intersection of multiple trails. If possible, cameras should be placed at a height of 3 to 5 feet, ensuring visibility of the trail and/or ground.

c. Select desired settings, including the number of images per trigger event and the lapse time in between trigger events. A trigger event occurs when the camera detects motion, resulting in the capturing of an image or images, depending on the camera settings (see steps i-ii below).

    i. We recommend that the camera traps be set for a single-photo capture of each trigger event, which is an appropriate setting when the goal of camera trapping is occurrence analysis and/or quantification.

        1. If the goal of trapping is behavioral analysis, then the multiple-images per trigger event setting may prove useful (this will result in several photos per second).

    ii. We also suggest that the trigger interval be set to 20 seconds or longer, so that trigger events will not occur less than 20 seconds apart.

d. Set to the correct date and time on the camera trap for accurate analysis.

e. Camera traps should be checked every four or five weeks to change batteries, download photos, and clear the SD card as needed.
    i. The date and time may need to be re-set in the event of malfunction or batteries becoming completely discharged.
    ii. If the camera trap is in an area with vegetation that tends to trigger the camera often, then the SD card will need to be checked more frequently.

D. Data Processing Protocol

Steps 1-2 below describe the processing of the raw occurrence data. The camera trap data can be analyzed both for the period of observation overall, and on a seasonal basis (if the period of observation spans multiple seasons). An overall analysis provides information about the total wildlife use around IRP, while a seasonal analysis allows for an assessment of temporal differences of wildlife presence throughout the Preserve.

1. Reviewing Camera Trap Images

a. Calculate the number of trap days (a trap day is a 24-hour period in which a single camera trap is in operation) for:
    i. Each camera.
    ii. The period of observation overall. This provides a measurement of the total sampling "effort."
        1. The total number of trap days for the period of observation is calculated by summing the number of trap days of all cameras.

b. Determine the number of images collected (the number of trigger events).
    i. Images that are from the same trigger event should only be counted once. If the camera is set for multiple images for each trigger event, count the event as a single image capture.

c. Review contents of images.
    i. For each image record the date, time, species, photo number, whether the image was taken during day or at night (based on the timestamp of the photo), and the occurrence number. See Table 5.2 for an example of camera trap raw data entry.

Table 5.2. Example of raw data entry from camera trap image review.						
Cam 3 - Gozzie Trail						
Date	Time	Species	Day/ Night	Occurrence #	Photo #	Comments
5/21	15:54:41	Black Bear	Day	1	5210019	
5/22	7:15:50	Spruce grouse	Day	2	5220024	
5/23	5:55:45	Moose	Day	3	5230033	
5/24	6:40:39	Moose	Day	4	5240034	
5/24	23:12:00	Snowshoe Hare	Night	5	5240035	
5/26	7:38:56	Moose	Day	6	5680038	
5/28	22:34:11	Spruce grouse	Day	7	5280043	
5/30	20:19:45	Spruce grouse	Day	8	5300052	
5/30	22:46:28	Moose	Day	9	5300053	
5/30	22:46:43	Moose	Day	9	5300054	
5/31	5:27:37	Spruce grouse	Day	10	5310056	In flight
5/31	10:31:57	Black Bear	Day	11	5310058	
5/31	10:37:12	Black Bear	Day	11	5310059	
5/31	12:24:19	Black Bear	Day	12	5310060	
5/31	13:41:24	Black Bear	Day	13	5310062	
5/31	18:15:07	Moose	Day	14	5310063	
5/31	18:15:18	Moose	Day	14	5310064	

ii. Determine the number of occurrences for each species, *at each camera trap*.

1. An occurrence is defined as the detection (image) of a single individual.
2. Consecutive images of the same species should be counted as the same occurrence if the photos were taken less than 20 minutes apart.
3. However, if two photos of the same species are taken less than 20 minutes apart but the photos clearly depict different individuals (e.g. A moose bull with antlers versus a female moose), then the sightings should be counted as separate occurrences.
4. In photos containing multiple individuals, each individual should be counted as a separate occurrence.
5. These occurrences should be visually represented in a graph, such as the one provided in the *Results* section (Figure 5.12).

Note: Although intervals besides 20 minutes may be used when determining the number of occurrences, this is the interval utilized for the 2018 field season and was also used for the baseline inventory conducted in 2016. In order to allow for accurate comparison of occurrences across observation periods, we recommend that a 20-minute interval continue to be used in further camera trapping on IRP.

2. Standardizing data

Standardize the number of occurrences to allow for the comparison of occurrences across camera locations during the period of observation. If the number of trap days differs for each camera trap, then the number of occurrences should be standardized by scaling the number of occurrences for each camera trap to the number of occurrences per trap day.

a. Divide the number of occurrences per species for each camera trap by the respective number of traps days that the camera was operating to calculate *occurrences per trap day*.
b. *Occurrences per trap day* could be calculated for each season.
    i. Define seasons, e.g. Spring: May-June, Summer: July-August, etc.

Note: For example, for the current assessment, the period of observation was divided into three seasons: late spring (5/18/2018-6/30/2018), summer (7/1/2018-8/31/2018), and fall (9/1/2018-11/5/2018).

    ii. Once occurrences are grouped by season and summed for each species, occurrences of each species should be standardized for each camera trap by dividing occurrences by the number of trap days for a given camera, as described above.
    iii. Day/night data standardization of occurrences could be done for day and night records separately.
c. Calculate the percent of occurrences that took place during nighttime versus daytime hours for:
    i. Each camera trap overall (allows for comparison of diel activity across locations).
    ii. Each species observed (first sum the occurrences of each species from all camera traps; (allows for comparison of activity across species).
        1. Create visual representation of these data to facilitate comparison, such as the one provided in Appendix IV (Figure 12.1).

3. Bringing the Data into ArcGIS

a. In order to create a shapefile of any new camera trap locations, first create an Excel file containing the camera trap names and coordinates. The cells cannot contain spaces (instead, underscores may be used). See Table 5.3 below for example of spreadsheet format.
b. Save the file as a CSV (comma delineated).

c. Open ArcMap and add the CSV file.

d. In the *Table of Contents*, right-click on the CSV file | *Display XY Data...* | Verify that *Longitude* is selected for X Field and *Latitude* is selected for Y Field. Leave all defaults. A file will be added to the *Table of Contents.*

Table 5.3. Example of spreadsheet format required for bringing data into ArcGIS.

Location	Latitude	Longitude
Cam1	59.69895354	-151.41332611
Cam2	59.70089806	-151.40702066
Cam3	59.70054635	-151.40501915
Cam4	59.70637538	-151.41192617
Cam5	59.70237143	-151.41000948
Cam6	59.70058981	-151.42236524
Cam7	59.70351874	-151.44028801
Cam8	59.70324755	-151.42664387
Cam9	59.70106247	-151.42723857

e. Export the file as a shapefile. Use next to the *Output Dataset or Feature Class* to navigate to the desired output location and indicate desired output name (e.g. *CameraTrapLocations*) (See Exporting Data Protocol within the Monitoring Long-Term Vegetation Changes Protocol for more details).

f. Define the projection/datum of the new layer: Open *ArcToolbox* | *Data Management Tools* | *Projection and Transformations* | *Define Projection*. For *Input Feature Dataset*, click the drop-down menu or use to select the shapefile created in step e. Click the icon next to the *Coordinate System* window. Expand *Geographic Coordinate Systems* | *North America* | *US and Territories* | Select *NAD 1983* (Figure 5.2).

g. Transform the shapefiles's projection to NAD 1983 (2011) Alaska Albert (Meters). This will create a new shapefile with the new projection. Open *ArcToolbox* | *Data Management Tools* | *Projection and Transformations* | *Project.* For *Input Dataset or Feature Class*, select the same layer saved in Step e (*CameraTrapLocations*). Use next to the *Output Dataset or Feature Class* to navigate to the desired output location and indicate desired output name (e.g. *CameraTrapLocations_reproject*). Next, click on icon next to the *Output Coordinate System*. Expand *Projected Coordinate Systems* | *State Systems* | *NAD 1983 (2011) Alaska Albers (Meters)* (Figure 5.3).

h. Next, repeat steps a-g to create a shapefile of the wildlife occurrence data, which can later be use for mapping purposes. The CSV file should be structured as seen below (Table 5.4).

   i. There can be no spaces in any cell.

   ii. An example of the mapping that can be completed with the camera trap data is provided in the Results section below (Figure 5.11). Additional maps can be found in Appendix VII.

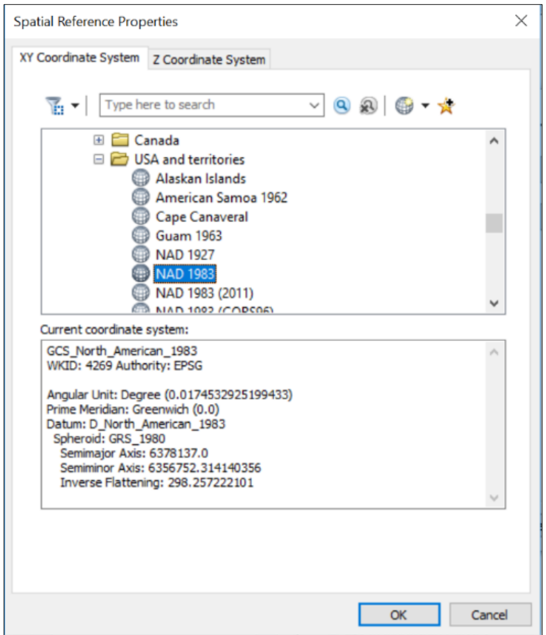


Figure 5.2. Projection name to select in defining projection of *CameraTrapLocations* shapefile.

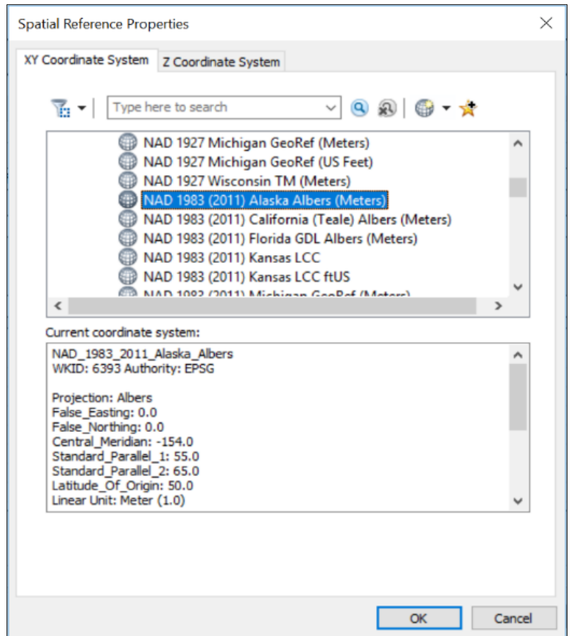


Figure 5.3. Projection name to select when reprojecting *CameraTrapLocations* shapefile.

Table 5.4. Example of appropriate CSV structure of camera trap data for ArcMap.

Location	Latitude	Longitude	Moose	Moose_per_trap_day	Black_bear	Black_bear_per_trap_day
Cam1	59.69895354	-151.41332611	26	0.201550388	12	0.093023256
Cam2	59.70089806	-151.40702066	82	0.488095238	3	0.017857143
Cam3	59.70054635	-151.40501915	56	0.329411765	14	0.082352941
Cam4	59.70637538	-151.41192617	17	0.126865672	0	0
Cam5	59.70237143	-151.41000948	95	0.673758865	1	0.007092199
Cam6	59.70058981	-151.42236524	31	0.348314607	0	0
Cam7	59.70351874	-151.44028801	24	0.258064516	0	0
Cam8	59.70324755	-151.42664387	17	0.182795699	0	0
Cam9	59.70106247	-151.42723857	19	0.204301075	0	0

Additional Analyses

The camera trap data should be further analyzed to gain a deeper understanding of the differences in wildlife activity across IRP. First, the wildlife occurrence data can be compared with the proportions of vegetation types (trees, shrubs, herbaceous vegetation) that are located within an established radius from each camera trap location. The goal of this analysis is to determine if a relationship exists between vegetation type and wildlife use on IRP. In addition, wildlife activity on IRP may also be highly influenced by anthropogenic activity and proximity. Therefore, relationships between wildlife occurrences and the distance between each camera trap and the nearest major road (Skyline Drive, Ohlson Mountain Road, and Eagleaerie Avenue) and/or the nearest house can be analyzed. The following steps describe how these analyses can be completed.

When the camera traps are placed in the same locations as those sampled in the 2018 field season, then performing steps 4-11 will not be necessary until the next vegetation assessment is completed. The vegetation proportions and the distances to the nearest major road or building have already been established for these locations, and are provided in this report (Appendix IV). These values may be used with any further occurrence data collected for these same locations. However, we recommend repeating the drone imagery capture, vegetation classification, and quantification process described below every five years or after a major disturbance to account for changes in vegetation over time.

Note: The steps described below differ slightly from the methods utilized in the wildlife analysis for the 2018 field season. See Appendix IV for additional details on the 2018 wildlife analysis.

Complete the following steps if the camera traps have been placed at new locations:

4. Drone Imagery Capture for New Camera Trap Locations

Aerial images taken directly above each camera trap location can be used to quantify the vegetation surrounding each camera trap. Note that if camera trap locations coincide with locations photographed in the *Monitoring Long-Term Vegetation Changes Protocol* above, then those images can be used for this analysis and the locations do not need to be photographed again. Alternatively, vegetation quantification for the purpose of wildlife analysis may be conducted on the ground without the use of a drone. However, the use of drone imagery for this assessment is an excellent way to make the most of the data already being collected and to link the vegetation analysis described above with data collected on wildlife activity. Furthermore, conducting vegetation composition analysis using drones may be more efficient and more comprehensive than on-the-ground assessment.

a. Drone operating protocols as described in the *Monitoring Long-Term Vegetation Changes Protocol* should be followed to capture images over any new camera trap locations.

Note: The following analysis steps are similar to those described in the Monitoring Long-Term Vegetation Changes Protocol, however some variations do exist. We therefore recommend utilizing the *steps below when processing and analyzing the drone images specifically for the camera trap locations. Subsections within the [Monitoring Long-Term Vegetation Changes Protocol]() will be referenced whenever the steps are equivalent.*

5. Georeferencing

In ArcMap, all images should be georeferenced by following the steps outlined in the *Georeferencing Protocol* above.

6. Selecting Radius for Vegetation Quantification

a. Add each drone image taken at 393 feet (119 meters) to ArcMap.

b. Add the file containing the locations (points) of the camera traps (*CameraTrapLocations*).

   i. Make sure this shapefile is visible above the drone images. If not, in the *Table of Contents*, drag the camera trap shapefile above the drone images.

c. For each camera location, use the *Measure* function to determine the distance from each camera trap location from the nearest edge of the corresponding drone image.

   i. Click *Measure* | *Measure Line.*

   ii. Click on the location of a camera trap, drag mouse to the closest edge of the corresponding drone image, and note the distance (see Figure 5.4).

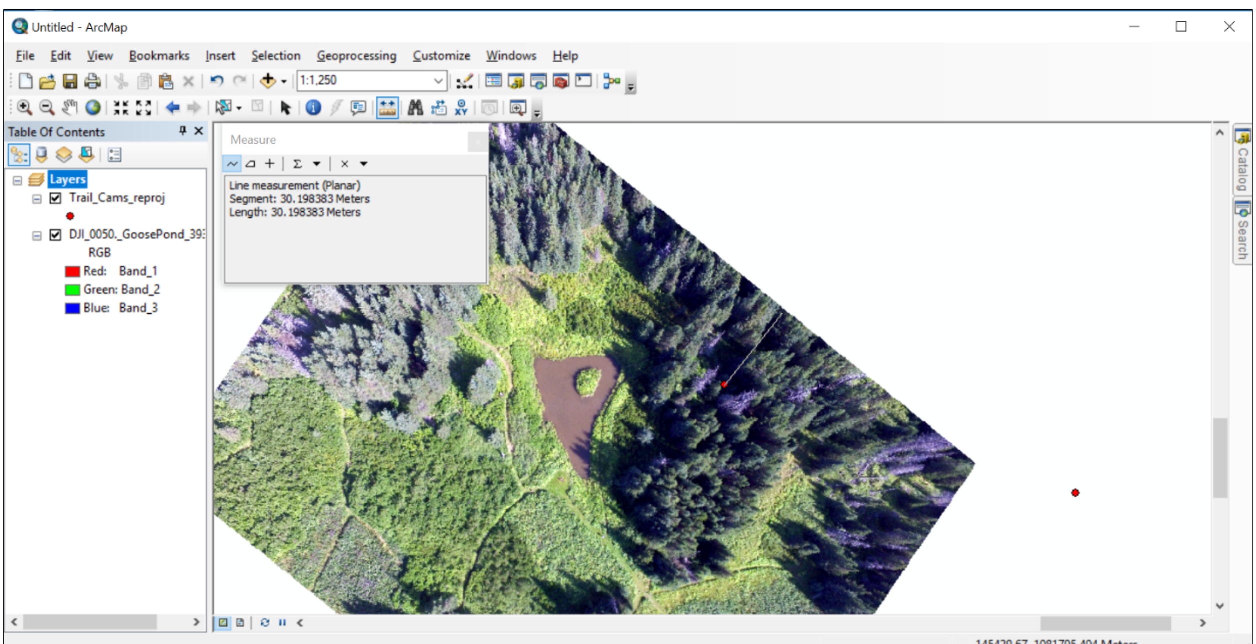


Figure 5.4. Measuring distance from camera trap location to edge of an image.

iii. Repeat for all other camera trap locations.

iv. The drone image that provides the smallest radius will determine the maximum radius that can be utilized for the vegetation quantification steps below. A smaller radius may be selected, if desired.

7. Creating a Geodatabase

a. Digitization of camera trap drone images can be completed in the same geodatabase as all other drone images. Refer to the *Building Attribute Domains and Topology Protocol* for instructions on how to create the geodatabase.

8. Digitizing Drone Images

a. Digitize drone images according to the *Digitizing Protocol*.

b. After completing digitization for all camera traps, export the vegetation polygons to individual shapefiles for each camera trap. Follow the steps described in the *Exporting Data Protocol* to complete this process.

   i. Save each shapefile *CameraTrapName_Vegetation* (using the correct name of the corresponding camera for each file, e.g. GoosePond_Vegetation).

9. Buffer and Clipping Classified Images

These steps will create new shapefiles that contain only the vegetation located within a desired radius of the actual trap locations. This will be completed individually for each camera trap. Additional details and figures of this process can be reviewed in the *Vegetation Composition Analysis Protocol*.

a. First, using the *CameraTrapLocations* shapefile, create a polygon (i.e. a circle with the desired radius) around each camera trap. This will be saved as a new shapefile.

   i. Using the *Select Feature* function, click on one of the camera trap points from the *CameraTrapLocations* shapefile to select it. It will be highlighted in blue (Figure 5.5).

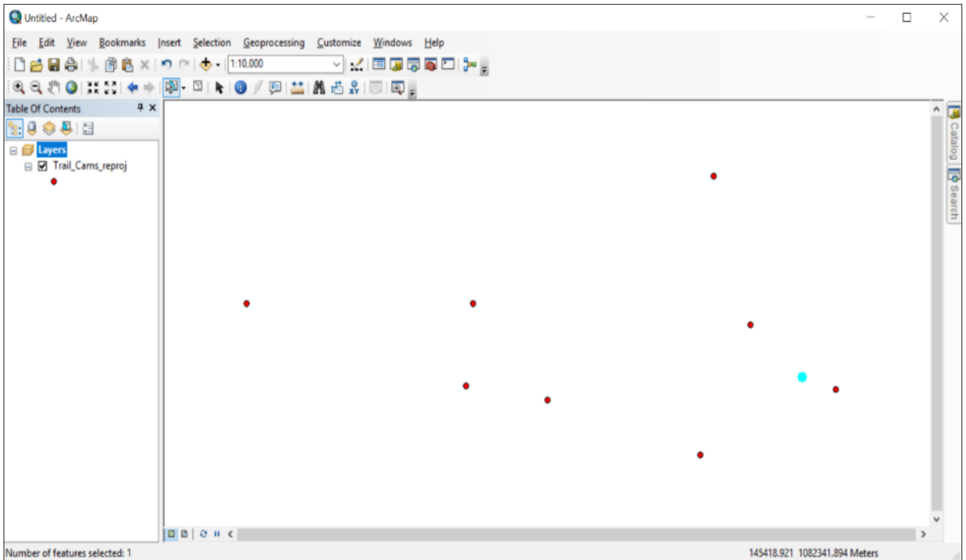


Figure 5.5. *Select Feature* function in ArcMap.

ii. In the *Geoprocessing* tab, click *Buffer*. Set *Input Feature* as the *CameraTrapLocation* shapefile. For *Output Feature Class,* click on the folder button and navigate to desired output location. Name the buffer layer *CameraTrapName_Buffer* (using the corresponding name of the selected camera, e.g. GoosePond_Buffer). Under *Distance – Linear Unit,* type the desired radius established above, make sure units are set to the appropriate units. Leave all other defaults. (Figure 5.6).

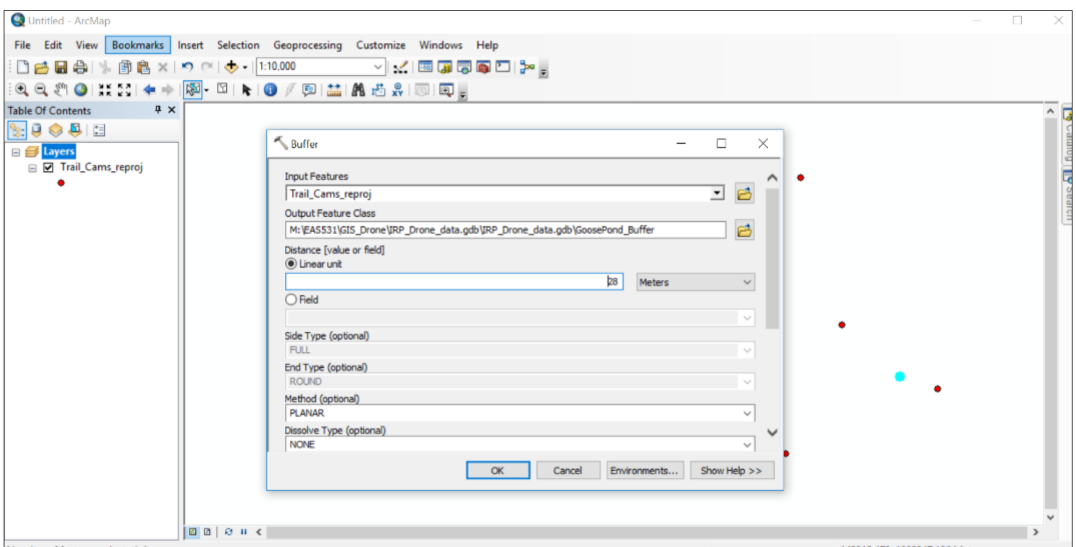


Figure 5.6. *Buffer* function in ArcMap.

iii. Repeat steps i-iii for all other camera traps, making sure to click *Clear Selected Features* after each buffer is created and select the next location for which the buffer

b. Next, the "Buffers" shapefiles will be used to clip out the digitized vegetation that falls within the designated radius. This will again be completed for each camera individually, resulting in new shapefiles that contain the vegetation located only within the designated radius from each camera trap. All vegetation outside of the circles is disregarded.

i. The classified drone images and the buffer shapefiles will need to be added if they are not currently in your ArcMap session.

ii. In the *Geoprocessing* tab, click *Clip*. Set *Input Feature* as the one of the digitized vegetation layers (e.g. *GoosePond_Vegetation*). Set *Clip Features* as the corresponding buffer shapefile for that camera (e.g. *GoosePond_Buffer*). For *Output Feature Class,* click on the folder button and navigate to desired output location. Name the clipped shapefile *Clip_Vegetation_CameraTrapName* (using the corresponding camera name, e.g. *Clip_Vegetation_GoosePond*) (Figure 5.7).

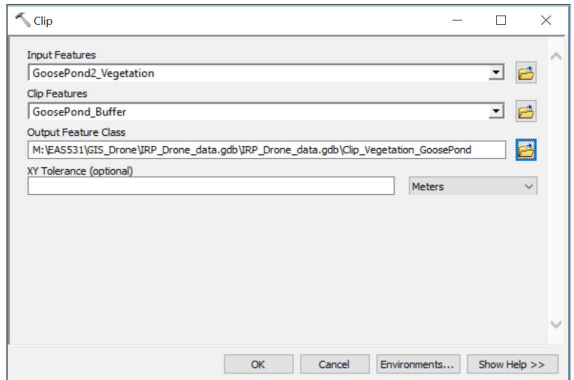
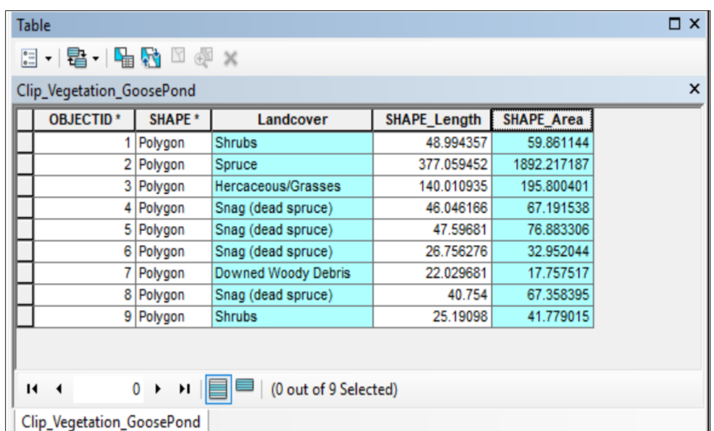


Figure 5.7. Clip function in ArcMap.

iii. Repeat steps i-ii for all other camera traps.

10. Vegetation Quantification

a. Using the attribute table of a clipped classified image (right-click the layer in the *Table of Contents* | *Open Attribute Table*), manually copy and paste the "Landcover" and "SHAPE_Area" columns into an Excel spreadsheet (Figure 5.8).



Table

Clip_Vegetation_GoosePond

OBJECTID *	SHAPE *	Landcover	SHAPE_Length	SHAPE_Area
1	Polygon	Shrubs	48.994357	59.861144
2	Polygon	Spruce	377.059452	1892.217187
3	Polygon	Hercaceous/Grasses	140.010935	195.800401
4	Polygon	Snag (dead spruce)	46.046166	67.191538
5	Polygon	Snag (dead spruce)	47.59681	76.883306
6	Polygon	Snag (dead spruce)	26.756276	32.952044
7	Polygon	Downed Woody Debris	22.029681	17.757517
8	Polygon	Snag (dead spruce)	40.754	67.358395
9	Polygon	Shrubs	25.19098	41.779015

0 (0 out of 9 Selected)

Clip_Vegetation_GoosePond

Figure 5.8. View of attribute table of a clipped classified image. Highlighted columns indicate data that should be copied into a spreadsheet.

b. In Excel, add a third column named "Type". Manually fill in this column by classifying the vegetation type of each row as either Tree, Shrub, Herbaceous, or Other vegetation. These categories were selected based on their implications for providing wildlife cover and ease of wildlife movement.

i. The Tree category should include any area classified as spruce, cottonwood, mixed forest, and other hardwood. The Shrub category includes willow, alder, spirea, and elderberry. The Herbaceous category includes cow parsnip, fireweed, goldenrod, blue joint grass, mixed grasses, and mixed herbaceous. Classify all other areas as Other or NA (Table 5.5).

Table 5.5. Example spreadsheet format for quantifying vegetation.

Landcover	SHAPE_Area	Veg type
Fireweed	24.108891	Herbaceous
Cow Parsnip	14.079155	Herbaceous
Cow Parsnip	5.683525	Herbaceous
Mixed Herbaceous	160.805753	Herbaceous
Snag (dead spruce)	2.194321	NA
Snag (dead spruce)	1.936687	NA
Bare Earth/Sparsely Vegetated	240.52817	NA
Snag (dead spruce)	27.734585	NA
Downed Woody Debris	0.276258	NA
Snag (dead spruce)	8.5521	NA
Snag (dead spruce)	6.654675	NA
Snag (dead spruce)	12.424818	NA
Downed Woody Debris	3.869783	NA
Snag (dead spruce)	15.129272	NA
Downed Woody Debris	15.549377	NA
Willow	245.260498	Shrub
Willow	37.233108	Shrub
Willow	29.012514	Shrub
Spruce	1027.959329	Tree
Spruce	772.928264	Tree
Total area	2651.921083	

c. Calculate the proportion of the clipped classified image that is comprised of each vegetation type (Tree, Shrub, or Herbaceous), using the total area of that layer (the Sum of the SHAPE_Area column) as the denominator.

i. In the example above, the proportions would be calculated as follows:

Tree: (1027.959329 + 772.928264) / 2651.921083 = 0.771766361

Shrubs: (245.260498 + 37.233108 + 29.012514) / 2651.921083 = 0.041455313

Herbaceous: (24.108891 + 14.079155 + 5.683525 + 160.805753) / 2651.921083 = 0.079859841

Note: Since some of the vegetation classes used for digitizing do not fall into either of these three categories (e.g. snags, downed woody debris, and trails), the sum of the proportions of Trees, Shrubs, and Herbaceous vegetation within the buffer of a given camera trap will not necessarily equal 1.

d. Repeat steps a-c for the clipped classified images of all other camera traps. An example of the final data resulting from these steps is provided in Table 5.6.

Note: These proportions can now be compared to the overall wildlife occurrence data for each camera trap to determine if correlations exist between the occurrence of a given species and the surrounding vegetation. For example, standardized occurrences for each species may be graphed against the proportion of trees, shrubs, and herbaceous vegetation to reveal potential relationships.

Table 5.6. Example of vegetation quantification data.

Trap number	Distance to nearest building (m)	Distance to nearest road (m)
Camera Trap 1	143	305
Camera Trap 2	208	480
Camera Trap 3	326	578
Camera Trap 4	164	77
Camera Trap 5	136	239
Camera Trap 6	165	202
Camera Trap 7	482	409
Camera Trap 8	448	561
Camera Trap 9	213	339

11. Distance Between Camera Traps and Nearest Road and Building

a. Determine the distance between each camera trap and the nearest major road (i.e. Skyline Drive, Ohlson Mountain Road, or Eagleaerie Avenue) and the nearest building:

i. Add the Camera Trap Location shapefile and a recent aerial image of the property (such as imagery2013sharp) to ArcMap.

ii. Using the *Measure* function, as described above, measure the shortest straight-line distance of a camera trap location to the nearest major road. Repeat for the distance between the camera and the nearest building. Record the distances in a spreadsheet.

iii. Repeat steps i-ii for all other camera traps.

Note: These distances can now be compared to the overall wildlife occurrence data for each camera trap to determine if correlations exist between the number of occurrences and human proximity for any of the observed species. For example, standardized occurrences for each species may regressed against the distance to road/house to reveal potential relationships using a linear regression model. An example of a regression model that can be produced from these data is provided in Appendix IV.

E. Results from 2018 Data Collection

1. Wildlife Signs

A total of 73 wildlife signs were observed on IRP during the sampling period (May-August 2018). Wildlife sign data are summarized in Table 5.7. Wildlife sign locations were mapped for moose and bear individually, and for all other species collectively (Appendix VII).

Table 5.7. Wildlife Signs on IRP, May-August 2018.

Species	Sign Type	Total
Moose	Scat (31), Bed(s) (9), Fur (1), Tracks (1), Trail (1)	43
Bear	Scat (8), Scratching/Marking (7), Den (2), Trail (1)	18
Coyote	Scat (6)	6
North American Porcupine	Fur/Quills (1), Possible porcupine tree (1)	2
Spruce Grouse	Dust bowl (1)	1
Red-tailed Hawk	Sighting (1)	1
Sharp-shinned Hawk	Sighting (1)	1
Snowshoe Hare	Carcass (1)	1
		73

2. Camera Trap Setup

We tested the protocol described above by first walking the trails and installing camera traps throughout IRP. Nine camera traps in total were placed throughout IRP (Brands: Bushnell, Moultrie Apeman). In May and June 2018, five cameras were placed throughout IRP Lot 1. In August 2018, four additional cameras were installed in the IRP Lot 2, Mead 40, and Wong 80 Lots, on the western portion of property. The camera trap locations were selected based on the observations of areas often experiencing high wildlife use (N. Faust, personal communication, 2018). Exact camera trap locations were documented by collecting GPS coordinates at the time of their installation (Figure 5.9, coordinates provided in Table 5.8).

The images were extracted from Camera Traps 1-5 on five occasions (mid-July, early August, late August, mid-October, and early November) and from Camera Traps 6-9 on three occasions (late August, mid-October and early November). See Table 5.9 for additional details on camera trap setup and exact dates of data uploads. The batteries of Camera Trap 4 expired on an unknown date between July 31 and August 22, 2018. For the purpose of counting the number of trap days, this camera is assumed to have stopped operating on August 1, as the last images from this time period occurred on July 31. Camera trap images were then analyzed using the protocol provided herein. It should be noted that our procedures contained minor deviations from the recommended protocol provided in this report. These deviations are detailed in Appendix IV. The results of the camera trap analyses are provided in the following sections.

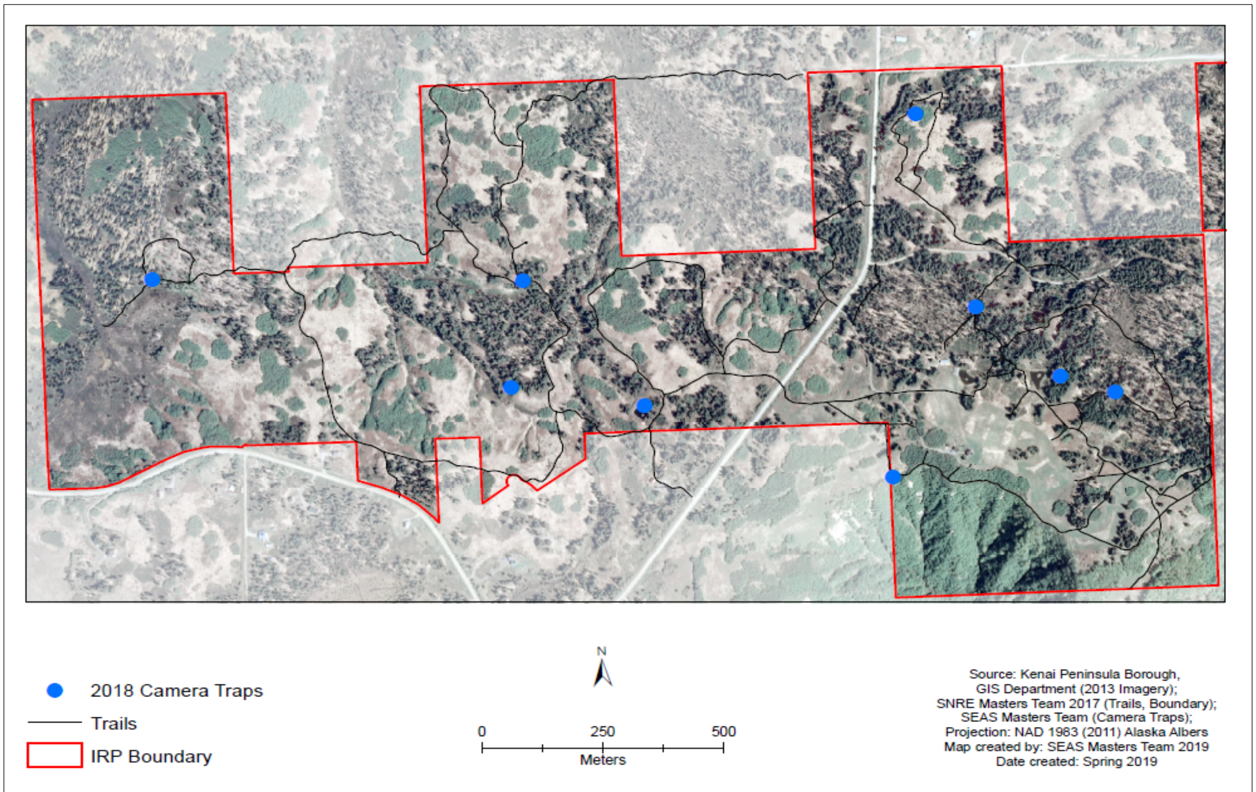


Figure 5.9. Camera trap locations for period of observation (May-November 2018). Full-sized map available in Appendix VII.

Table 5.8. Coordinates and names of camera traps from period of observation (May-November 2018).

Trap Number	Camera Trap Location/Name	Latitude	Longitude
Camera Trap 1	Ridge Trail	59.69895354	-151.41332611
Camera Trap 2	Goose Pond	59.70089806	-151.40702066
Camera Trap 3	Gozzie Trail	59.70054635	-151.40501915
Camera Trap 4	Knoll Loop	59.70637538	-151.41192617
Camera Trap 5	Greenhouse Trail	59.70237143	-151.41000948
Camera Trap 6	Moose Pond	59.70058981	-151.42236524
Camera Trap 7	Cottonwood Loop	59.70351874	-151.44028801
Camera Trap 8	Hummingbird Cam/ 103 Trail	59.70324755	-151.42664387
Camera Trap 9	Moose Valley	59.70106247	-151.42723857

Table 5.9. Dates of data collection from camera trap SD cards for period of observation (Camera Traps 6 -9 not installed until early August).

Trap Number	07/12/18	07/31/18	08/01/18	08/21/18	08/22/18	10/10/2018
Camera Trap 1	✔		✔	✔		
Camera Trap 2	✔	✔		✔		
Camera Trap 3	✔		✔	✔		
Camera Trap 4	✔	✔		✔		
Camera Trap 5	✔		✔	✔		
Camera Trap 6					✔	✔
Camera Trap 7					✔	
Camera Trap 8					✔	✔
Camera Trap 9					✔	

(continued)	10/11/2018	10/17/18	10/18/18	11/4/2018	11/05/18
Camera Trap 1			✔		✔
Camera Trap 2		✔		✔	
Camera Trap 3			✔		✔
Camera Trap 4			✔		✔
Camera Trap 5			✔		✔
Camera Trap 6				✔	
Camera Trap 7	✔			✔	
Camera Trap 8				✔	
Camera Trap 9	✔			✔	

3. Camera Trap Results

General Occurrence Analysis

A total of 510 wildlife occurrences in 1,057 photos were observed during the trapping period. Total occurrences (unstandardized) for the entire period of observation are shown in Figure 5.10. To account for differences in sampling effort (trap days) across camera traps, standardized occurrences (occurrences per trap day) were computed for all species. In addition, occurrences per day was scaled up to occurrences per 30 trap days to allow for easier conceptualizing of the typical number of occurrences observed in a particular timeframe (in this case, a

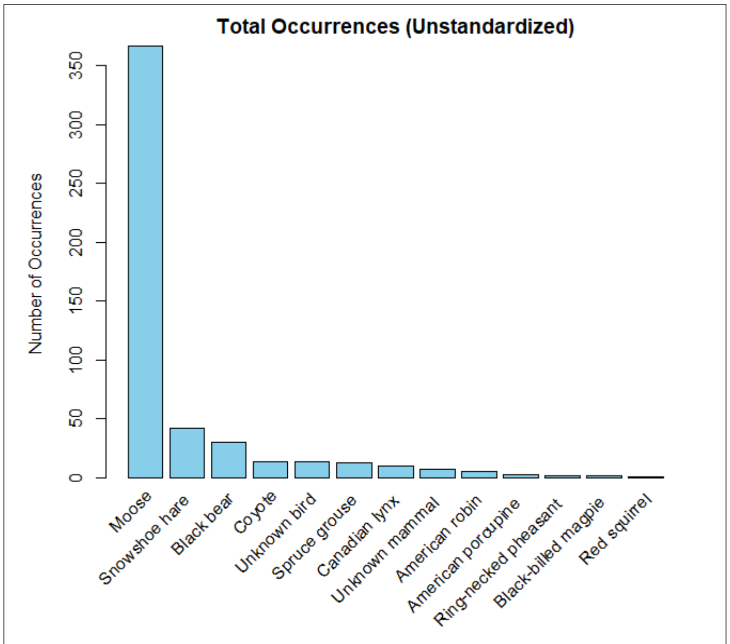


Figure 5.10. Total wildlife occurrences for the period of observation (May-November 2018). Moose were the most frequently observed species, followed by snowshoe hare and black bear.

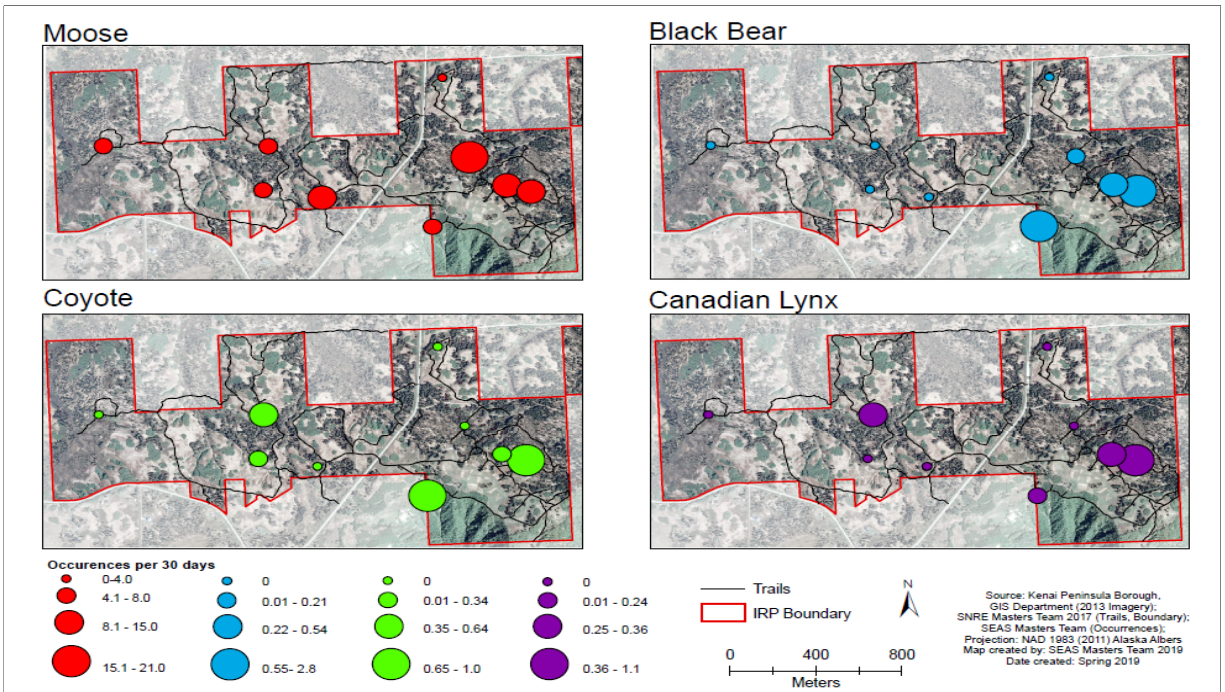


Figure 5.11. Standardized occurrences (scaled to occ. per 30 days) of moose, black bear, coyote, and Canadian lynx for the period of observation (May-November 2018). Moose were commonly seen throughout the entire property. Black bear was observed exclusively in the eastern portion of IRP. Coyote and Canadian lynx were also seen throughout the property, but appeared more frequently in the eastern portion of the property. Full-sized map available in Appendix VII.

month). Occurrences per 30 days was mapped for the larger mammal species, including moose, black bear, coyote and Canadian lynx (Figure 5.11). A summary of the overall data for each camera trap, including total number of occurrences, standardized occurrences, number of unique species observed, and percent of total occurrences that were observed during the day, is provided in Table 5.10. The standardized occurrence data is also summarized on a per species basis in Table 12.1, Appendix IV. The proportions of daytime versus nighttime occurrences (standardized) is shown graphically in Figure 12.1, Appendix IV. Overall, approximately 70% of occurrences took place during the day, suggesting that wildlife activity on IRP may be greater during daytime hours.

Table 5.10. Camera trap data for overall period of observation (May-November 2018). Camera Trap 1 observed the highest number of both unique species and standardized occurrences.

Trap Number	Trap days	Number of images	Total occurrences	Occurrences standardized (occ./trap day)	Occurrences standardized (occ./30 trap days)	Total species observed (excluding unknown)	Species standardized (species observed per trap day)	Percent of total occurrences seen during day
Camera Trap 1	129	310	101	0.78	23.49	11	0.09	57.43
Camera Trap 2	168	185	89	0.53	15.89	4	0.02	67.42
Camera Trap 3	170	243	102	0.60	18.00	7	0.04	68.63
Camera Trap 4	134	67	17	0.13	3.81	1	0.01	100.00
Camera Trap 5	141	74	96	0.68	20.43	2	0.01	64.58
Camera Trap 6	89	51	36	0.40	12.13	2	0.02	75.00
Camera Trap 7	93	28	25	0.27	8.06	2	0.02	76.00
Camera Trap 8	93	31	21	0.23	6.77	3	0.03	76.19
Camera Trap 9	93	68	23	0.25	7.42	2	0.02	86.96
Totals	1110	1057	510	3.87	116.01			

Analysis of Seasonal Differences and Distance to Nearest Road

Spatial differences in occurrences were graphed for moose, black bear, coyote, and Canadian lynx (Figure 5.12). Full maps of seasonal occurrences are also provided in Appendix VII, Wildlife Assessment. It should be noted that Camera Traps 5-9 were not installed during the spring season, therefore no occurrence data is available for the western portion of the property for the spring. This makes visual analysis of spatial differences in occurrences across seasons difficult. To provide sufficient data for such comparison, more camera trapping will be needed at these locations.

We also analyzed the relationship between the number of occurrences per day (for each species), season, and distance to roads for moose, black bear, coyote, and Canadian lynx by means of linear regression models, which provide the predicted number of wildlife sightings (occurrences) and the standard deviation (Figure 5.13). These models reveal the effect of distance to nearest road (effect size represented as the slope of the lines) and the effect of season (represented as the y-intercept) on the predicted occurrences of a given species. There were no significant findings when distance to nearest building was included, therefore this variable is not discussed further in these results. All wildlife occurrence data utilized in the temporal analysis (including total and standardized occurrences per season and season lengths) is provided in Tables 12.2-12.4, Appendix IV. In addition, the distances from each camera trap to the nearest major road (Skyline Drive, Ohlson Mountain Road, or Eagleaerie Avenue) and house are provided in Table 12.5, Appendix IV.

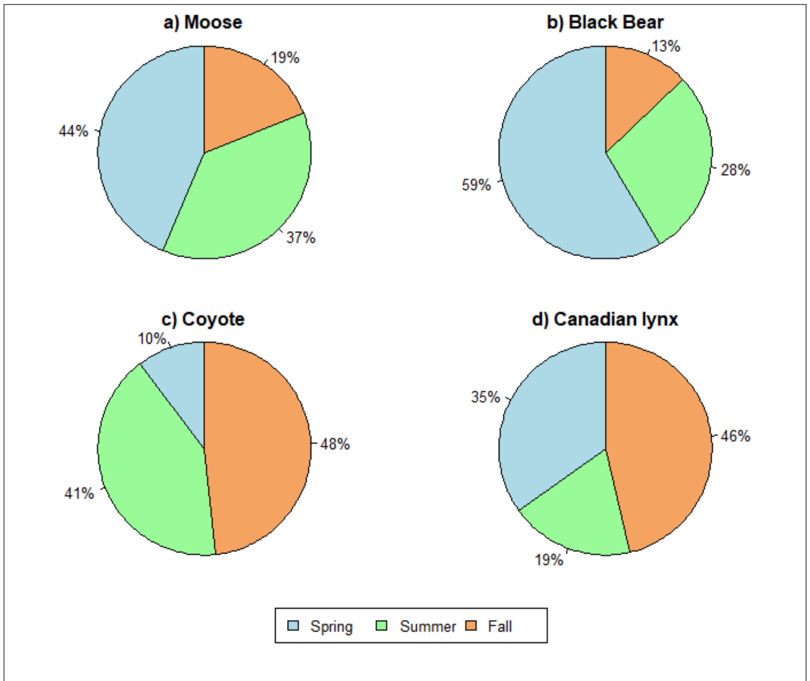


Figure 5.12. Percentages of occurrences (standardized to occurrence per trap day) recorded during spring, summer, and fall (2018 observation period) for a) moose, b) black bear, c) coyote, and d) Canadian lynx. Note: occurrences are not significantly different across seasons for coyote and Canadian lynx, but spring occurrences of moose and black bear are significantly different than those of summer and fall (See Figure 5.13).

The linear regression models (Figure 5.13) indicate that moose and black bear sightings (occ./trap day) are significantly more likely to occur in the spring than in either summer or fall (95% confidence interval). Coyote and Canadian lynx show no significant differences across seasons. However, as noted above, Camera Traps 5-9 were not operating during the spring season. In addition, the small sample size of occurrences for black bear, coyote, Canadian lynx, and to a lesser degree, moose significantly hinders the analysis of the seasonal wildlife use around IRP. Thus, more camera trapping during the spring season in particular, as well as at all camera trap locations, is needed to confirm the patterns observed in this assessment.

The models (Figures 5.13) also show that distance to road (our proxy for human activity) and occurrences of black bear, coyote, and Canadian lynx are positively correlated (as evidenced by the slopes); as the distance to road increases, the predicted number of sightings of these species increases as well. In contrast, moose activity is not affected by distance to road, suggesting that this species may be less sensitive to disturbances by cars or human proximity.

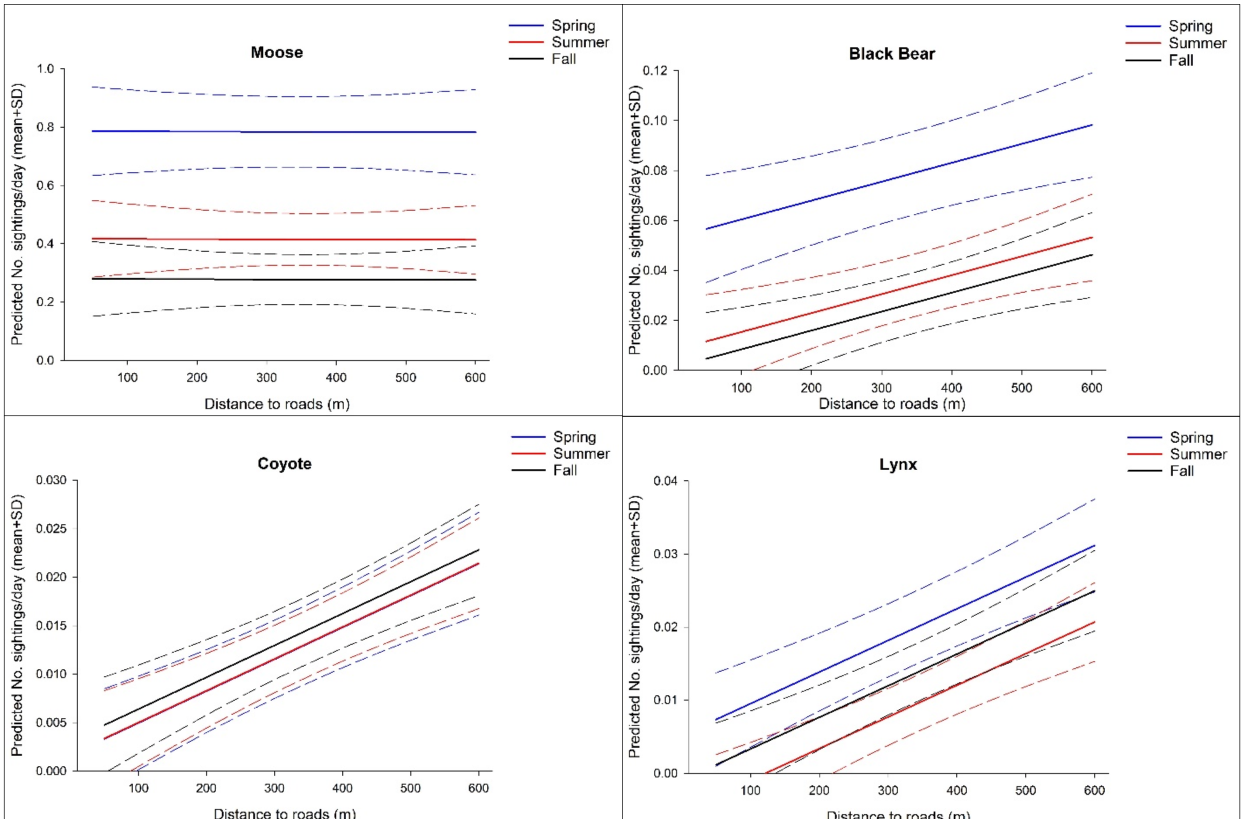


Figure 5.13. Predicted number of sightings (occurrences) per day in different seasons and distance to major road for a) moose, b) black bear, c) coyote, and d) Canadian lynx.

F. Recommendations

1. Continue Monitoring Wildlife Activity

We recommend that CACS continue to monitor wildlife populations and habitat use on IRP.

a. Reinstall camera traps in the same locations annually to monitor changes in wildlife activity at those locations over time.
b. If more camera traps are acquired, add camera traps location across IRP to better assess wildlife uses of unsampled area. Alternatively, rotate the nine cameras such that each location is sampled every other year (see Figure 5.14 for suggested additional locations). Particularly one or two

cameras should be installed in the Hogback Lot, as this lot was not sampled in the 2018 study and so wildlife activity in that area is not well known. The remaining seven or eight cameras may be placed in unsampled locations around the main IRP lots, including the southeast portion of IRP Lot 1, the northeast portion of IRP Lot 1, the north portion of IRP Lot 2, and in Wong 40, off of the established trail system. CACS should also install camera traps in the areas of proposed future construction, such as parking lots or new buildings, prior to these alterations, in order to assess wildlife activity in those areas and understand the potential impact of the changes on wildlife. If feasible, additional camera trap sampling should be conducted during winter months to provide a more comprehensive understanding of wildlife on the property in all seasons.

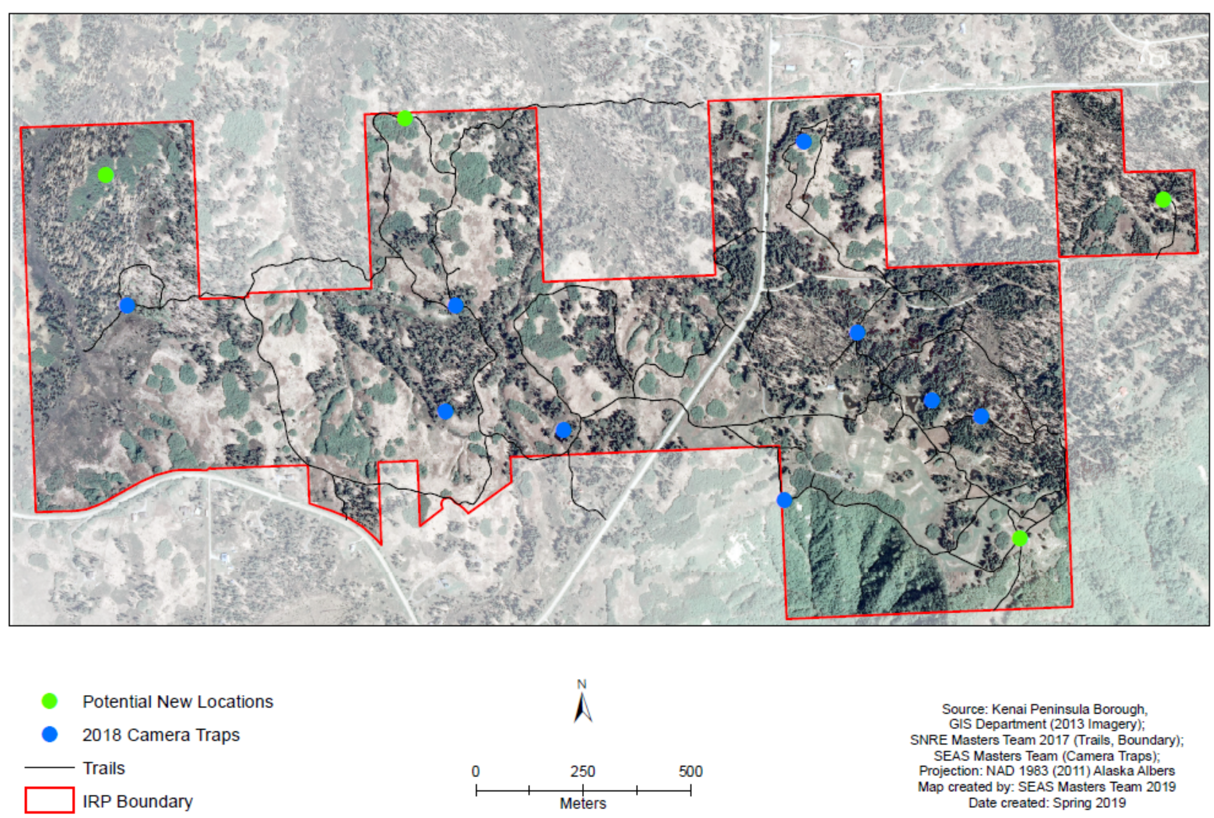


Figure 5.14. Potential new camera trap locations (excluding Hogback Lot). Full-sized map available in Appendix VII.

c. Assess wildlife activity for night/day differences, seasonal differences, and spatial differences to inform management decisions.

d. Some of the camera traps have video capabilities. Video mode may be alternatively used if the goal of monitoring is behavioral analysis or for educational purposes.

2. Trail Use Recommendations

Based on the results of our camera trap analyses, we provide the following visitor access recommendations to CACS. These recommendations may be tailored to fit the specific goals of CACS regarding managing IRP for different wildlife species.

a. *Day/nighttime activity*: Based on occurrence data from camera trap monitoring, moose, black bears, and to a lesser degree, Canadian lynxes, appear to be more active during the day, while coyotes and snowshoe hares are more active at night. If CACS aims to encourage and maintain moose and black bear activity on the property, we recommend minimizing daytime public use of the areas in which moose and black bear are most frequently observed in order to avoid potential encounter and/or disturbance of these species, which may discourage their continued use of those areas of IRP.

b. *Distance to major road:* The correlation between distance to nearest road and occurrences of black bear, coyote, and Canadian lynx, as revealed by the models (Figures 7.8-7.11) suggests that these species may be more sensitive to disturbance by vehicles and/or by humans. Therefore, CACS should minimize anthropogenic disturbance to the areas and time of day in which these species are most frequently observed, if their objectives include promoting the presence and movement of these species on IRP.

VI. Sandhill Crane Monitoring through Kachemak Crane Watch Application

A. Introduction

IRP has hosted a migratory population of sandhill cranes since the early 1990s. This population has been monitored throughout its summer breeding season both on the IRP property and in the greater Homer area by the citizen science group Kachemak Crane Watch (KCW). While paper records of crane observations have been maintained, if future population viability or fecundity analysis is to occur, an electronic and more consistent and organized database is required. Therefore, to facilitate a more collaborative citizen science monitoring program, we created a data recording application functional on multiple devices including phones, desktops, and tablets. This application, "Kachemak Crane Watch," was created as an extension of KCW using ESRI AppStudio. The app, which is publicly accessible, has the capacity to record key characteristics in a standardized way with the option of providing additional comments and attaching photos. Historic data from paper files can be added to the app database at any time.

In addition to a mobile version, a connected web map application was created, enabling users who cannot or prefer not to download the app to their device to record observations online. Succinct and continuously updating summary data can be viewed through an online dashboard. All data from the native and web map apps will be uploaded to a database hosted by the online feature service, managed by CACS, and can be used in conjunction with the dashboard summary data for research, monitoring, and educational programs. Restrictions were set for the public apps and dashboard to ensure user privacy and crane safety.

B. Sandhill Crane Population in Homer

To document the history of the crane populations in Homer, the formation of Kachemak Crane Watch (KCW), and provide context for the KCW Application, a series of personal interviews with Nina Faust, founder of KCW and IRP, were conducted in August 2018. This retelling of N. Faust's account is an invaluable part of the history of IRP and KCW. (N. Faust, personal communication, 2018).

Since the late 1990s, a population of over 100 sandhill cranes (*Antigone canadensis*) has utilized the greater Homer area as its summer nesting grounds. While there is no written indication of cranes prior to this and long-term town residents do not recall cranes being around during their childhood, locals believe cranes previously used the Fritz Creek Critical Habitat to the north of Homer as their breeding grounds.

Citizens in Homer began to notice the sandhill cranes when pairs took residence at base of the bluff and near farm fields. As more birds moved into town, awareness and interest in the sandhill cranes grew. Long-term Homer residents, creators of IRP, and nature enthusiasts, Nina Faust and Ed Bailey, founded the citizen science-based organization KCW in 1996 in order to leverage the town's new awareness to study the cranes.

In 2014, a pair nested in the accessible downtown Beluga Slough allowing the citizens of Homer an intimate glimpse into the breeding behavior of the birds. Some residents wanted cranes to gather in their yards and set out corn, consequently drawing more crane pairs into town. These "town cranes," however, were exposed to new threats such as loose dogs, cars, and other associated urban threats. Additionally, not all residences felt positively about the influx of cranes in town, viewing the cranes as a nuisance when they tore up their gardens and yards and picked at their window insulation and cars. Concerned for crane safety, KCW circulated informational pamphlets and articles and conducted educational programs throughout the community to caution citizens about the potential hazards of feeding cranes. These actions were somewhat effective in stopping some supplemental feeding and changing the location or method of how the cranes were fed in town. Feedings were moved to protected areas such as tree lines instead of parking lots and corn was scattered widely in a thin layer instead of concentrated, so as not to attract predators. However, feeding on private property still occurs, necessitating that KCW continue public education about proper crane viewing etiquette and the hazards of attracting crane into urban areas.

Population size estimates (ranging from 150-200 individuals) come from the number of reported nests and extrapolations of single time observations (e.g. 100 individuals have been seen at one time on IRP). Population estimates are approximate, as there is no way to completely eliminate double counting with citizen science observations. Additionally, while crane pairs breed in the wetlands and more natural areas surrounding Homer, a thorough study has not been conducted to count them. Kachemak Crane Watch founder E. Bailey conducted low-flying plane surveys in the early 2000s with little success.

Other crane experts, such as Dr. Gary Ivey from the International Crane Foundation, successfully studied the population's migration by attaching satellite and radio trackers to ten individuals. His research on this population was used to inform conservation planning in the Sacramento-San Joaquin River Delta region of California, where the crane population over-winters (International Crane Foundation 2008). Dr. Ivey still remains in contact with N. Faust to help verify website and pamphlet information.

1. Inspiration Ridge Preserve Past and Current Management for Cranes

Currently an 18.3 acre area between the Faust Residence and the bluff is mowed annually to provide attractive crane habitat (Figure 6.1). Lawn areas directly next to the house are mowed more frequently. Management records show that this area has a long history of intermediate disturbance. The field was cut annually for hay by the property homesteaders and continued to be hayed after the transition of ownership to N. Faust and E. Bailey in 1993. Although the haying of IRP ceased in 2015, the field continued to be mowed annually to facilitate suitable crane habitat.

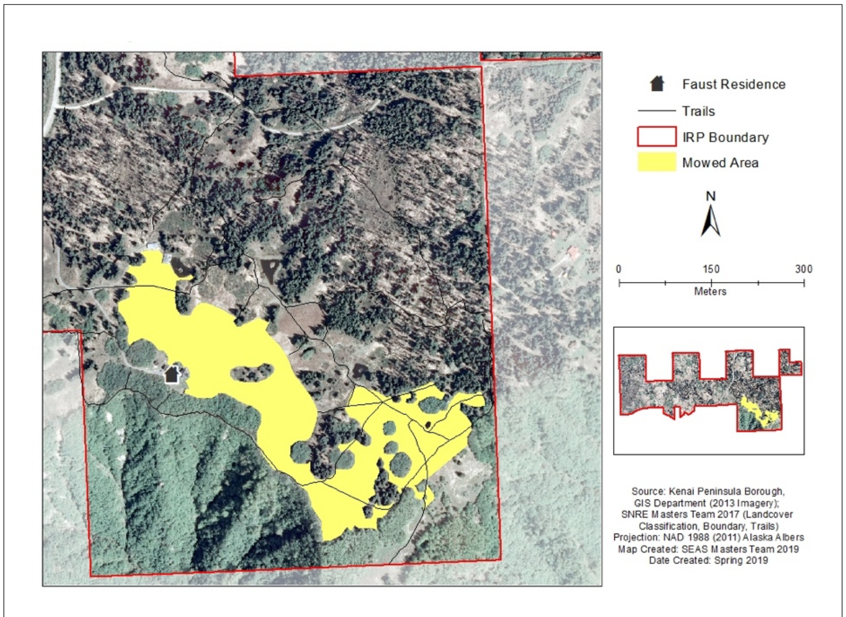


Figure 6.1. Annual mowed area for crane habitat IRP.

In 2010, E. Bailey recommended leaving cover strips throughout the field to allow tall grass corridors for wildlife. While this new mowing technique provided more heterogeneity in habitat for other wildlife on IRP, these cover strips also allowed predators such as lynx to hide in the tall grass and easily prey upon the cranes. Since one of IRP's management goals is to provide habitat for cranes, N. Faust reverted back to mowing the whole area. On average, the yearly late summer mowing takes thirteen hours, and the hired mower is paid at an hourly rate of $40/hour.

There has also been a history of food supplementation on IRP. A mix of barley and corn, similar grains to those eaten during the winter in California, are scattered for the cranes after the first observed arrival. Microwaved egg shells are also occasionally scattered as a crane calcium supplement. The feed is scattered in close proximity to the house every few hours, or once the last grains are eaten.

2. Inspiration Ridge Preserve Past and Current Crane Data Collection

With the creation of Kachemak Crane Watch, people in town who observed the cranes or their nests on public or private property can call the KCW hotline or submit an email report to record their observation.

These reports include the date, time, location, numbers, age, injuries, mortalities, and whether the young colts could fly. As a small knit community, word about Kachemak Crane Watch spread quickly with the assistance of radio notices, newspapers, and flyers scattered around town. As residents began to report sightings, concern grew surrounding maintaining property privacy, as well as concern for crane safety. Observations from hesitant individuals were only possible when KCW representatives assured them specific location data would never be made public. Reports of injured cranes are added to the organization's observational database and are reported to the U.S. Fish and Wildlife Service, who are responsible for recovering injured cranes.

Since 2015, in early to mid-September, KCW has hosted three count day events in which citizens and birdwatchers gather at Beluga Sough to count the cranes gathering in preparation for migration.
While past count days were conducted solely at IRP, with more cranes gathering in town to roost at night in Beluga Slough, the boardwalk on the Slough has become a more ideal location. Additional counts are still conducted on IRP to provide a continuous observation location over time. Count days typically occur on the Saturdays leading up to the cranes' migration back to California. The weekends are picked based on the sandhill cranes' migration history, as well as from careful assessment of the current observed crane gathering data. Citizens throughout the area, from Anchor Point to the head of Kachemak Bay, are also encouraged to participate in the count by reporting their crane observations from sunrise to sunset, since some cranes still fly north into the wetlands in the Fritz Creek Critical Habitat. While these count days mark the main migration back to the cranes' winter habitat, observations still trickle in to the KCW hotline throughout October when the late nesters prepare to migrate.

While hotline and email crane observations throughout the entire summer season have been recorded since 2002, paper records require manual entry into a database in order to perform analyses. Furthermore, observation reports did not always capture the same parameters, making it difficult to collect long-term data. Some residents, who closely knew KCW organizers, used alternative methods (e.g. social media) to make observation reports, however this resulted in lost or delayed reports. As part of adopting this new preserve, CACS expressed interest in expanding the research component of their organization, including building upon the Kachemak Crane Watch program. For future population analysis to occur, a more consistent and organized database is required.

C. Data Collection Protocol

1. Overview

We developed the application "Kachemak Crane Watch" to better facilitate study of the sandhill crane population through citizen science. The app records crane abundance and health parameters, as well as capturing measurements of observation validity. Photographs, sound clips, or comments can also be attached to individual observation reports. For users who cannot or prefer not to download the app, a connected web map app through ArcGIS Online was created from the app's feature service, enabling users to still record observations online. All data from the native and web map app will be uploaded to a database hosted by the online feature service and managed by CACS. Dashboards summarizing the reported data from the database can also be viewed through ArcGIS Online. Public versions of the dashboard and web app allow users to view and edit only their own observation points.

2. Glossary

a. *ArcGIS Online*: Online version of ArcGIS that hosts the feature service, web maps, dashboards, web application (AppBuilder), native application (AppStudio), and story map. The *My Content* tab contains all of the Kachemak Crane Watch extensions.

b. *Feature Service:* Published from the geodatabase made in ArcGIS Desktop, this online feature service is the base for all the apps and extensions. All data from the native app and the web app are stored in the feature services database. The main feature service hosting the data will only be accessible to administrators.

c. *Web Map:* Map of observation points made from the feature service. This is the basemap where the app will be locating observations. Other versions of the web map, including heat maps, were created for the public web app and public dashboard, though restrictions were set to ensure user privacy and crane safety.

d. *Native Application:* Downloadable app available on all devices. Data from the app will be added to the feature service database. The app will allow observation points in areas with poor service to be submitted or saved as a draft.

e. *Web Application:* For users who do not want to download an app, there is an equivalent online app (accessed through URL or QR code) where observation points can be dropped. This app can be opened on any smartphone, tablet, or desktop computer with an internet connection. All data points will also be added to the feature service database. Public users can only access observation points they created.

f. *Dashboard:* This is an up-to-date summary of the feature service database. There is one dashboard available to administrators and a separate dashboard for public distribution. Again, the public dashboard only lets users view their own observation points summary data.

g. *Story Map:* The story map is an educational tool that provides more context for viewers, including more detailed directions for dropping an observation point.

3. Feature Service

a. To access the feature service and its content, log on to ArcGIS online: [https://www.arcgis.com/home/signin.html.](https://www.arcgis.com/home/signin.html)

b. Go to the *Content* tab.

c. Open Kachemak Crane Watch Folder.

d. Select *Feature Service* (Figure 6.3).

Figure 6.3. Feature Layer in Contents Tab.

e. *Overview* tab holds the description, layer, credits, terms and conditions, tags, and a menu of action buttons related to the feature service (Figure 6.4).

f. *Data* tab shows the data or attribute table of all the data collected on the native app and web app. The data points can be edited and managed here. The menu on the upper left allows user to *Show/Hide Columns* – unhide creator and editor data as needed.

g. *Visualizatio*n allows user to view data points by zooming to Homer, AK. User can also create another web map from this page.

h. *Usage* tab tracts the usage of the feature service page.

i. *Settings* tab allows user to change the settings including extent (boundaries of the map), control editing, or export data. This is one of the places where public use can be restricted.

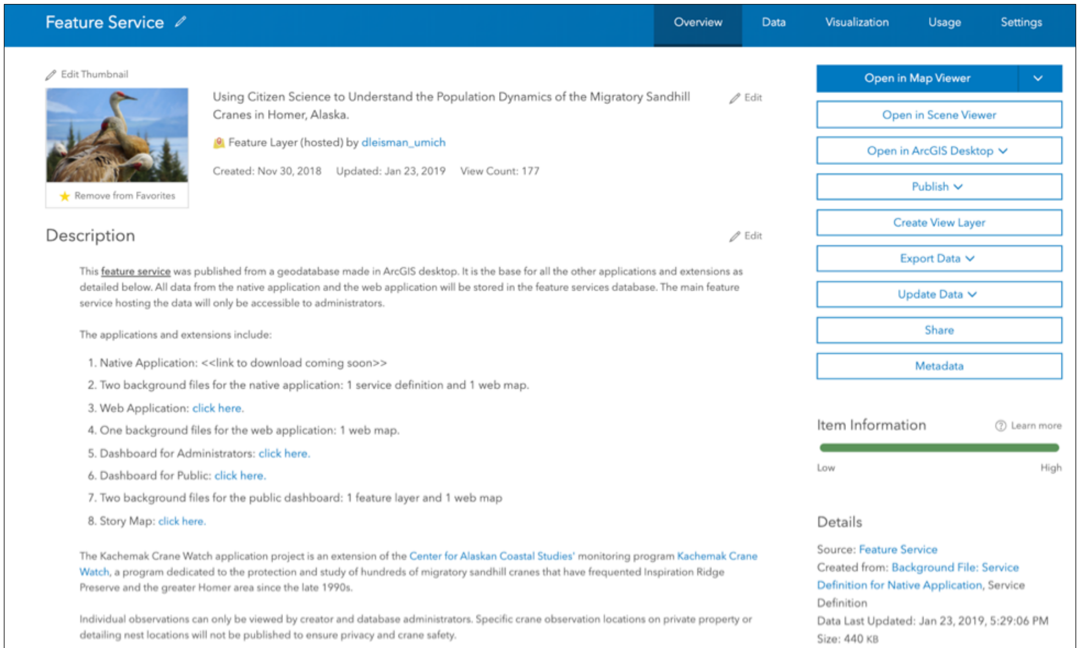


Figure 6.4. Feature Service Overview.

4. Native Application

a. Download files for the application can be found on the Center for Alaskan Coastal Studies and Kachemak Crane Watch webpages.

b. Download app to device.

c. Open app.

i. Click the *New* (+) button or open a previously saved draft point from the *Drafts* button (Figure 6.5a). Accept terms and conditions (Figure 6.5c).

ii. Select an *Observation Type* from the provided menu (Figure 6.5d).

iii. Let internal GPS find current location or click and hold observation location on the map until an address appears to drop pin (Figure 6.5e)

iv. Attach photos (select the *Camera* icon to take picture or select the *Album* to add existing pictures) and audio files (select the *Audio* icon to add file) as wanted.

v. Select best response for each question from drop down menu or enter a number or comment as prompted (Figure 6.5f).

1. *Number of Observed Adults* - Enter the number (1,2,3, etc.) observed. Adults sandhill cranes are typically large, around four feet or 120cm long, with rusty grey plumage, black legs, and have a noticeable red crown (Figure 6.5g-h).

2. *Number of Observed Juveniles* - Enter the number of juveniles or colts observed. Younger colts are typically golden to tan in color and fluffy, but grow quickly to be rusty or gray color and as large as their parents. Juveniles eyes are dark, unlike the yellow eyes of an adult, and they also will not have a red crown (Figure 6.5g-h).
3. *Juvenile Fledging Status* - If juveniles are observed, select from the menu whether the juveniles/colts have fledged (learned to fly) or not, or unsure. If no juveniles are observed, select the corresponding option (Figure 6.5g-h).
4. *Sex of the Observed Cranes* - Select from the menu if observed cranes were male, female, both, or unsure. Male cranes tend to be larger than females. Males have a lower pitch call than females and throw their heads back all the way while females will throw their head back at a 45-degree angle (Figure 6.5g-h).
5. *Crane Injury?* - If injured crane observed, select from the menu the best fitting description of the crane(s). If no injured crane, select the corresponding option (Figure 6.5g-h).
6. *Please Provide Details on Observed Injury* - If injury reported above, describe details of observed injury (extend, location, source/type, etc) (Figure 6.5g-h).
7. *Crane Mortality?* - If crane mortality observed, select from the menu the best fitting description. If no crane mortality, select the corresponding option (Figure 6.5g-h).
8. *Please Provide Details on Observed Mortality* - If crane mortality reported above, describe details of observed mortality (location details, cause, etc) (Figure 6.5g-h).
9. *Duration of the Crane Observation* - Select from the menu the time frame that best fits the duration of crane observation (Figure 6.5g-h).
10. *Confidence in Accuracy of Observation* - Select user's level of confidence in the accuracy of above observations details (Figure 6.5g-h).
11. *Additional Comments (Behavior, Vocalizations, Surrounding Habitat, etc.)* - Describe any other observations including crane behavior, any vocalizations, the habitat in which the cranes were observed, and any additional comments or observations (Figure 6.5g-h).

vi. *Submit* observation or save it as a *Draft*.

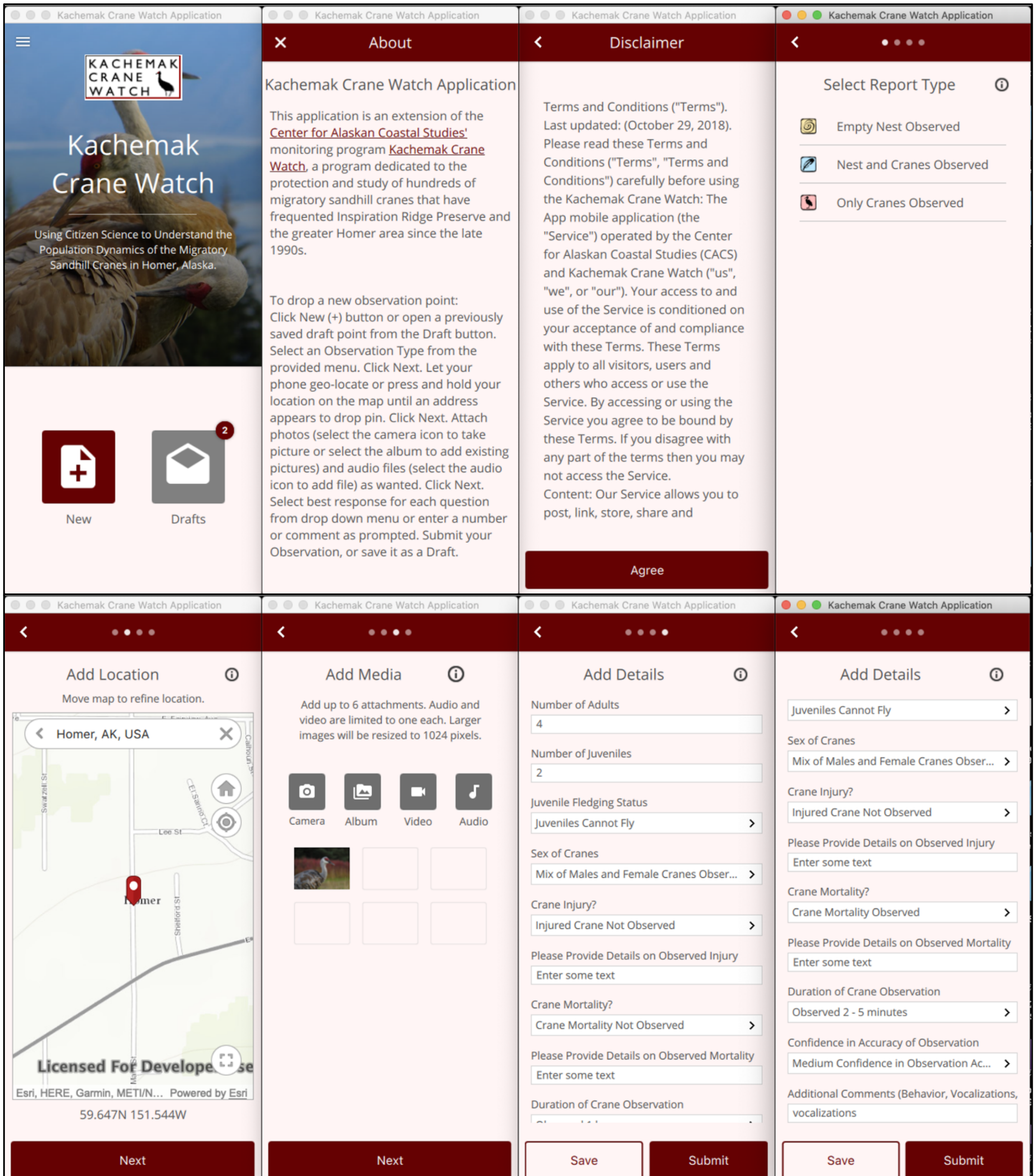


Figure 6.5a-h. Screenshots of the native application. The *About* and *Settings* menu selected from three-line icon in the upper left corner of the home screen on small screened devices or from labeled tabs along the bottom of the home screen for large screened devices.

5. Web Application

a. Open through: https://umich.maps.arcgis.com/home/item.html?id=63938e4b3db44121a65a1d649cfad022 or the QR code (Figure 6.6).

b. Alternatively, select *Kachemak Crane Watch – Web Application* from the content menu.

Figure 6.6. QR code.

c. Select *View Application* from side menu.

d. Seven unique widgets allow interaction with the web app.

e. To drop a new observation point:

  i. Make sure view is zoomed out to where heat map is visible.

  ii. Select the *Edit* icon (Figure 6.7, 5th from the left).

  iii. Click on the best fitting *Observation Type* icon.

  iv. Use current location or hover over the map and zoom until the location where observation occurred is found. Click to drop the point.

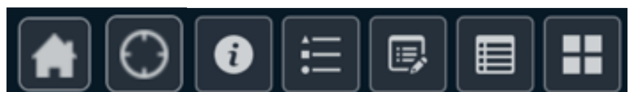


Figure 6.7. Widgets from left to right: *Home* icon returns to the default spatial extent. *Location* finds users current location using device GPS. *Information* provides more information about the web app. *Legend* details the heat map legend. *Edit* allows user to drop a new point and edit or delete an existing point. *Table* allows user to view a table of the points they have created in the map extent they are currently viewing. *Basemap* allows user to change the basemap of the web app.

  v. Select the best response for each question from drop down menu or enter a number or comment as prompted.

  vi. Attach photos (select the *Camera* icon to take picture or select the album to add existing pictures) and audio files (select the *Audio* icon to add file) as wanted.

  vii. Click *Save* and close window. Arrow in the corner shows larger area view as depicted below.

Note: Administrators and users will view a heat map until dropping a point. Administrators can view and edit all data points. Users can only view and edit data points they created.

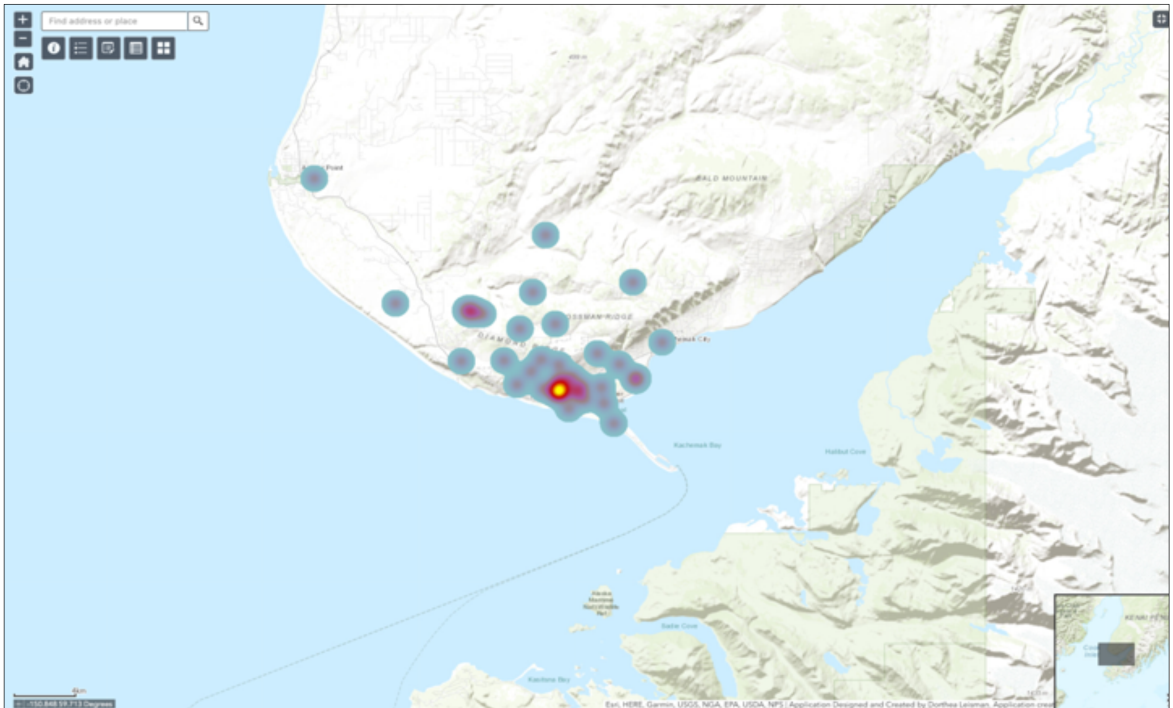


Figure 6.9. Web app including widgets with location finding, additional, information, legends, edit or dropping new points, opening the data table, changing the basemap, and viewing the larger contextual area.

6. Online Dashboard (Administrators)

a. Select *Kachemak Crane Watch – Dashboard (Administrators)* from *Content* menu or click this link: https://umich.maps.arcgis.com/home/item.html?id=f2ac85e5a54b427fb9133edacc605978.

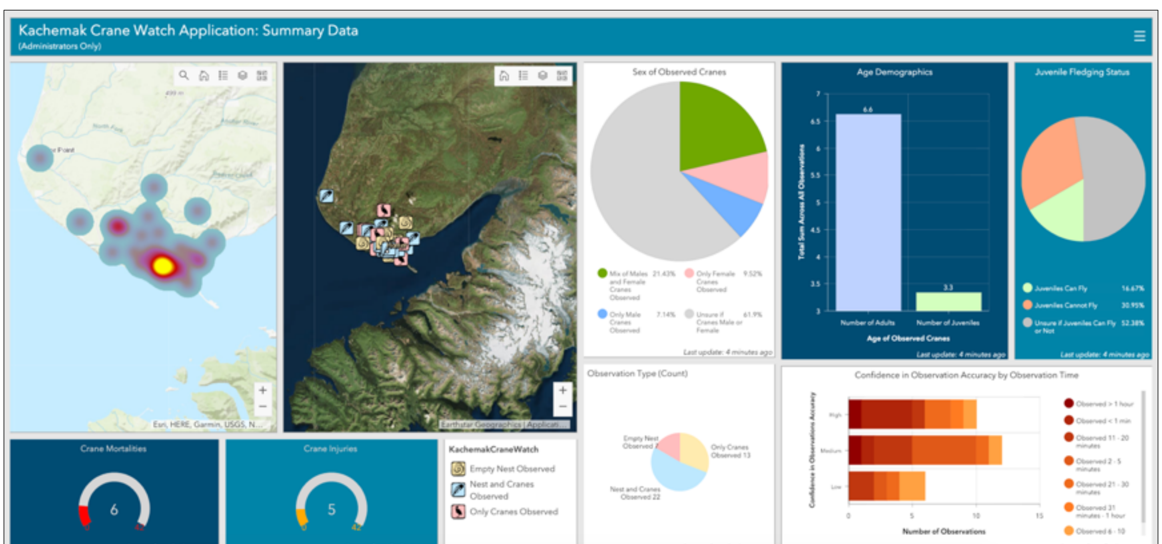


Figure 6.10: Administrator dashboard with summary data.

b. Select *View Dashboard* from side menu.

c. Summary data includes:

    i. Interactive map of data points.

    ii. Legend.

    iii. Pie chart of observation types count data.

    iv. Pie chart of reported crane sex data.

    v. Injury and mortality gauges out of total observation.

    vi. Bar chart of age demographics.

    vii. Pie chart of juveniles' fledging status.

    viii. Bar chart comparing frequency of reported confidence in observation accuracy and the correlating observation time frame.

d. All graphs in the dashboard:

    i. Are interactive, including counts and percent when cursor hovers over field (Figure 6.11a).

    ii. Can temporarily exclude any variable by clicking its icon in the legend (Figure 6.11b).

    iii. Can be maximized and minimized within the screen.

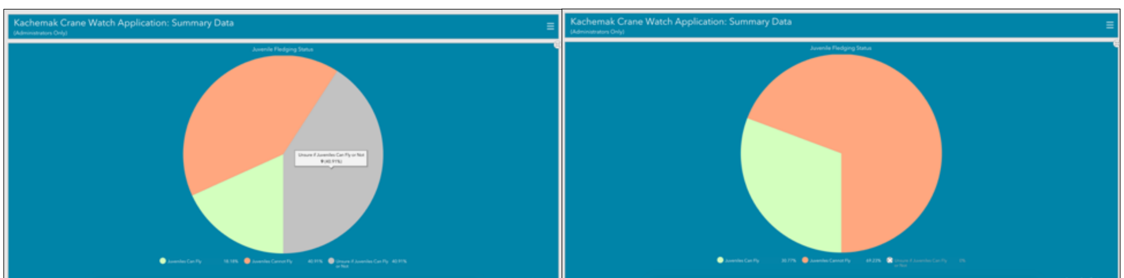


Figure 6.11a & b: Interactive abilities of the graphs including field statistics when hovered over (left) and exclusion of variables (right).

7. Online Dashboard (Public)

a. Select *Kachemak Crane Watch – Dashboard (Public)* from *Content* menu or click this link: https://umich.maps.arcgis.com/home/item.html?id=eac3e3fa923144f380888d610cdd7a03.

b. Select *View Dashboard* from side menu.

c. Summary data includes:

    i. Interactive heat map of data points.

    ii. Pie chart of observation type count data.

iii. Pie chart of reported crane sex data.

iv. Injury and mortality gauges out of total observation.

v. Bar chart of age demographics.

vi. Pie chart of juveniles fledging status.

vii. Note: Users only see data points they created. Zoom restrictions have been set for observer and crane privacy.

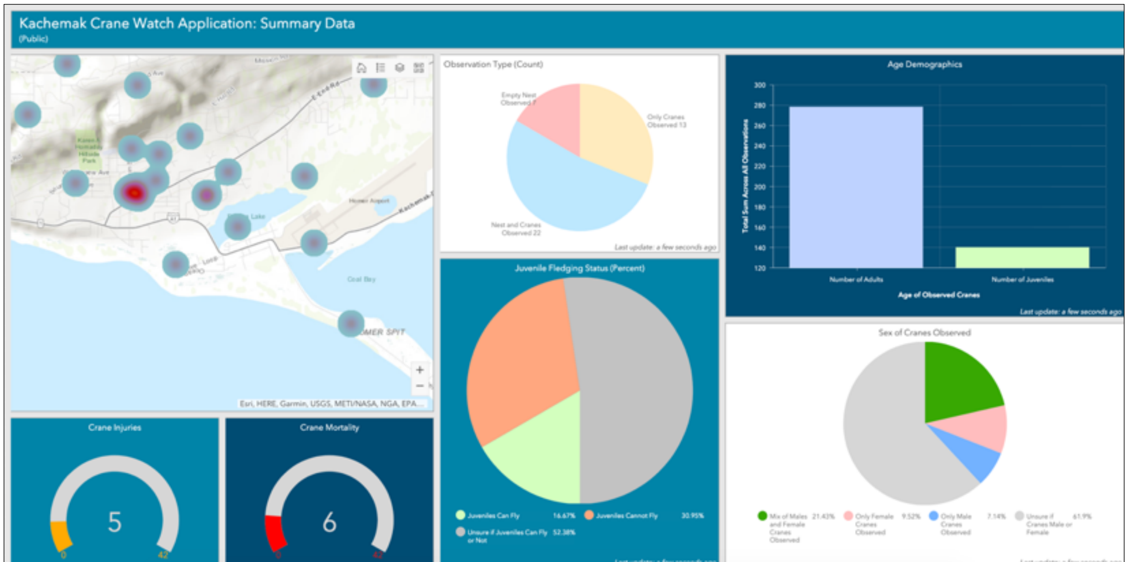


Figure 6.12: Public dashboard with summary data.

d. All graphs in the dashboard:

i. Are interactive, including counts and percent when cursor hovers over field (Figure 6.13a).

ii. Can temporarily exclude any variable by clicking its icon in the legend (Figure 6.13b).

iii. Can be maximized and minimized within the extent of the screen.

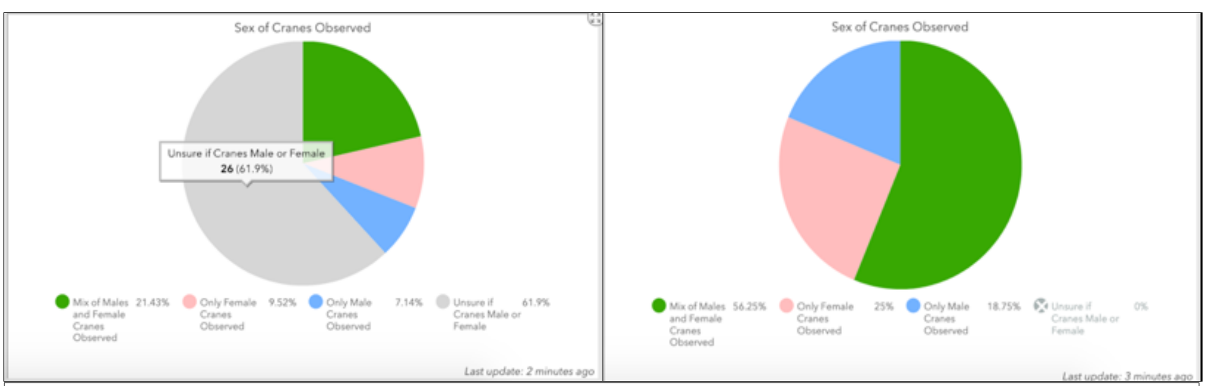


Figure 6.13a & b: Interactive abilities of the graphs including field statistics when hovered over (left) and exclusion of variable (right).

8. Story Map

a. Find the story map from this link: https://arcg.is/b5Tze or access it via the info page: https://umich.maps.arcgis.com/home/item.html?id=3fbba18347d841bb89fbbc53ba60d2cb.

Figure 6.14. Story map from *Story Maps* menu.

b. Scroll through the story map for more background information and directions on how to make an observation, including more images and information on crane identification.

c. To edit:

   i. Select the *Grid* icon next to username and open *Story Maps*.

   ii. Click *Kachemak Crane Watch Application*.

   iii. Select *Edit Story*.

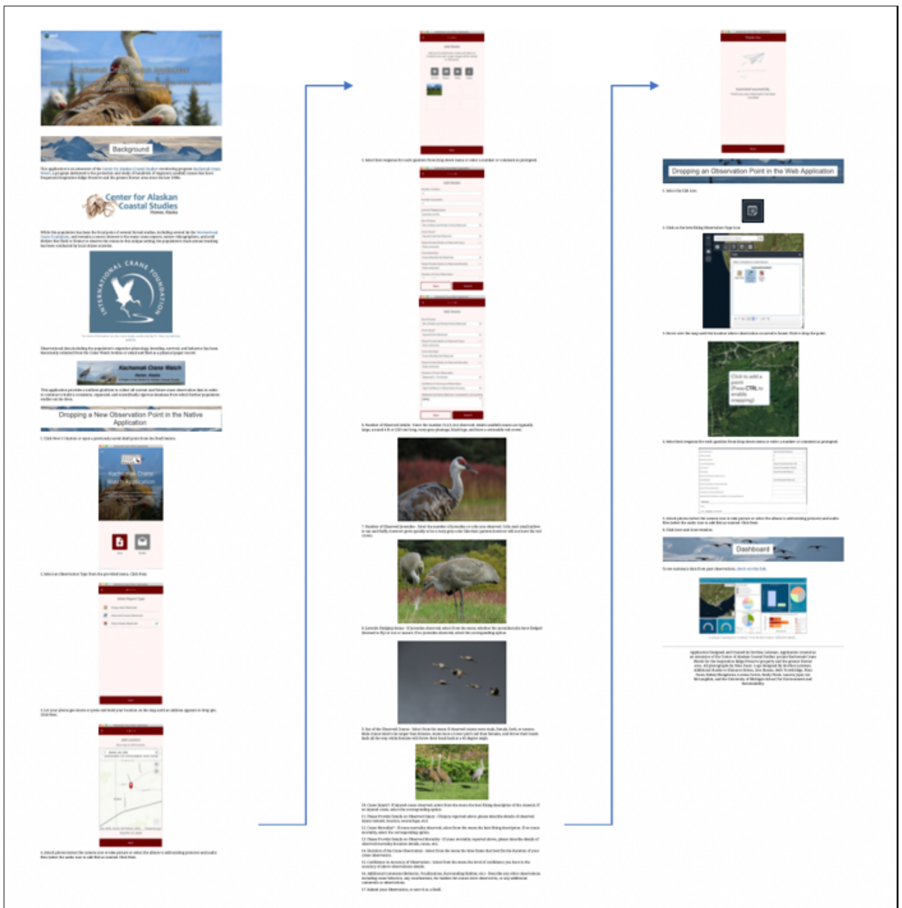


Figure 6.15. Example story map. The user simply scrolls through the cascading story online.

D. Recommendations

As IRP transitions to new management, CACS hopes to build off of KCW's work and continue to educate the public about crane populations though limited tours with N. Faust. Additionally, CACS hopes to use IRP to build a database to attract crane researchers through partnerships with local groups and universities.

1. Crane Monitoring

To improve data collection and management, we recommend that CACS use the Kachemak Crane Application we created to electronically record all future sandhill crane data in the area. Historic paper data should be added to the existing app database at a later time when funding for an intern or staff person is available.

2. Mowing

The previous management plan from the 2016 SNRE Master's Team recommended the cessation of mowing to allow the present grass and herbaceous landscape to revert to pre-disturbance processes (Carlson et al. 2017). However, one of IRP's primary goals is to maintain a large continuous area of suitable habitat for sandhill cranes. As development pressures in the area increase and existing nearby fields are subdivided, thus limiting potential nesting and staging areas for the migratory population, the currently maintained IRP field will likely become an important pre-migration gathering point. While the cranes most heavily utilize the areas further up the on the hill (the far northwest end of the mowed area) including Goose Pond, they have also been observed chasing off coyotes and foraging further down the field. As sandhill cranes prefer expansive open areas where predators are easily visible, in order to better promote IRP's goal to create suitable crane habitat, we recommend the continuation of the annual mowing of the 18.3 acres between the Faust Residence and bluff.

Should the future goals of IRP shift to facilitate more habitat heterogeneity or management resources grow limited, we recommended that an assessment of crane use at that time occur in order to determine priority areas for continued selective mowing management.

3. Supplemental Feeding

While the practice of supplemental feeding on IRP draws cranes away from the threats of town and into the currently managed crane habitat, the impacts of this supplemental feeding on the Homer crane population are unknown and therefore should be investigated further.

Case studies on the effects of food supplementation on bird populations are inconclusive. While many are generally positive, suggesting that supplemental feeding in the winter or throughout the entirety of breeding season may increase breeding success (Davis et al. 2015, Robb et al. 2005, Ruffino et al. 2014), others suggest declines in clutch numbers or hatching rates or raise concern about unintentional feeding consequence such as disease, malnutrition, or behavior changes (Harrison et al 2010, Jones and Reynolds 2008). The Florida Fish and Wildlife Conservation Commission has made it illegal to intentionally feed sandhill cranes due to the unintended risks to the population (Florida Fish and Wildlife Conservation Commission). Still other studies and meta-analyses are inconclusive, showing no benefits or costs to supplemental feeding (Margalida 2010; Arnold 1992; Ruffino et al. 2014).

Therefore, the impacts of the current supplemental feeding on the Homer crane population should be assessed to inform decisions on the frequency and quantity of future supplements.

VII. Photo Monitoring

A. Introduction

The Kachemak Heritage Land Trust (KHLT) follows standard protocols for every easement they acquire. In accordance with these protocols, the IRP property should be photo monitored annually. Photo monitoring is conducted to provide baseline documentation of the physical state of easements. The 2016 group of Master's students conducted photo monitoring that was continued in 2018 and shall be for all subsequent years.

B. Rationale

Natural and anthropogenic changes that occur on the easement will be documented through photo monitoring to ensure the property owners are managing the property in a accordance with the current land owner's wishes. Photos taken annually at monitoring locations can identify any easement violations or significant natural changes and are to be used as a means of communication with the property owner. For further information on photo monitoring, the KHLT Photo Monitoring Protocols should be reviewed.

C. Photo Monitoring Protocol

1. Monitoring Timeline

Photo monitoring must take place during similar times of the year annually. Peak bloom time, particularly of native fireweed, is the most ideal due to the apparent contrast between different vegetation types. Before the spring bloom, grassy areas will have no live vegetation to monitor and tree species will be difficult to differentiate without leaves present.

2. Photo Capture

A list of photo points, along with their coordinates, bearings, and elevation is provided below (Table 7.1), as well as a map of all locations (Figure 7.1). When possible, photos should be taken during similar weather conditions, preferably sunny or clear to ensure consistency over each year. Each photo point has associated bearings for which photos should be taken. Some points may only have two bearings, while others have four. This depends on the relevance of each orientation from the photo point. Some orientations may produce useless photos (e.g. a north-facing photo is only two feet from a large wall of 5-foot grasses) and thus it is not necessary to take images from these bearings.

A map with the photo point locations along with the previous year's pictures should be taken into the field to aid in the process of identifying photo points. Additionally, a field notebook should be brought to record all photos taken, their bearings, photo ID number, and photo point number. The metadata must be recorded in the format below:

Picture ID	Notes	Photo Point	Bearing	Elevation	Latitude	Longitude

If any of the above information is omitted, labeling, documenting, and photo replication errors may result. It is imperative to record the photo ID from the camera being used so the photos can later be matched with the appropriate photo points.

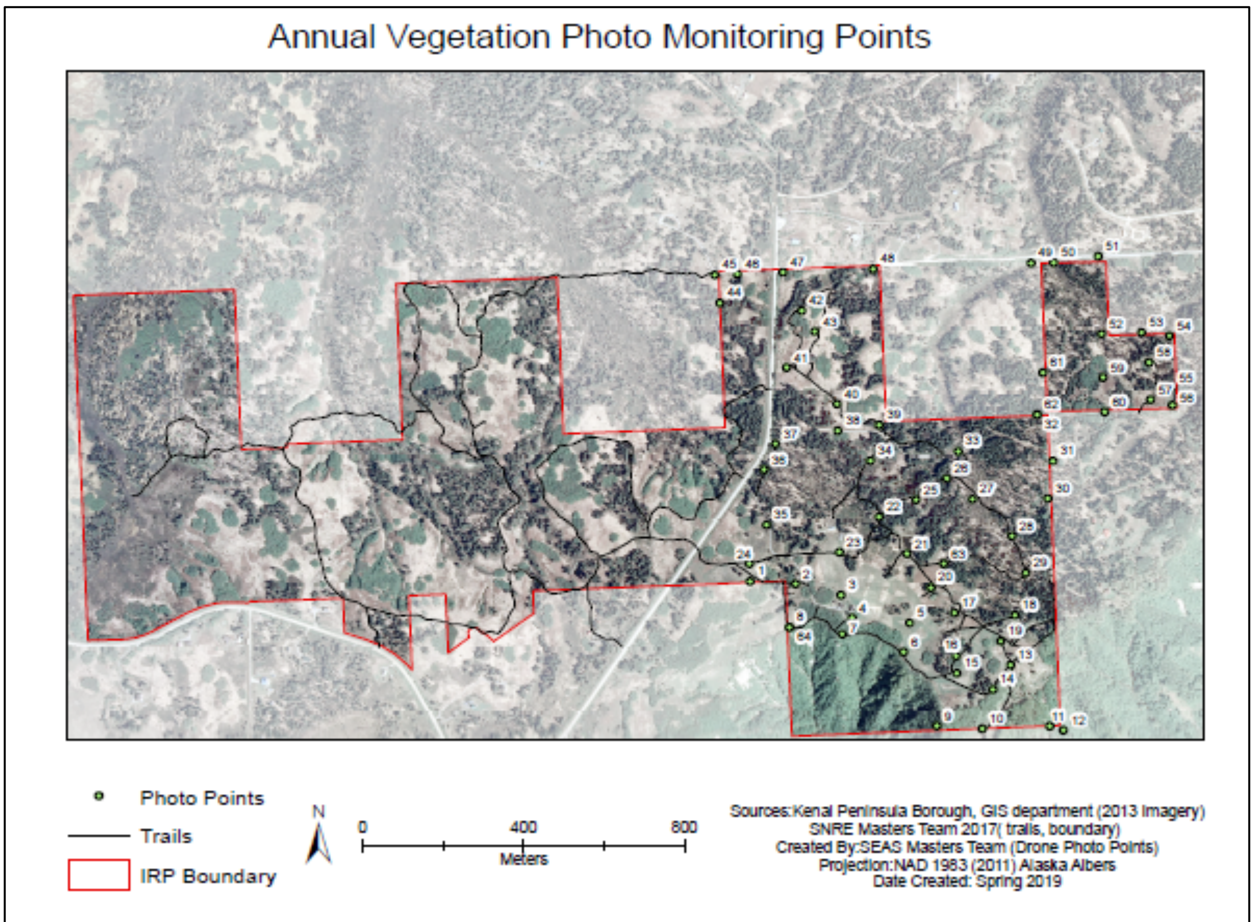


Figure 7.1. 2018 photo monitoring points.

In previous years, orientations (North, South, etc.) were used in place of bearings. However, bearings are more accurate and more easily replicated. Reference the bearings from the previous year's photos while monitoring to replicate them as closely as possible. Photo monitoring photos from 2018 are provided in Appendix VI. Upon completion of photo capture, manually input all photo metadata organized as shown above. The digital photos are then to be uploaded, organized neatly in a folder, and renamed according to the protocol outlined below for future reference.

3. Photo Point Naming

Photo points are to be named in the following manner:

a. First two to four letters of the name of the property followed by an underscore followed by "BDR" (Baseline Documentation Report) followed by the photo point number.
    i. For example: IRP_BDR_1
b. If a photo is removed from the list, the original photo numbers are to remain the same. No renumbering is to take place and the reason for the point's removal should be documented.
c. If a new photo point is created, name it with the first two to four letters of the property, the year, and photo point number.
    i. For example, if the last photo point taken was IRP_BDR_45 and a new point is added it will be named IRP_2019_46. Document the reason for the additional point.

Note: The previous management plan specified 33 different photo monitoring points. This was insufficient to monitor the large spatial area of the Preserve. There are now photo 64 monitoring points to be monitored annually. This can be reduced if certain points are deemed to be too similar or close in proximity.

Note: All photo points were taken between May 19th and May 21st of 2018.

Table 7.1. Photo monitoring coordinates and metadata from 2018.

Photo Point	Notes	Latitude	Longitude	Bearings	Elevation (Feet)
IRP_BDR_1		59.7000999	-151.4149933	339N, 94E, 256W	1340
IRP_BDR_2	Near bluff by Alders, just before the bluff trail	59.70000	-151.4129944	70E, 167S,58W	1350

IRP_BDR_3	E to Alpaca cage	59.6996994	-151.4109955	19N,99E, 319NW	1290
IRP_BDR_4	Trail behind greenhouse	59.69916667	-151.4105556	339N, 69E, 165S	1300
IRP_BDR_5	NW to house	59.6990013	-151.4080048	20N,129S ,238SW, 301NW	1860
IRP_BDR_6	On bluff, next to elderberries and broken stump in path	59.6983333	-151.4083333	31NE, 103E	1300
IRP_BDR_7	Bluff Trail near bench	59.6987991	-151.4109955	52NE, 161S,270W	1330
IRP_BDR_8	Nearby first camera trap	59.699000	-151.4133333	72E, 150SE, 256W	1340
IRP_BDR_9	Along S property line	59.6966019	-151.4069977	6N, 92E, 139SE,267 W	1220
IRP_BDR_10	Photo point on trail/property line below	59.6964989	-151.4049988	87E, 160SE, 175S, 256W 310NW	1130
IRP_BDR_11	close ??, get to property corner. bear bed, bear poop, bear scat. W-property line, N-towards property line, E-along property line.	59.6964989	-151.4019928	349N, 75E, 178S, 249W	1020
IRP_BDR_12		59.69638889	-151.4013889	111E, 225SW,	1160
IRP_BDR_13		59.69794444	-151.4036111	33NE, 122SE, 209SW, 291W	1230

IRP_BDR_14	Dead tree stump, above cottonwood forest, low point in field trail	59.69738889	-151.4044444	107E	1230
IRP_BDR_15	Bench	59.6977997	-151.4060059	112SE	1210
IRP_BDR_16	E of lower field; back on trail	59.6982002	-151.4060059	92E	1140
IRP_BDR_17	Mallard Pond	59.6991997	-151.4060059	22NE, 115SE, 289W	1040
IRP_BDR_18	Parking pad in front of rental cabin	59.99083333	-151.4033333	34NE, 135SE, 238SW	1220
IRP_BDR_19	Snipe Pond	59.6985016	-151.404007	75E, 158S, 282W	1290
IRP_BDR_20	Frog Pond	59.6997986	-151.4069977	88E, 215SW	1270
IRP_BDR_21	Goose Pond	59.7005997	-151.4080048	352N,111E, 235SW	1260
IRP_BDR_22	Gozzie trail junction with Jeff Oils Bus Trail	59.70147222	-151.4091667	30NE, 112SE, 257W	1280
IRP_BDR_23	Goose Pond	59.706986	-151.4109955	25NE, 155SE, 245W, 311NW	1390
IRP_BDR_24	Bottom of field	59.7005005	-151.4149933	18N, 265W	1390

IRP_BDR_25	Gozzie Trail, loop opening	59.70183333	-151.4075	25NE, 121SE, 241SW	1280
IRP_BDR_26	Gozzie trail junction N of the bog	59.70230556	-151.4061111	32NE, 110E, 260W	1220
IRP_BDR_27	Bog	59.7018013	-151.4049988	1N, 95E 187S, 271W	1290
IRP_BDR_28	South of bog on Gozzie trail in riparian zone	59.70092	-151.4033333	8N, 105E, 278W	1220
IRP_BDR_29	On Gozzie Trail	59.70005556	-151.4027778	90E, 210SW, 310NW	1220
IRP_BDR_30	Halfway back to gate on major ravine	59.70175	-151.4016667	156SE, 224SW	1210
IRP_BDR_31	South of old road	59.70261111	-151.4013889	51NE, 340N, 52SE	1240
IRP_BDR_32	Driveway corner	59.703701	-151.4019928	57NE, 129SE, 213SW, 258W	1120
IRP_BDR_33	Off alder ridge connects road to Gozzie Trail	59.70291667	-151.4055556	353N, 78E, 265W	1210
IRP_BDR_34	Halfway to the dip on the Greenhouse Trail	59.70277778	-151.4094444	2N, 122SE, 213SW	1210
IRP_BDR_35	Trail behind cabin	59.70138889	-151.4141667	157S, 228SW, 319NW	1330

IRP_BDR_36	Halfway on Bypass Trail	59.7026667	-151.4141667	43NE, 186S, 302NW	1310
IRP_BDR_37	Road on Bypass Trail	59.70325	-151.4136111	160S, 76E, 270W	1310
IRP_BDR_38	Alder Ridge Road driveway	59.7035	-151.4108333	353N, 78E, 265W	1310
IRP_BDR_39	1996 property mark	59.7036018	-151.4089966	4N, 200S, 277W	1270
IRP_BDR_40	Pinch point of 3 trails next to a spruce	59.70411111	-151.4108333	21N, 155SE, 297NW	1310
IRP_BDR_41	Over the fireweed field and towards the road. Top of the knoll with elderberry cluster in center	59.7050018	-151.4129944	340N, 199S, 270W	1340
IRP_BDR_42	Second clearing from turn point in front of a spruce	59.70630556	-151.4122222	15N, 113SE, 238SW	1300
IRP_BDR_43	Below knoll loop and field	59.70580556	-151.4116667	169S, 266NE, 330NW	1370
IRP_BDR_44	Spruce forest and open meadow	59.70580556		9N, 266W	1290
IRP_BDR_45	Top western corner of property	59.7071991	-151.4160004	159SE, 28SW	1290
IRP_BDR_46	Fireweed meadow with alder along road	59.7071991	-151.4149933	70E	1280
IRP_BDR_47	Edge of Eagle Aerie and Skyline	59.7071991	-151.4129944	208SW	1280
IRP_BDR_48	NE property corner	59.7071991	-151.4089966	165S	1260
IRP_BDR_49	NW corner of property	59.7071991	-151.4019928	99E, 157SE, 250W	1090

IRP_BDR_50	Riparian habitat from road (cottonwoods coming in)	59.7071991	-151.401001	162SE	1090
IRP_BDR_51	NE property corner of 15, S down property line	59.7072983	-151.3990021	103E, 168S, 233SW	1090
IRP_BDR_52	NW corner 7.5	59.705501	-151.3990021	345N, 75E, 189S	1130
IRP_BDR_52	Property corner of 2 north parcels Defibaugh	59.70551	-151.3972222	351N, 80E, 261W	1130
IRP_BDR_54	NE-corner of 2.5	59.7053986	-151.3957778	359N, 156S, 271W	1140
IRP_BDR_55	Back to property line (patch of spruce)	59.7042007	-151.3959961	350N, 158S	1170
IRP_BDR_56	SE corner of 2.5	59.7038002	-151.3959961	18N, 264W	1180
IRP_BDR_57	First clearing	59.70394444	-151.3969444	356N, 91E, 218SW, 288W	1190
IRP_BDR_58	Old junk clearing	59.70481	-151.3969444	342N, 61NE, 135SE, 205SW	1170
IRP_BDR_59	Fireweed meadow/ property overlook, moose trail?	59.7044983	-151.3990021	15N, 62NE, 110E, 165S	1180
IRP_BDR_60	SE corner of 15, SW of 2.5	59.703701	-151.3990021	358N, 84E, 262W	1170
IRP_BDR_61		59.70466667	-151.4016667	100E, 175S	1200
IRP_BDR_62	S corner and W boundary of parcel	59.703701	-151.4019928	345N	1220
IRP_BDR_63	End of Gozzie Trail intersect with U Trail along the NE side of Frog Pond	59.70033333	-151.4063889	114SE, 222SW, 325NW	1280
IRP_BDR_64	Directly above Skyline Rd where trails intersect	59.699	-151.4133333	93E, 210, SW 299NW,	1310

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Appendix I: Sound Mapping

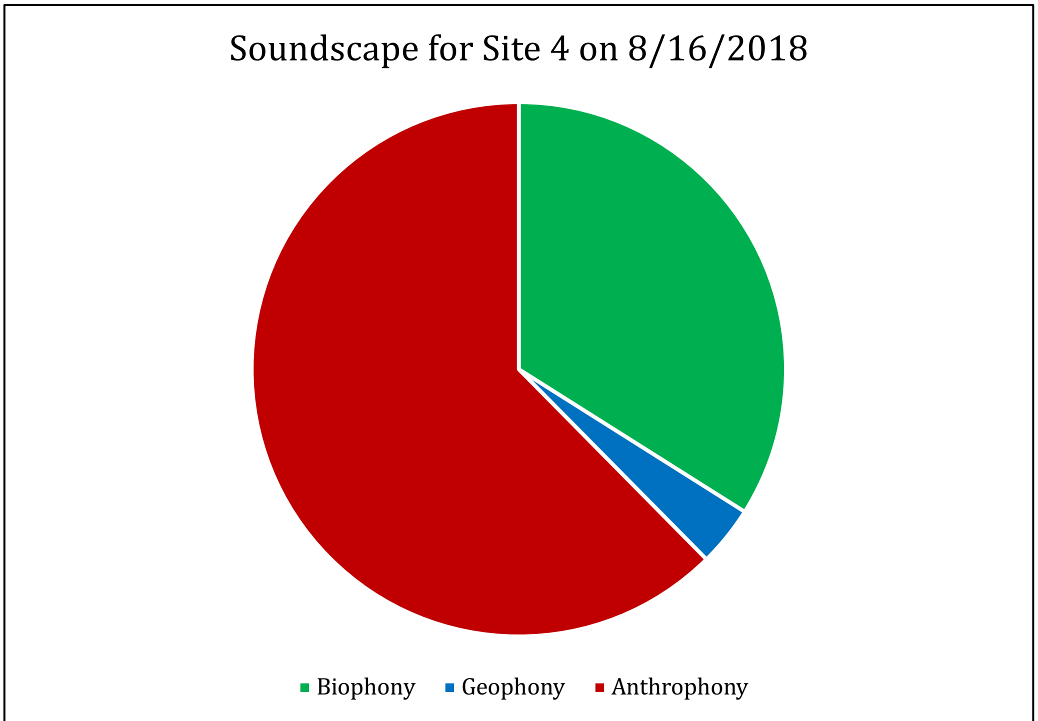
Part A. Tables of Final Soundscape Breakdowns for Each Site Per Day

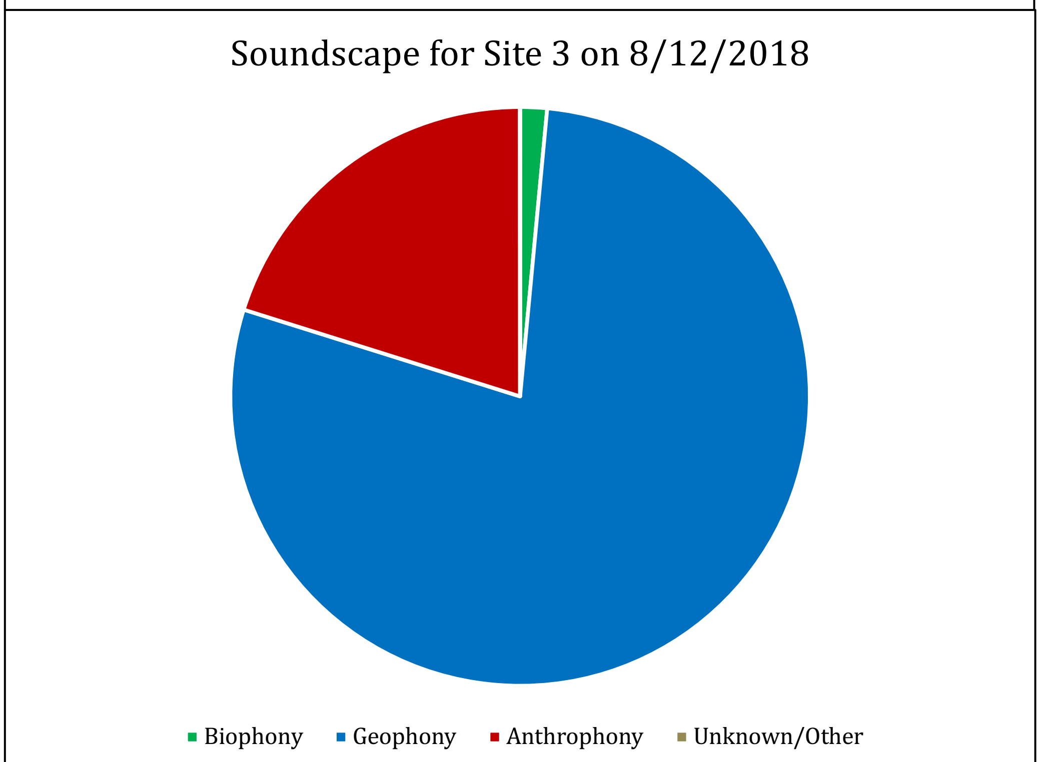
Table 9.1 Sound Analysis Table for Sound Point 3, 8/12/2018			
Sound	*Component*	*Number*	*Duration(seconds)*
Bear	B	2	1.422
Bird	B	49	34.184
Car	A	12	29.333
Dog	B	10	8.851
Motor	A	11	167.048
GHOW	B	12	29.938
Helicopter	A	3	19.390
Plane	A	27	786.947
Rain	G	2	600.000
Unknown	U	1	0.427
Wind/Rain	G	11	3300.000
Biophony		73	74.395
Geophony		13	3900.000
Anthrophony		53	1002.718
Unknown/Other		1	0.427
Total		140	4977.540

Table 9.2 Sound Analysis Table for Sound Point 4, 8/16/2018			
Sound	*Component*	*Number*	*Duration(seconds)*
AMRO	B	5	3.688
Bird	B	744	507.503
Bird (Flycatcher?)	B	1	0.777
Bird (hawk)	B	1	0.701
Bird(AMRO and nuthatch)	B	1	1.035
Bird(AMRO and other)	B	1	1.089
Bird(AMRO?)	B	20	14.035
Bird(AMRO+)	B	1	0.755
Bird(AMRO)	B	17	8.322
Bird(chickadee)	B	7	6.868
Bird(flycatcher?)	B	5	6.682
Bird(Warbler?)	B	2	1.175
Bird(Nuthatch)	B	7	13.507
Bird(nuthatch)	B	7	13.507
Bird(chicadee)	B	2	1.542

Bird(chickadee?)	B	1	1.153
Bird(SACR)	B	4	2.221
Bird(warbler?)	B	2	1.175
Bird(SACR flock!)	B	1	15.765
Bird(SACR flock)	B	1	5.433
Bird(STJA)	B	1	0.658
Car	A	7	104.250
Eagle?	B	1	1.455
Frogs	B	1	0.938
Hawk	B	3	2.791
hawk?	B	1	0.823
Hawks?	B	1	1.662
Jay	B	1	3.780
Moose?	B	1	1.099
Motor	A	1	9.329
Plane	A	37	1063.944
RTHA	B	1	1.056
Squirrel	B	1	2.737
STJA	B	19	27.256
Traffic	A	2	18.049
Unknown_anthro	A	1	1.037
Wind	G	10	69.868
Biophony		861	651.188
Geophony		10	69.868
Anthrophony		48	1196.609
Unknown/Other		0	0
Total		75	1199.817

Part B. Graphs of Final Soundscape Breakdowns for Each Site Per Day





Figures 9.1 a) and b). Soundscapes for Site 4 (in part a) and Site 3 (in part b). These charts show the relative portion of each sound component by seconds recorded. Charts are examples of how a soundscape can be represented using the data analysis techniques described in the protocols.

Appendix II: Fish Trapping

Part A. Additional Data and Results

Table 10.1. Fish Trapping Data from 2018.

Location ID	Latitude (decimal degrees)	Longitude (decimal degrees)	Datum	Coordinate determination method	Name of water body	Date	Fish collection method	Species	Life stage	Length (mm) (NO estimates or ranges)	Length method
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	105	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	100	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	98	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	115	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	110	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	94	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	95	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	110	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	97	Total
Site 1	59.7026237	-151.44205	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	106	Total
Site 5	59.704408	-151.43285	NAD83	GPS	Unnamed tributary of Fritz Creek	8/7/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	103	Total
Site 4	59.7072142	-151.4428	NAD83	GPS	Unnamed tributary of Fritz Creek	8/8/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	118	Total
Site 4	59.7072142	-151.4428	NAD83	GPS	Unnamed tributary of Fritz Creek	8/17/18	Minnow Trap	*Salvelinus malma*	juvenile/adult	110	Total

Part B. Materials

- Uncured raw salmon eggs (enough for 2-3 tablespoons to be used at each planned trap)
- 1% Betadine or Iodine solution
- Perforated plastic bag (e.g. small Ziploc bag poked with a fork)
- Flagging tape
- Twine or metal chain
- Fish traps
    - Collapsible fish netting traps, which include a built-in pocket in which to put the eggs
    - Or, Galvanized steel fish traps
- Photarium
- Latex-free rubber gloves
- GPS
- Camera
- Bucket
- Field notebook or data sheets to record the following information:

Site	Date	Species	Total Length (Tip of Snout to Tip of Tail)	Fork Length (Tip of Snout to Fork of Tail)	Notes or Other Identifying Characteristics

Part C. Water Quality Assessment

According to the *State of Alaska Integrated Water Quality Monitoring and Assessment Report* for the years 2012, 2014 and 2016, Fritz Creek is classified as a Category 3 Waterbody. This classification refers to water bodies where there is insufficient or no data to determine if the water quality standards (WQS) are attained. With this in mind, water quality measurements could be taken at IRP, the headwaters of Fritz Creek, to determine a baseline health of the water.

Information about the quality of ground and surface water will help inform management of Fritz Creek's water resources now and in the future. The necessary information and tests used depend on the specific management questions and goals, but may include:

- Physical characteristics (e.g. temperature, color, turbidity and sediment suspended in the water).
- Chemical characteristics (e.g. dissolved oxygen (DO), acidity (pH), salinity, nutrients and other contaminants).
- Biological characteristics (e.g. bacteria, macroinvertebrates, diatoms and algae).

These characteristics can be measured by sending water samples collected from the creek to a laboratory for analysis or by using on site instruments (e.g. pH meter, thermometer, etc.). These instruments can be set up to record data at a single point in time or logged at regular intervals over an extended period. The results obtained from the physical and chemical measurements can then be compared to the *2018 Water Quality Standards (WQS) of the State of Alaska Department of Environmental Conservation* (https://dec.alaska.gov/water/water-quality/standards/) to determine if the streams are in good condition.

Once the water quality baseline has been established, future testing can compare water quality changes over time and space, potentially providing insight into the influence of factors such as changes in land use and climate change. Establishing a baseline, however, is a complex task which requires the consideration of numerous factors and may necessitate analysis beyond the traditional chemical and physical assessments to fully study the ecological integrity of a waterbody. Additional bioassessments, such as macroinvertebrate and diatom surveys, should also be conducted to distinguish between potential stressors on aquatic ecosystems. Both bioassessments have been carried out in Cook Inlet Basin streams such as Fritz Creek. For example, macroinvertebrate assessments conducted in 2007 at Fritz Creek showed relatively high biodiversity index values in the stream, thus indicating a healthy stream system. (Rinella & Bogan 2007). These tests, however, are not carried out frequently and provide insufficient

information to determine a stream's overall health. For this reason, multiple tests as those mentioned above should be carried out at least every 3 years to assess Fritz Creek's water quality.
More information on these bioassessments can be found in Southern Cook Inlet, 2007: https://dec.alaska.gov/water/water-quality/reports.

Appendix III: Monitoring Long-Term Vegetation Changes

Part A. Additional Data and Results

Vegetation photo points were picked due to their accessibility and representability of current plant composition. The photo points vary in plant communities, representing all vegetation types on the Preserve no matter how small a contribution they make to overall plant composition. Therefore, analyzing overall data from the points would not correctly represent the true proportions of plant communities on the Preserve. In future data analysis, the 2018 plant composition at each photo point should be compared with the current composition data to calculate changes in each classification type. Vegetation shifts at each point could then be analyzed as a function of any potential drivers of change, such as warming temperatures, succession.

Table 11.1. Vegetation Composition Quantification Data.

Classification Type	**Vegetation Area (m^2)**	**Overall Percentage**
Alder	4251.956	6.560
Bare Ground	284.720	0.439
Cottonwood	1311.128	2.023
Cow Parsnip	10057.872	15.518
Elderberry	1039.324	1.604
Fireweed	14685.037	22.657
Goldenrod	124.473	0.192
Mixed Herbaceous/Grass	8485.895	13.093
Moss	10.771	0.017
Mowed Grass	2582.018	3.984
Other Built	69.202	0.107
Pond	1046.868	1.615
Spirea	541.963	0.836
Spruce	10230.557	15.784
Trail	372.366	0.575
Willow	9720.038	14.997
Overall Land Cover	64814.187	100.000

Tables of individual drone photo point vegetation composition can be found below.

Classification Type Point 1	Vegetation Area (m^3)
Trail	58.31973274
Alder	15.66938617
Willow	29.86654719
Fireweed	1060.111748
Cow Parsnip	7.733256397
Total Area	1171.70067

Classification Type Point 2	Vegetation Area (m^3)
Trail	52.02190348
Alder	787.2233294
Elderberry	176.6590008
Cow Parsnip	158.1219794
Mixed Herbaceous/Grasses	594.2920461
Fireweed	674.3045527
Total Area	2442.622812

Classification Type Point 3	Vegetation Area (m^3)
Trail	124.8701098
Fireweed	2331.612268
Spruce	1172.999229
Cow Parsnip	45.71024534
Alder	135.6846619
Willow	32.12571717
Total Area	3843.002231

Classification Type Point 4	Vegetation Area (m^3)
Trail	137.3615842
Spruce	897.9660323
Fireweed	924.404037
Elderberry	11.94539794
Mixed Herbaceous/Grasses	70.55047807
Total Area	2042.22753

Classification Type Point 5	Vegetation Area (m^3)
Trail	92.46047614
Elderberry	34.5196283
Spruce	368.7503387
Mixed Herbaceous/Grasses	957.3199097
Alder	91.20341128
Willow	184.9074225
Total Area	1729.161187

Classification Type Point 6	Vegetation Area (m^3)
Trail	28.26592709
Spruce	28.05390669
Cow Parsnip	29.03471187
Cottonwood	426.2496736
Mixed Herbaceous/Grasses	1477.053769
Total Area	1988.657988

Classification Type Point 7	Vegetation Area (m^3)
Spruce	67.69569148
Cottonwood	711.576814
Mixed Herbaceous/Grasses	217.3183334
Willow	436.74085
Trail	83.9880196
Total Area	1517.319708

Classification Type Point 8	Vegetation Area (m^3)
Trail	46.38399033
Elderberry	45.63979222
Spruce	275.5618681
Cow Parsnip	634.7980449
Fireweed	600.9115258
Total Area	1603.295221

Classification Type Point 9	Vegetation Area (m^3)
Alder	1500.717698
Trail	50.07600776
Mixed Herbaceous/Grasses	524.7509846
Elderberry	69.62094538
Fireweed	184.2580146
Total Area	2329.42365

Classification Type Point 10	Vegetation Area (m^3)
Trail	74.37936318
Spruce	383.9400258
Fireweed	1481.767323
Willow	254.733217
Elderberry	29.61699472
Total Area	2224.436924

Classification Type Point 11	Vegetation Area (m^3)
Trail	71.58632266
Spruce	969.0693463
Bare Ground	163.8794355
Elderberry	9.833310991
Spirea	22.15961661
Moss	10.77060322
Mixed Herbaceous/Grasses	66.34529973
Fireweed	372.834669
Total Area	1686.478604

Classification Type Point 12	Vegetation Area (m^3)
Trail	53.65998291
Elderberry	66.77132369
Fireweed	476.3048439
Mixed Herbaceous/Grasses	720.0941371
Alder	312.7367738
Spruce	83.2539372
Cow Parsnip	16.195413
Total Area	1729.016412

Classification Type Point 13	Vegetation Area (m^3)
Trail	119.7023564
Spruce	94.51193519
Cow Parsnip	61.0907169
Fireweed	276.3806191
Spirea	519.8030617
Willow	2364.935905
Mixed Herbaceous/Grasses	757.7010468
Total Area	4194.125641

Classification Type Point 14	Vegetation Area (m^3)
Trail	89.18291334
Spruce	473.6078244
Elderberry	19.17095073
Mixed Herbaceous/Grasses	1037.510396
Bare Ground	120.840868
Alder	128.6711798
Total Area	1868.984132

Classification Type Point 15	Vegetation Area (m^3)
Fireweed	746.946988
Mixed Herbaceous/Grasses	202.0298815
Cow Parsnip	581.6515037
Spruce	7.833517017
Willow	800.1216404
Elderberry	6.743074202
Trail	114.3157817
Total Area	2459.642387

Classification Type Point 16	Vegetation Area (m^3)
Trail	97.368896
Cow Parsnip	565.2156782
Fireweed	15.05693388
Alder	283.9494375
Total Area	961.5909456

Classification Type Point 17	Vegetation Area (m^3)
Spruce	1754.948259
Trail	49.57755211
Willow	2265.053021
Total Area	4069.578832

Classification Type Point 18	Vegetation Area (m^3)
Trail	213.5568261
Pond	403.5578704
Other Built	0.696909999
Willow	1806.22284
Cow Parsnip	1525.006086
Mixed Herbaceous/Grasses	253.0799265
Spruce	615.8469668
Total Area	4817.967426

Classification Type Point 19	Vegetation Area (m^3)
Trail	312.2181356
Spruce	1874.771625
Fireweed	1567.193097
Cow Parsnip	1594.372444
Pond	23.6194714
Total Area	5372.174773

Classification Type Point 20	Vegetation Area (m^3)
Trail	342.1980076
Fireweed	1961.772617
Total Area	2303.970625

Classification Type Point 21	Vegetation Area (m^3)
Trail	222.9260145
Cow Parsnip	921.0563431
Fireweed	69.85109611
Willow	171.8913169
Mowed Grasses	231.2988564
Alder	137.8202927
Spruce	560.1751427
Elderberry	410.8216822
Total Area	2725.840745

Classification Type Point 22	Vegetation Area (m^3)
Trail	245.8562495
owed Grasses	742.3275935
Other Built	0.602377326
Fireweed	431.8286861
Cow Parsnip	115.791708
Goldenrod	51.11351004
Spruce	159.1409409
Willow	543.1428917
Mixed Herbaceous/Grasses	127.7480505
Total Area	2417.552008

Classification Type Point 23	Vegetation Area (m^3)
Trail	672.6185337
Mowed Grasses	732.4482572
Other Built	67.90317875
Pond	619.6910064
Spruce	442.4302941
Goldenrod	73.3593098
Fireweed	1022.945037
Cow Parsnip	2631.573884
Willow	830.2970252
Alder	191.7020501
Total Area	7284.968576

Classification Type Point 24	Vegetation Area (m^3)
Trail	315.2965002
Cow Parsnip	1141.72105
Mixed Herbaceous/Grasses	1480.10103
Fireweed	486.5524917
Total Area	3423.671072

Classification Type Point 25	**Vegetation Area (m^3)**
Mowed Grasses	875.9435022
Trail	59.17527002
Elderberry	157.9821694
Cottonwood	173.3011518
Cow Parsnip	28.79857929
Alder	666.5775466
Total Area	1961.778219

Part B: Drone Capture Locations

Table 11.3 Drone Capture Locations.		
Point	**Latitude**	**Longitude**
1	59.6998593	-151.43202
2	59.700862	-151.43392
3	59.702753	-151.43482
4	59.7035753	-151.43543
5	59.703646	-151.43739
6	59.703433	-151.43899
7	59.70341	-151.44037
8	59.704307	-151.4288
9	59.705979	-151.42646
10	59.70392	-151.42697
11	59.703247	-151.42681
12	59.700555	-151.42566
13	59.700091	-151.42205
14	59.700795	-151.4216
15	59.701209	-151.41931
16	59.701563	-151.41948
17	59.700916	-151.40952
18	59.700602	-151.4081
19	59.700298	-151.40736
20	59.700055	-151.40686
21	59.698778	-151.40637
22	59.698822	-151.40571
23	59.699259	-151.40555
24	59.698388	-151.40379

25	59.698353	-151.40846
Cam Trap 1	59.69895354	-151.4133261
Cam Trap 2	59.70089806	-151.4070207
Cam Trap 3	59.70054635	-151.4050192
Cam Trap 4	59.70637538	-151.4119262
Cam Trap 5	59.70237143	-151.4100095
Cam Trap 6	59.70058981	-151.4223652
Cam Trap 7	59.70351874	-151.440288
Cam Trap 8	59.70324755	-151.4266439
Cam Trap 9	59.70106247	-151.4272386

Part C. Land Cover Classification Scheme

Classes were selected based on pilot data collected in the field, as well as level of detail discernible within drone images collected from a height of 120 feet above ground. As vegetation composition of the Preserve changes over time, the classification scheme can be modified to reflect those changes.

1 Built
- 11 Building
- 12 Parking Lot
- 13 Trail
- 14 Other Built

2 Forest
- 21 Alder
- 22 Cottonwood
- 23 Spruce
- 24 Willow
- 25 Mixed Forest
- 26 Other Hardwood
- 27 Dead Tree (Snag)
- 28 Downed Woody Debris

3 Herbaceous/Grasses

31 Blue Joint Grass

32 Cow Parsnip

33 Fireweed

34 Goldenrod

35 Mixed Grasses

4 Shrubs

41 Elderberry

42 Spirea

5 Open/Other Vegetation

51 Lawn

52 Mowed Grasses

53 Bare Ground

54 Moss

6 Water

61 Pond

62 Wetland

Part D. Limitations to Protocol

Studies have successfully used drones to monitor forest and wildlife biodiversity; however, there are limitations, particularly in flying time and low spectral resolution (Getzin et al. 2012; Jones et al. 2006; Zhang 2016). The DJI drones that CACS own exemplify these limitations by having a 15-minute battery life and a camera with only three spectral bands. In particular, the latter is deficient for classifying vegetation through drone imagery. The DJI drone cameras exclusively capture images in visible wavelengths of the electromagnetic spectrum – the red, green, and blue bands (Figure 11.1). In the visible

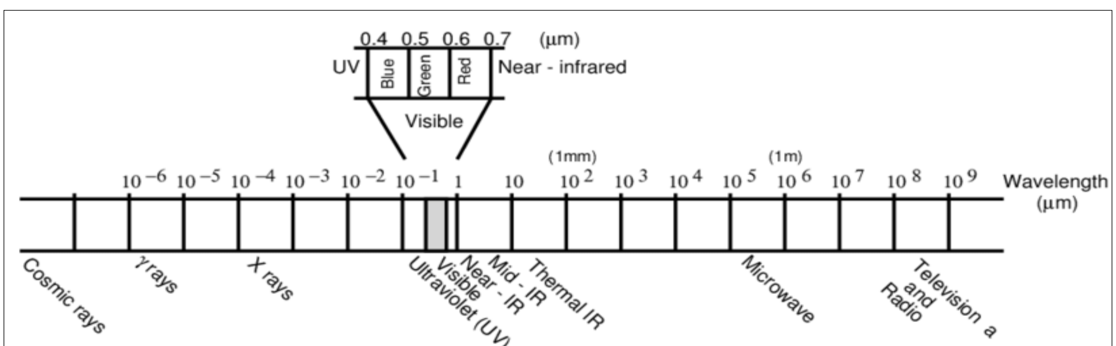


Figure 11.1. The electromagnetic spectrum (image adapted from Lillisand and Kiefer 2015). Images from the DJI drones capture reflectance from wavelengths exclusively in the visible bands (0.4-0.7 micrometers). Images that also capture reflectance from the near-infrared band (0.7-1.3 micrometers) are superior for vegetation classification.

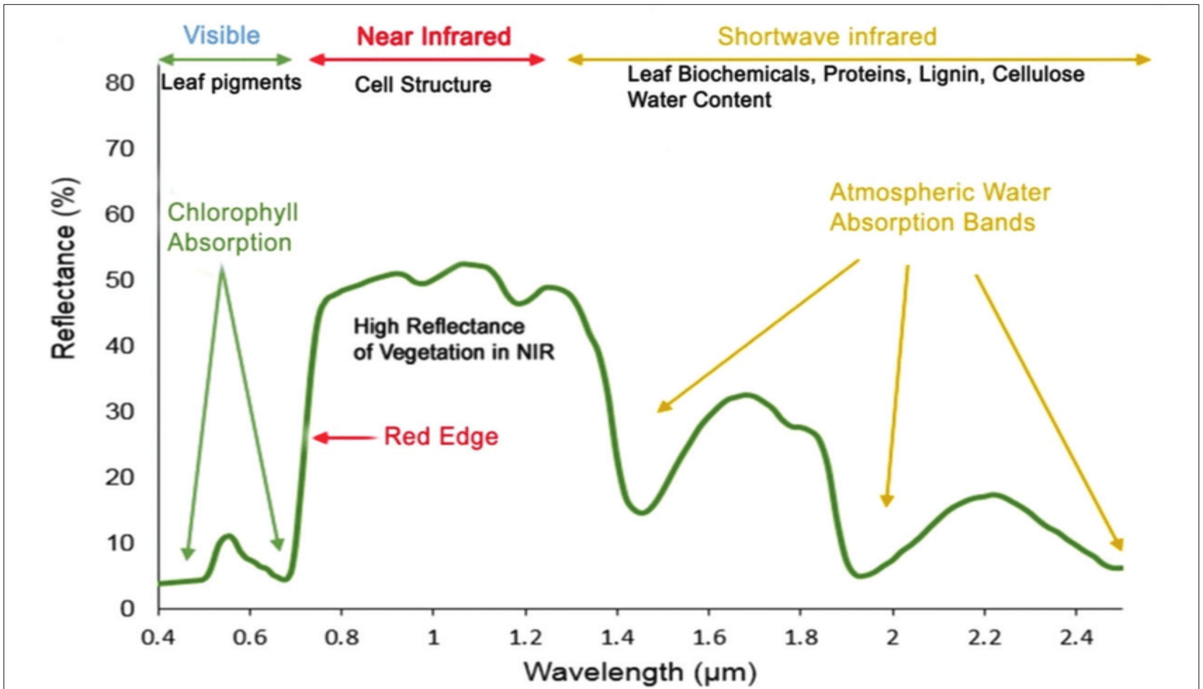


Figure 11.2. The spectral reflectance of vegetation (Roman and Ursu 2016). In the visible bands, the chlorophyll of healthy vegetation absorbs 70-90 percent of incoming radiation, meaning very little is reflected back to the drone camera. At the red edge (~0.7 micrometers), reflectance from vegetation increases significantly and continues to be high throughout near-infrared wavelengths. In this range, reflection is influenced by the cell structure of the leaves, making it easier to distinguish between differing types of green vegetation.

wavelength, energy reflectance (i.e. the amount of energy that is reflected from the plant and captured by the camera) is dictated by chlorophyll pigment, which is largely similar across vegetation types (Figure 11.2). For this reason, near-infrared bands are preferred for vegetation classification. At the edge of the visible wavelength range, the transition to near-infrared range is marked by a sharp increase in leaf reflectance, known as the red edge. At near-infrared wavelengths, reflectance is dependent upon the cell structure of a leaf, including its cell walls and air space, which is more variable across plant species. A near-infrared band is also used to calculate the normalized difference vegetation index (NDVI), a commonly used index to classify vegetation and determine plant health (Meera Gandhi et al. 2015). NDVI is calculated using pixel values from the red and near-infrared bands, which makes it exceptionally useful in distinguishing between vegetation types that have reflectance variability based on photosynthetic activity.

Images captured by a four-band camera (i.e. one with blue, green, red, and near-infrared bands) would yield more sophisticated pixel information that can be used in automated supervised classification. Supervised classification leverages user-defined training samples to develop algorithms that assign classifications based on pixel similarities and spectral signatures. It has potential for a high degree of accuracy and is most commonly used in other ecological remote sensing studies (Hasmadi 2009; Cruzan 2016). A supervised classification was attempted for this project, however, there was too much overlap within the spectral signatures of each defined vegetation class. This made vegetation types indistinguishable and thus rendered it an ineffective method for classification (Figure 11.3). See Part F, Section 4 of this Appendix for further details about performing supervised classification.

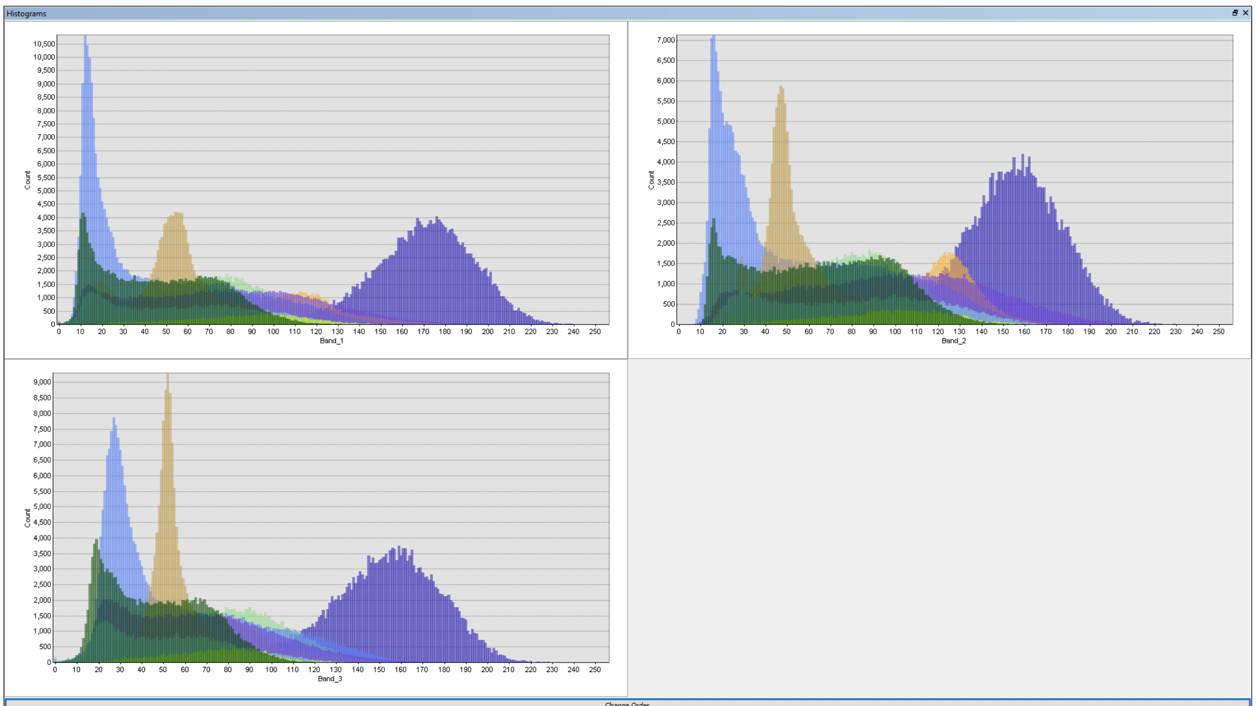


Figure 11.3. Histograms showing the count of pixels for different reflectance values for different vegetation classes found in IRP drone images. Each graph represents a different band (Blue, Green, Red, respectively) in the image. Most vegetation classes have a significant number of pixels within the 10 to ~120 range, leading to overlap of all classes which prevents ArcMap from being able to distinguish between them.

Without a near-infrared band, the process of supervised classification is not feasible. A viable replacement is heads up digitizing, as is outlined in the *Digitizing Protocol*. However, heads up digitizing requires a high level of time and effort and could be a drain on CACS' limited resources. Further, drawing land cover polygons in such a patchy and continuously vegetated landscape as IRP can be subjective. Determining the boundary between two different vegetation classes is not exact in areas where one vegetation species blends into neighboring species. Given this subjectivity, it is preferable to have one person do all digitizing so as to maximize consistency.

Part E. Additional Recommendations on Technical Approaches to Alleviate Limitations

1. Protocol for Flying in a Grid Pattern

Note: Further details and support regarding Pix4D capabilities and operations can be found at: https://support.pix4d.com/hc/en-us/articles/202557459-Step-1-Before-Starting-a-Project-1-Designing-the-Image-Acquisition-Plan-a-Selecting-the-Image-Acquisition-Plan-Type

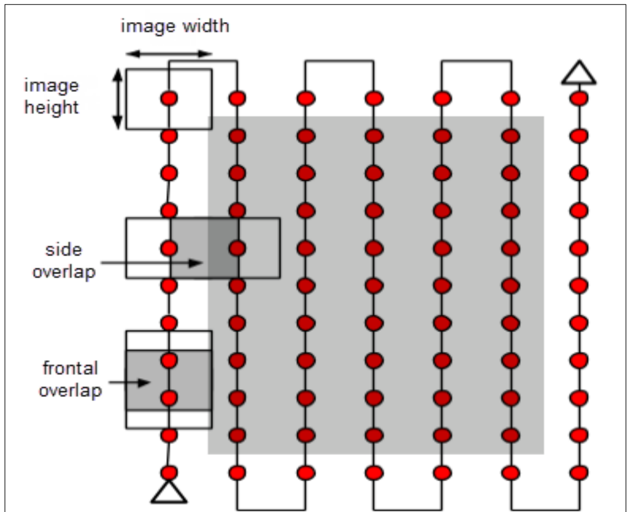


Figure 11.4. Grid Flight Pattern Outline (Pix4D

a. Launch Pix4D and select the correct drone being operated.
b. Select a mission - *Grid.*
c. Adjust the settings of the "Normal" grid mission.
    i. Camera angle at 90 degrees.
    ii. Front overlap at 80 percent.
    iii. Side Overlap at 75 percent.
    iv. Drone Speed at Medium.
d. Adjust the size of the mission by selecting the desired area on the map (Figure 11.5). All flight missions should be square in shape. Set flight height to 119 meters (393 feet).

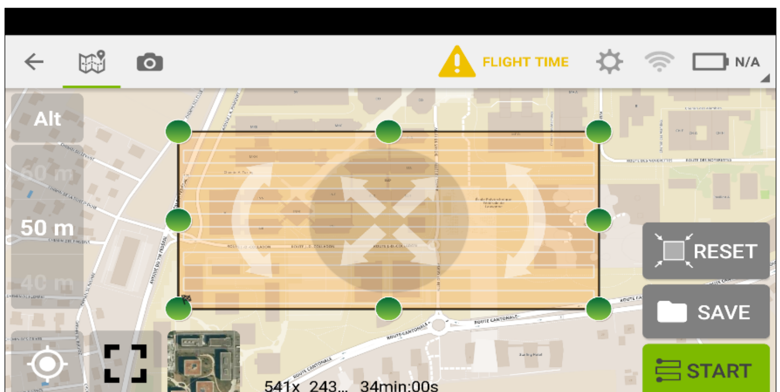


Figure 11.5. Android screen display when selecting grid area.

e. Begin the mission. The drone will fly its pre-programmed course.
f. Check results to ensure photos are high-resolution and not distorted.

2. Use of a More Sophisticated Drone

To alleviate the previously discussed spectral limitations, a more sophisticated and technically advanced drone could be purchased. Based on conversations with researchers using drones at the University of Michigan, a Parrot Bluegrass Fields quadcopter drone is recommended (https://www.parrot.com/business-solutions-us/parrot-professional/parrot-bluegrass#parrot-bluegrass-fields). The advantages of this drone are:

- *High Spectral Variability*: The Parrot Bluegrass Fields system has two integrated sensors, a front-facing camera with standard red, green, and blue bands, as well as a multispectral sensor with green, red, red edge, and near-infrared bands. The latter covers the electromagnetic spectrum from 550nm to 790nm, the range in which vegetation is most easily distinguishable. In particular, the red edge and near-infrared bands will be invaluable in performing a supervised classification of drone imagery. Furthermore, the Parrot Bluegrass Fields has built-in capability to calculate NDVI.
- *Longer Battery Life:* The battery capacity of the Parrot Bluegrass Fields drone is roughly 25 minutes. Longer battery life would extend the time in which the drone could be flown and images could be captured, allowing for a more efficient data collection process.
- *Full Integration with Pix4D:* The Parrot Bluegrass Fields system has full integration with Pix4D, the flying and analysis software recommended above. The integration is so seamless that purchase of a Parrot Bluegrass Fields includes a term subscription to the full Pix4D platform.
- *Sunshine Sensor:* An included sunshine sensor records the amount of light emanated from the sun at the time of each image. Because of this, it is possible to compare images taken at different times, regardless of the amount of light. A calibrated level of light will eliminate the variability of taking images on different days or in multiple years and allow more accurate analysis of changes in vegetation over time.
- *Automated Flight Paths:* Through its native ParrotFields app, the Parrot Bluegrass Fields drone allows for both fully and semi-automated flight paths, as well as manual flying. Automated flight paths, whether through the native app or through Pix4D, will be useful for ensuring images are collected from consistent locations across years. Establishing an automated flight path further ensures that images are sufficiently overlapped so as to perform mosaicing, as discussed above.
- *Compatibility with Ground Truthing:* The native ParrotFields mobile app has the capability to take ground truthing images directly through the app, allowing them to be easily paired and synched with drone images taken from the same location.

3. Multispectral Sensor Attachments

As an alternative to purchasing a new quadcopter drone system, CACS could purchase a multispectral camera (including blue, green, red, and near-infrared bands) to attach to their existing DJI Phantom and Mavic drones. Some options for this are:

- Parrot Sequoia+ Sensor (https://www.parrot.com/business-solutions-us/parrot-professional/parrot-sequoia#parrot-sequoia-): This is simply a detached version of the same multispectral sensor outlined above. It includes green, red, red edge, and near-infrared spectral bands, as well as the sunshine sensor. This sensor is compatible with all drones through a simple USB connection. Like the full quadcopter, the Sequoia+ is fully integrated with the Pix4D technology for easy mapping and analysis.
- Sentera Double 4K Sensor (https://sentera.com/product/inspire-double-4k-upgrade-crop-health-sensor/): The Sentera Double 4K Sensor is compatible with all quadcopter drones but is particularly friendly with the DJI Phantom, including an option for Sentera to complete the hardware integration (including removable attachment system). This system would add red edge and near-infrared bands to CACS' current drone band capabilities. Furthermore, the Sentera Double 4K Sensor calculates NDVI automatically. Although the Sentera comes with a license to its own app and desktop software, it also is fully integrable with Pix4D.
- SlantRange Sensor (https://www.slantrange.com/product-sensor/): The SlantRange Sensor is also compatible with many different quadcopter drones and provides kits through which CACS can integrate the sensor with their existing drones. It includes green, red, red edge, and near-infrared bands, as well as a sunlight calibration that mitigates analytical errors due to varying amounts of light. This sensor has a high degree of precision, capturing spectral resolution up to 10nm, as opposed to some the Parrot which has a resolution of 40nm and the Sentera with a resolution ranging from 20 to 70nm, depending on the band.

4. Protocol for Performing Supervised Classification

It is recommended that supervised classification be performed in ArcPro, which is included in the standard ArcGIS package. ArcPro has improved classification processing algorithms and a more streamlined user interface, making it easier to use and more accurate. In particular, the *Classification Wizard* walks the user through the different steps of the classification process and automatically does much of the post-processing that would otherwise need to be done manually in ArcMap. ESRI has a well outlined tutorial for using the *Classification Wizard* (https://pro.arcgis.com/en/pro-app/help/analysis/image-analyst/the-image-classification-wizard.htm).

a. Create a new project in ArcPro and, within that, a new map with georeferenced drone images. The *Classification Wizard* tool is located under the *Imagery* tab, within the *Image Classification* section (Figure 11.6).

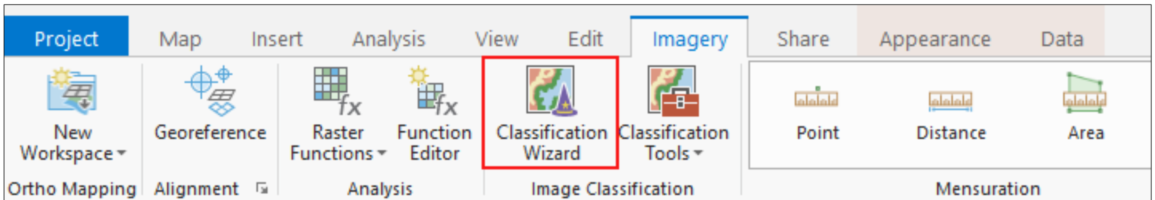


Figure 11.6. The Classification Wizard tool is located under the Imagery tab.

b. Within the *Configure* page of the *Classification Wizard,* choose a *Supervised* classification method and an *Object based* type.

c. The first time that the supervised classification is performed, the classification scheme will need to be constructed manually. This can be done at a later step so, for now, choose the default option (NLCD2011).

d. The next page, *Segmentation,* allows the user to determine the granularity desired in classification. Segmentation is the process of merging neighboring pixels based on similarity in color, shape, and other characteristics. The parameters to be set on this page will likely need to be tested in multiple iterations to determine the ideal balance.

   i. *Spectral detail:* This parameter determines to what degree pixels with different spectral signatures should be combined. It is recommended to start with a high value for spectral detail which will give a high level of importance to spectral differences. This is important given the closeness of spectral signatures in different vegetations.

   ii. *Spatial detail:* This parameter determines to what degree proximity of features should be considered. Since IRP has small patches of highly interspersed vegetation, it is recommended that spatial detail be set to a high value. This will make it easier to classify neighboring features as different classes.

   iii. *Minimum segment size in pixels:* This parameter will set the minimum mapping unit. Any segments smaller than the specified value will be merged with a larger neighboring segment. Segment size can be set between 20-9999 pixels. The minimum segment size should be set such that output polygons are not prohibitively small – which will result in a salt-and-pepper appearance – but not too large so that a lot of detail is lost in an over-generalized classified output.

   iv. S*how Segmented Boundaries Only:* This option should be checked to show polygons without an opaque filling.

e. The *Training Samples Manager* is where the classification schema will be defined. The default schema uses classes from the 2011 National Land Cover Database.

   i. Use the *Remove Class* tool to remove these classes and the *Add New Class* tool to add IRP land cover classes (Figure 11.7). Note that when adding a new class, *Name* will be a text value (e.g. Alder) while *Value* should be numerical (e.g. 21).

   ii. Change the name of the classification scheme by right-clicking on the *NLCD2011* title and selecting *Edit Properties* (Figure 11.7).

   iii. Once the classification scheme has been created completely, save it as a new schema (.ecs file) for later use.

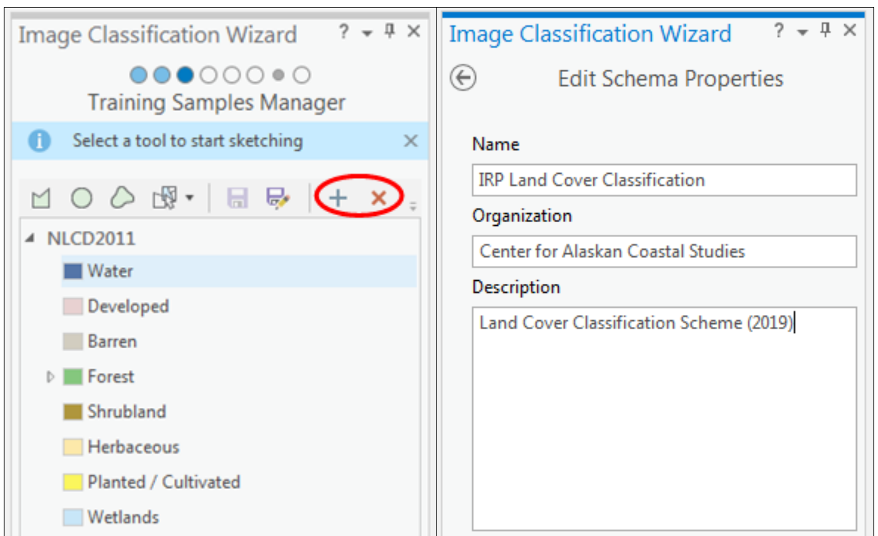


Figure 11.7. (Left). The default classification schema with the *Add* and *Remove Class* tools circled. (Right) Editing the properties of the default schema.

f. The *Training Samples Manager* page is also where the training samples will be defined (Figure 11.8). Training samples are crucial to building the algorithms that ArcPro uses to perform the automated classification. It will use the training samples as a basis for what the spectral signature of each class should look like. As such, training samples will need to be created for each land cover class that is present within the image. The more training samples that are defined, the more accurate the final output would be, but a minimum of three to five should be created for each class. If an insufficient number of samples is created for each class, the process will fail and an error message will be returned.

   i. To define training samples, select the appropriate land cover class and use the *Polygon* drawing tool to draw areas within each class.

   ii. Since the actual classification will be done by ArcPro, polygons do not need to perfectly outline a vegetation patch; it is merely a sampling of pixels for each class. It is important to draw polygons in areas of differing appearance though (e.g. a fireweed area in full sun versus in shadow) so that the full variety of spectral characteristics is captured.
   iii. Training samples should be based on ground truthing.

g. In the *Train* page, the defaults can be maintained. For more information about the different classifying options, see the ESRI tutorial: https://pro.arcgis.com/en/pro-app/help/analysis/image-analyst/classify.htm.

h. Press *Run* to train the classifier. Once it is completed, adjustments can be made to the classifier based on a visual inspection of the output.

i. Once satisfied with the trained classifier, *Run* the classification.

j. After the classification has been run, classes can be merged or edited based on a visual inspection of the output.

k. It is likely that, especially at first, this will need to be an iterative process as CACS determines the more appropriate parameter settings for IRP drone images. The *Reclassifier* will be useful in this process. However, once the ideal parameters are determined, the supervised classification process will be easily replicable on future images.

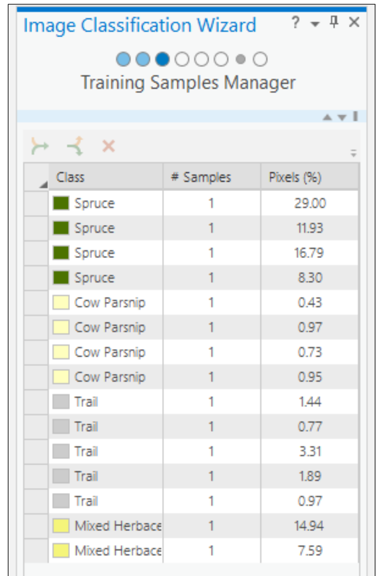


Figure 11.8. Example of defined training samples.

Appendix IV: Wildlife Assessment through Camera Trapping

Part A: Additional Data and Results

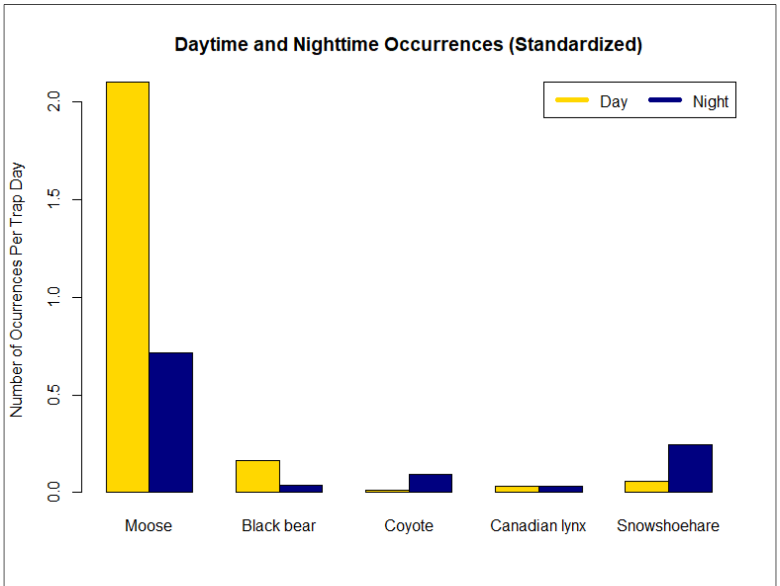


Figure 12.1. Proportion of moose, black bear, coyote, Canadian lynx, and snowshoe hare occurrences during day or at night for all nine camera traps. Showing occ. per trap day, not total (unstandardized) occurrences. Moose, black bear, and Canadian lynx were observed more frequently during the day (75%, 81% and 52%, respectively). Coyote and snowshoe hare were observed more at night (89% and 81%, respectively).

Table 12.1. Number of standardized occurrences (occ./trap day) of each species per camera and relative proportion of total standardized occurrences for each species (for example, 73% of all occurrences were of moose). After standardization, moose was the most frequently observed species for all camera locations except Camera Trap 1, which observed snowshoe hare more than any other species.

	Occurrence per trap day										
Species	Cam 1	Cam 2	Cam 3	Cam 4	Cam 5	Cam 6	Cam 7	Cam 8	Cam 9	Total	Proportion relative to all Occ.
Moose	0.20	0.49	0.33	0.13	0.67	0.35	0.26	0.18	0.20	2.81	0.73
Black bear	0.09	0.02	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.20	0.19
Coyote	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.02	0.01	0.10	0.12
Can. lynx	0.01	0.01	0.04	0.00	0.00	0.00	0.00	0.01	0.00	0.07	0.09
Snowshoe hare	0.22	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.11
Red squirrel	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00

Porcupine	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
Spruce grouse	0.06	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.03
Ring-necked pheasant	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
American Robin	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01
Black-billed magpie	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.01
Unknown bird	0.07	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.02	0.12	0.04
Unknown mammal	0.02	0.00	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.07	0.02

Table 12.2. Wildlife occurrence data (total occurrences and occurrences per trap day) from seasonal analysis - Camera Traps 1-5.

		Cam 1		Cam 2		Cam 3		Cam 4		Cam 5	
	Species	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day
Late Spring May 18-June 30	Moose	21	0.4773	40	0.9302	14	0.3182	13	0.4194	27	1.6875
	Black bear	3	0.0682	2	0.0465	10	0.2273	0	0	0	0
	Coyote	0	0	0	0	1	0.0227	0	0	0	0
	Can. lynx	0	0	1	0.0233	2	0.0455	0	0	0	0
	Snowshoe hare	0	0	0	0	7	0.1591	0	0	0	0
	Red squirrel	0	0	0	0	0	0	0	0	0	0
	Porcupine	2	0.0455	0	0	0	0	0	0	0	0
	Spruce grouse	0	0	0	0	4	0.0909	0	0	0	0
	Ring-necked pheasant	0	0	0	0	0	0	0	0	0	0
	American Robin	5	0.1136	0	0	0	0	0	0	0	0
	Black-billed magpie	0	0	0	0	0	0	0	0	0	0
	Unknown bird	6	0.1364	0	0	0	0	0	0	0	0
	Unknown mammal	0	0	0	0	0	0	0	0	0	0
		Cam 1		Cam 2		Cam 3		Cam 4		Cam 5	
	Species	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day
Summer July 1-Aug. 31	Moose	1	0.0204	27	0.4576	23	0.3898	2	0.0339	49	0.8305
	Black bear	4	0.0816	1	0.0169	3	0.0508	0	0	1	0.0169
	Coyote	2	0.0408	1	0.0169	2	0.0339	0	0	0	0
	Can. lynx	0	0	0	0	0	0	0	0	0	0
	Snowshoe hare	8	0.1633	0	0	0	0	0	0	0	0
	Red squirrel	0	0	0	0	0	0	0	0	0	0

	Porcupine	0	0	0	0	0	0	0	0	0	0
	Spruce grouse	0	0	0	0	0	0	0	0	0	0
	Ring-necked pheasant	0	0	0	0	0	0	0	0	0	0
	American Robin	0	0	0	0	0	0	0	0	0	0
	Black-billed magpie	0	0	0	0	0	0	0	0	0	0
	Unknown bird	3	0.0612	0	0	0	0	0	0	0	0
	Unknown mammal	1	0.0204	0	0	0	0	0	0	0	0

		Cam 1		Cam 2		Cam 3		Cam 4		Cam 5	
	Species	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day
Fall Sept. 1-Nov.5	Moose	5	0.0758	15	0.2308	18	0.2727	2	0.0303	19	0.2879
	Black bear	5	0.0758	0	0	0	0	0	0	0	0
	Coyote	1	0.0152	1	0.0154	2	0.0303	0	0	0	0
	Can. lynx	1	0.0152	1	0.0154	4	0.0606	0	0	0	0
	Snowshoe hare	21	0.3182	0	0	7	0.1061	0	0	0	0
	Red squirrel	1	0.0152	0	0	0	0	0	0	0	0
	Porcupine	0	0	0	0	1	0.0152	0	0	0	0
	Spruce grouse	8	0.1212	0	0	1	0.0152	0	0	0	0
	Ring-necked pheasant	2	0.0303	0	0	0	0	0	0	0	0
	American Robin	0	0	0	0	0	0	0	0	0	0
	Black-billed magpie	1	0.0152	0	0	0	0	0	0	0	0
	Unknown bird	0	0	0	0	0	0	0	0	0	0
	Unknown mammal	1	0.0152	0	0	1	0.0152	0	0	0	0

Table 12.3. Wildlife occurrence data (total occurrences and occurrences per trap day) from seasonal analysis - Camera Traps 6-9.

		Cam 6		Cam 7		Cam 8		Cam 9	
	Species	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day
Late Spring May 18-June 30	Moose	NA	NA	NA	NA	NA	NA	NA	NA
	Black bear	NA	NA	NA	NA	NA	NA	NA	NA
	Coyote	NA	NA	NA	NA	NA	NA	NA	NA
	Can. lynx	NA	NA	NA	NA	NA	NA	NA	NA
	Snowshoe hare	NA	NA	NA	NA	NA	NA	NA	NA
	Red squirrel	NA	NA	NA	NA	NA	NA	NA	NA
	Porcupine	NA	NA	NA	NA	NA	NA	NA	NA
	Spruce grouse	NA	NA	NA	NA	NA	NA	NA	NA
	Ring-necked pheasant	NA	NA	NA	NA	NA	NA	NA	NA

	American Robin	NA	NA	NA	NA	NA	NA	NA	NA
	Black-billed magpie	NA	NA	NA	NA	NA	NA	NA	NA
	Unknown bird	NA	NA	NA	NA	NA	NA	NA	NA
	Unknown mammal	NA	NA	NA	NA	NA	NA	NA	NA

		Cam 6		Cam 7		Cam 8		Cam 9	
	Species	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day
Summer July 1- Aug. 31	Moose	17	0.6296	16	0.5926	5	0.1852	4	0.1481
	Black bear	0	0	0	0	0	0	0	0
	Coyote	0	0	0	0	0	0	0	0
	Can. lynx	0	0	0	0	1	0.0370	0	0
	Snowshoe hare	0	0	0	0	0	0	0	0
	Red squirrel	0	0	0	0	0	0	0	0
	Porcupine	0	0	0	0	0	0	0	0
	Spruce grouse	0	0	0	0	0	0	0	0
	Ring-necked pheasant	0	0	0	0	0	0	0	0
	American Robin	0	0	0	0	0	0	0	0
	Black-billed magpie	0	0	0	0	0	0	0	0
	Unknown bird	1	0.0370	0	0	0	0	0	0
	Unknown mammal	1	0.0370	0	0	1	0.0370	0	0

		Cam 6		Cam 7		Cam 8		Cam 9	
	Species	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day	Total occ.	Occ. per trap day
Fall Sept. 1- Nov.5	Moose	14	0.2154	8	0.1231	13	0.2	15	0.2308
	Black bear	0	0	0	0	0	0	0	0
	Coyote	0	0	0	0	2	0.0308	1	0.0154
	Can. lynx	0	0	0	0	0	0	0	0
	Snowshoe hare	0	0	0	0	0	0	0	0
	Red squirrel	0	0	0	0	0	0	0	0
	Porcupine	0	0	0	0	0	0	0	0
	Spruce grouse	0	0	0	0	0	0	0	0
	Ring-necked pheasant	0	0	0	0	0	0	0	0
	American Robin	0	0	0	0	0	0	0	0
	Black-billed magpie	1	0.0154	0	0	0	0	0	0
	Unknown bird	1	0.0154	1	0.0154	0	0	2	0.0308
	Unknown mammal	1	0.0154	0	0	0	0	1	0.0154

Table 12.4. Number of trap days that each camera trap was operating in each season (Late Spring, Summer, and Fall) and the total number of traps days in each season.			
Trap Number	Late Spring	Summer	Fall
Camera Trap 1	44	49	66
Camera Trap 2	43	59	65
Camera Trap 3	44	59	66
Camera Trap 4	31	59	66
Camera Trap 5	16	59	66
Camera Trap 6	0	27	65
Camera Trap 7	0	27	65
Camera Trap 8	0	27	65
Camera Trap 9	0	27	65
Total Days in Season	44	62	66

Analysis of Wildlife Occurrences and Vegetation Type

The proportions of vegetation type (Tree, Shrub, Herbaceous) surrounding a camera trap location did not have a significant impact on wildlife sightings for any species. However, this result may be a consequence of small sample size; several of the camera traps had zero occurrences of a particular species, which may have skewed the findings. This analysis should be repeated once additional camera trap sampling is completed at these locations in order to confirm whether or not there is a correlation between wildlife occurrence and proportions of the different vegetation classes. The proportions of trees, shrubs, and herbaceous vegetation within a 28-meter radius of Camera Traps 1-9 are provided in Table 12.6.

Table 12.5. Approximate distance from each camera trap to the nearest building and major road.		
Trap Number	Distance to nearest building (m)	Distance to nearest road (m)
Camera Trap 1	143	305
Camera Trap 2	208	480
Camera Trap 3	326	578
Camera Trap 4	164	77
Camera Trap 5	136	239
Camera Trap 6	165	202
Camera Trap 7	482	409
Camera Trap 8	448	561
Camera Trap 9	213	339

Table 12.6. Proportion of Trees, Shrubs, and Herbaceous vegetation location within 28 meters of each camera trap location.			
Trap Number	Proportion tree	Proportion shrub	Proportion herb
Camera Trap 1	0	0.421591302	0.546858004
Camera Trap 2	0.771766361	0.041455313	0.079859841
Camera Trap 3	0.652441807	0.083257893	0.137689386
Camera Trap 4	0.244676273	0.323370565	0.348419712
Camera Trap 5	0.912199641	0.087800359	0
Camera Trap 6	0.388251322	0	0.485884705
Camera Trap 7	0.419267054	0.262452572	0.233339762
Camera Trap 8	0.55060842	0.010339883	0.279696874
Camera Trap 9	0.679087928	0.117464325	0.077180775

Part B: Additional Details About Methods

1. Wildlife Image Processing

The total number of trap days (i.e. sampling effort) was calculated by summing the number of trap days of all cameras. For the 2018 period of observation, due to variation in installation and removal dates, as well as technical problems with memory cards and batteries, the number of traps days was different for each of the camera traps and thus occurrence data needed to be standardized, as described in the protocol. The total number of trap days was 1,110 days and the total number of wildlife images taken was 1,057.

2. Seasonal Assessment

Occurrences per season were standardized to the number of *occurrences per trap day*, without being scaled up to *occurrences per 30 days*. In addition, Camera Traps 5-9 were not installed until August 2018. Therefore, no occurrence data is available for these traps during the late spring season (see Table 7.5).

3. Drone Image Capture and Vegetation/Wildlife Analysis

The methods for the vegetation analysis for the camera trap locations utilized in the current assessment differed from the steps outlined in the protocol as follows. Due to technical problems, weather, and time constraints during field sampling, it was not feasible to take aerial images directly above all of the nine camera traps. Therefore, images used for this analysis were selected based on vicinity to the camera trap locations and distance of the camera trap from the edge of the image. Due to this limitation, images from both May and August 2018 and images from altitudes of 393 feet (119 meters) and 120 feet (37 meters) were used to allow for a sufficient area of land around the camera traps to be analyzed. This also contrasts with the 2018 vegetation data processing procedures, which included only images from August 2018.

A radius of 28 meters was selected for the vegetation quantification process. This radius was chosen based on the limitations of the drone images for Camera Trap 3 and 4. The available drone images in the vicinity of Camera Trap 4 were not directly above the camera's location, and so the camera trap was only 28 meters from the edge of the closest image. Therefore, a larger radius was not possible for this analysis due to this limiting factor. Furthermore, multiple drone images needed to be overlaid and digitized for Camera Trap 3, otherwise a radius of only nine meters would have been feasible. Even after overlapping two drone images, a narrow area within the desired radius was not covered by the drone images. Therefore, an aerial image (imagery2013sharp) was utilized to infer the land cover of that area.

Appendix V: Kachemak Crane Watch Application: Protocol for Creating Applications and Extensions with ESRI Software

Should CACS seek to build tools similar to the application and extensions detailed in this report, the following directions outline the procedures.

<u>Step 1: Feature Service (ArcDesktop and ArcOnline).</u>

1. *Geodatabase* Creation:
    a. Open *ArcCatalog.*
        i. Connect to desired folder (ex. *Crane App).*
    b. Create *Geodatabase.*
        i. In folder make:
            1. Create new geodatabase (e.g. *Kachemak_Crane_Watch).*
                a. Added *Domains* (see Appendix VI: Kachemak Crane Application: Text for Applications and Extensions).
            2. Copy, paste, and rename new geodatabase once one created.
                a. This enables user to edit geodatabase more easily without losing the original. Save both geodatabases.
    c. Add *Feature Class.*
        i. Change alias to *Kachemak Crane Watch.*
        ii. Choose *Point Features.*
        iii. Choose *Coordinate System.*
            1. Alaska Albers Equal Area Conic, "NAD_1983_Alaska_Albers."
        iv. Accept the *Defaults.*
        v. Enter *Fields* in desired order, as they cannot be changed later:
            1. Type of Observation.
            2. Number of Adults.
            3. Number of Juveniles.
            4. Juvenile Fledgling Status.
            5. Sex of Cranes.
            6. Crane Injury?
            7. Please Provide details on Observed Injury.
            8. Crane Mortality?

9. Please Provide details on Observed Mortality.
10. Duration of Crane Observation.
11. Confidence in Accuracy of Observation.
12. Additional Comments (Behavior, Vocalizations, Surrounding, Habitat, etc).

vi. Copy, Paste, and Rename *Fields* to the backup geodatabase using *Transferred Data.*

d. Right-click on *Feature Class* | *Manage* | *Add Attachments.*

2. Open the *Layer* in *ArcMap.*
   a. Change *Symbology* using "*Conservation*" symbols.
      i. Used same symbols but different colors for each iteration or geodatabase.
      ii. Used bird for crane only, tribe (feather) for nest and cranes, and spiral for nest only.
3. Publishing (from *ArcMap).*
   a. File | *Log in.*
   b. *File* | *Share As* | *Service* | *Publish Service* | Choose *Connection (Host*- "dropdown") | *Name.*
   c. *Service Editor* opens | *Capabilities* | Check *Feature Access* and uncheck *Tiled Mapping.*
   d. Feature Access | *Create, Update, Delete, Sync.*
   e. *Item Description* | *Add Data* tag.
      i. Add *Summary, Tags & Description* (see Appendix VI: Kachemak Crane Application: Text for Applications and Extensions).
      ii. Click *Publish* and close window when done (*Save* if prompted).
4. *Arc Web Map* Creation.
   a. Building *Web Map.*
      i. Click *Map* button on ribbon.
      ii. Pan to US (or study area).
      iii. Click *Basemap* and zoom to desired level (e.g. *Streets*).
   b. Add *Layer.*
      i. Add and Search for *Layers* | *My Content* | *Add.*
      ii. When done adding layers, go back to *Contents*.
      iii. Click *Edit*. Add feature to map by clicking location and filling out required fields.
         1. Add one point of each *Observation Type*.

iv. Save. Add *Name, Tags* and *Summary* to the main information page.
v. Test the pop up- zoom in on one and click on it.
1. Check to see if it works.

c. Configure Data Collection Form
i. *Table of Contents* of *web map* (on the left) | hover over *Layer* | … | *Configure Pop Up.*
ii. Click *Configure Attributes.*
iii. User can control what to display.

d. Customize the application.
i. About *(i)* on side panel | *More Details* | *Settings.*
ii. Choose any additional features (e.g. search hint).
iii. Reset the *Extent.*

e. Share map.
i. *Overview* | *Share* | *Groups* | *Ok.*
ii. Shares with *Groups* or *Everyone.*

f. Now user can open and drop points.

<u>Step 2: Set Up *Dashboard*</u>

1. Select the 3x3 grid next to the user name.
   a. Find *Dashboard.*
2. Connect to the created *Feature Service*.
3. Add features as desired.
   a. For ease and consistency, open two tabs next two each other or two desktops and mimic the parameters for the existing *Dashboard.*
   b. Colors, variables, and sizes can all be changed.
   c. Hover over *Widgets* to *Edit* or *Move.*
      i. Click and drag to new location.
      ii. Select separating lines to re-adjust sizes.
      iii. Select *Customize* to edit.

<u>Step 3: Set Up *Web App*</u>

1. Open the created *Web Map* on *ArcOnline.*
   a. From the right hand menu, select create *Web App* | Using *Web AppBuilder.*
   b. Fill out *Information* as prompted.

i. Must have fields filled out to continue.

c. Select *Theme* (e.g. *Billboard).*

d. *Maps* tab | Use *Web Map*'s default extent.

e. Widgets.

i. Under the existing *Widgets* (blue icons) check:

1. *Coordinates* - Shows the coordinates of the cursor along the bottom left of the screen.
2. *Full Screen* - Allows the *Web App* to fill the screen.
3. *Home* - Brings back to default extent.
4. *My Location* - Identifies users GSP location.
5. *Overview* - Shows larger map context.
6. *Scale Bar* - Shows the map scale.
7. *Search* - Can search a location or address.
8. *Zoom Slider* - Zoom in and out of map.

ii. Under the *Five Optional Additions* (grey icons) select:

1. *About* - Shows information about the web app.
2. *Legend* - Explains symbology used in map.
3. *Edit* - Allows a point to be dropped.
4. *Attribute Table* - Summary of points and values.
5. *Basemap* - Allows user to change the basemap type.

2. *Launch, Preview*, or *Save Web App* along bottom.

<u>Step 3: Push through into *AppStudio* (Edit and Build)</u>

1. Click the *AppStudio* button from *ArcOnline.*

a. Build from scratch:

i. Select *Quick Report* template.

ii. Add title, summary, and images (see Appendix VI: Kachemak Crane Application: Text for Applications and Extensions).

iii. Under *Quick Report Settings*:

1. Edit image and select *Feature Service* to connect to (e.g. Kachemak Crane Watch).

iv. *Save and Finish.*

v. To customize app, download *AppStudio* onto your desktop.

1. Can edit more settings in this version.

        2. Can enter licensing information.
    vi. Can build app from online version, but better to build from desktop version once all edits made.
    vii. *Landing page*: creates page where all the app can be downloaded from all platforms.

2. To build app with proper licensing:
    a. Make *ESRI Developer Account.*
    b. If application intended for Apple devices, user will have to pay $100 fee to become a developer. Steps online to help if interested.
        i. Once developer rights acquired, user need to get certificate for 1) development and 2) distributing.
        ii. User can also make provisioning profiles before releasing to app store. These profiles allow app distribution to a limited number of selected devices for testing.

Appendix VI: Kachemak Crane Watch Application: Text for Applications and Extensions

This appendix contains the necessary text for the formation of the desktop geodatabase, domains (i.e. the application's drop-down menus), feature class, and fields (i.e. the application's main questions). Additionally, the text displayed within the application and on the online information pages for each application and extension is provided. Terms and conditions, tags, and credits are also provided. All changes to the text should be noted and kept consistent throughout the applications and extensions.

Part A. Text for Desktop Geodatabase, Domains, and Feature Class & Fields

1. *Geodatabase:* KachemakCraneWatch.gdb.
2. *Domains:* SubFields or Drop-Down Lists for the Fields.
    a. *Name:* Crane_Injury?; *Description:* Was a Crane Injury Observed?
        i. *Field:* Text; *Domain Type*: Coded Value.
        ii. Code Values:
            1. *Code:* Yes, Injury Observed; *Description*: Injured Crane Observed.
            2. *Code:* No, Injury Not Observed; *Description*: Injured Crane Not Observed.
    b. *Name*: Crane_Mortality?; *Description:* Was a Crane Mortality Observed?
        i. *Field:* Text; *Domain Type*: Coded Value.
        ii. Code Values:
            1. *Code:* Yes, Mortality Observed; *Description:* Crane Mortality Observed.
            2. *Code:* No, Mortality Not Observed; *Description*: Crane Mortality Not Observed.
    c. *Name:* Juvenile_Fledging_Status; *Description:* Can the Juvenile Cranes Fly?
        i. *Field:* Text, *Domain Type*: Coded Value.
        ii. Code Values:
            1. *Code:* Juveniles Can Fly; *Description:* Juveniles Can Fly.
            2. *Code:* Juveniles Cannot Fly; *Description*: Juveniles Cannot Fly.
            3. *Code:* Unsure; *Description*: Unsure if Juveniles Can Fly or Not.
    d. *Name:* Number_of_Adults; *Description:* Number of Observed Adults.
        i. Long Integer.
    e. *Name:* Number_of_Juveniles; *Description:* Number of Observed Juveniles.

        i. Long Integer.

f. *Name:* Observation_Confidence; *Description:* How confident are you in the accuracy of your observation?
    i. *Field:* Text; *Domain Type:* Coded Value.
    ii. *Code Values:*
        1. *Code:* High Confidence in Observation Accuracy; Description: High Confidence in Observation Accuracy.
        2. *Code:* Medium Confidence in Observation Accuracy; Description: Medium Confidence in Observation Accuracy.
        3. *Code:* Low Confidence in Observation Accuracy; Description: Low Confidence in Observation Accuracy.

g. *Name:* Observation_Duration; *Description:* How long did you spend observing the cranes?
    i. *Field:* Text; Domain Type: Coded Value.
    ii. *Code Values*:
        1. *Code:* Observed 1 minutes or less; *Description:* Observed 1 min or less.
        2. *Code:* Observed 2 - 5 minutes; *Description:* Observed 2 - 5 minutes.
        3. *Code:* Observed 6 - 10 minutes; *Description*: Observed 6 - 10 minutes.
        4. *Code*: Observed 11 - 20 minutes; *Description*: Observed 11 - 20 minutes.
        5. *Code:* Observed 21 - 30 minutes; *Description*: Observed 21 - 30 minutes.
        6. *Code*: Observed 31 minutes - 1 hour; *Description*: Observed 31 minutes - 1 hour.
        7. *Code:* Observed 1 hour or more; *Description*: Observed 1 hour or more.

h. *Name*: Sex_of_Cranes; *Description:* Sex of Cranes Observed.
    i. *Field:* Text; *Domain Values:* Coded Value.
    ii. *Code Values:*
        1. *Code:* Only Males; *Description*: Only Male Cranes Observed.
        2. *Code:* Only Females; *Description*: Only Female Cranes Observed.
        3. *Code:* Mix of Males and Females; *Description*: Mix of Males and Female Cranes Observed.
        4. *Code:* Unsure; *Description:* Unsure if Cranes Male or Female.

i. *Name:* Type_of_Observation; *Description*: Observation Type.
    i. *Field:* Text; *Domain Type*: Coded Value.
    ii. *Code Values:*

1. *Code:* Nest Only; *Description:* Empty Nest Observed.
2. *Code:* Cranes Only; *Description:* Only Cranes Observed.
3. *Code:* Nest and Cranes; *Description:* Nest and Cranes Observed.

3. *Feature Class:* KachemakCraneWatch.
4. *Feature Services:*
   a. *Name:* Type_of_Observation; *Alias*: Type of Observation.
      i. Allow NULL, No Default, *Domain:* Type_of_Observation, *Length:* 50.
   b. *Name:* Number_of_Adults; *Alias:* Number of Adults.
      i. Allow NULL, *Default Value:* 0.
   c. *Name*: Number of Juveniles.
      i. Allow NULL, *Default Value*: 0.
   d. *Name:* Juvenile_Fledging_Status; *Alias:* Juvenile Fledging Status.
      i. Allow NULL, *Default Value:* Unsure, *Domain:* Juvenile_Fledging_Status, *Length:* 50.
   e. *Name:* Sex_of_Cranes; *Alias:* Sex of Cranes.
      i. Allow NULL, *Default Value:* Unsure, *Domain:* Sex_of_Cranes, *Length:* 50.
   f. *Name:* Crane_Injury_; *Alias:* Crane Injury?
      i. Allow NULL, *Default Value*: No, Injury Not Observed, *Domain:* Crane_Injury?, *Length:* 50.
   g. *Name*: Please_Provide_Details_on_Observed_Injury; *Alias:* Please Provide Details on Observed Injury.
      i. Allow NULL, *Length:* 100.
   h. *Name:* Crane_Mortality_; *Alias:* Crane Mortality?
      i. Allow NULL, *Default Value:* No, Mortality Not Observed, *Domain:* Crane_Mortality?, *Length:* 50.
   i. *Name*: Please_Provide_Details_on_Observed_Mortality; *Alias:* Please Provide Details on Observed Mortality.
      i. Allow NULL, *Length:* 100.
   j. *Name:* Duration_of_Crane_Observations; *Alias:* Duration of Crane Observations.
      i. Allow NULL, *Domain:* Observation_Duration, *Length:* 50.
   k. *Name*: Confidence_in_Accuracy_of_Observations; *Alias:* Confidence in Accuracy of Observations.
      i. Allow NULL, *Domain:* Observation_Duration, *Length:* 50.

l. *Name:* Additional_Comments_Behavior_Vocalization_Surrounding_Habitat_etc_; *Alias:* Additional Comments (Behavior, Vocalization, Surrounding Habitat, etc).
    1. Allow NULL, *Length:* 100.

Part B. Tags, Credits, and Terms of Use

1. Tags

Kachemak, Crane, Cranes, Watch, IRP, InspirationRidgePreserve, Inspiration, Ridge, Preserve, CACS, Population, Monitoring, Homer, Alaska, CitizenScience, Science, Citizen, CenterForAlaskanCoastalStudies, Sandhill, UniversityOfMichigan, SEAS

2. Credits (Attribution)

Application designed and created by Dorthea Leisman. Application created as an extension of the Center for Alaskan Coastal Studies' project Kachemak Crane Watch for the Inspiration Ridge Preserve property and the greater Homer area. All photographs by Nina Faust. Logo designed by Dorthea Leisman. Additional thanks to Shannon Brines, Inés Ibáñez, Beth Trowbridge, Nina Faust, Kelsey Blongewicz, Lorena Cortes, Emily Finch, Lauren Joyal, Liz McLaughlin, Peter Knoop, and the University of Michigan School for Environment and Sustainability.

3. Terms of Use

Terms and Conditions ("Terms"). Last updated: (April 2019).
Please read these Terms and Conditions ("Terms", "Terms and Conditions") carefully before using the Kachemak Crane Watch mobile application (the "Service") operated by the Center for Alaskan Coastal Studies (CACS) and Kachemak Crane Watch ("us", "we", or "our"). Your access to and use of the Service is conditioned on your acceptance of and compliance with these Terms. These Terms apply to all visitors, users and others who access or use the Service. By accessing or using the Service you agree to be bound by these Terms. If you disagree with any part of the Terms then you may not access the Service.
Content: Our Service allows you to post, link, store, share and otherwise make available certain information, text, graphics, videos, or other material ("Content"). Users may not falsify data or observations. All information made available will thereafter be owned and managed by the Center for Alaskan Coastal Studies (CACS) to be used at their discretion for research, education, and management. All data rights are reserved for CACS and may be shared with parties or individuals they deem necessary. However, specific locations detailing nesting sites or observations made on private property will NOT

published on social media, used for promotions, or widely distributed for the privacy of individuals and protection of the cranes. Individual citizen reporters will remain confidential.
Links to Other Websites: Our Service may contain links to third-party web sites or services that are not owned or controlled by CACS or Kachemak Crane Watch. Neither CACS nor Kachemak Crane Watch has control over, and assumes no responsibility for, the content, privacy policies, or practices of any third-party web sites or services. You further acknowledge and agree that CACS and Kachemak Crane Watch shall not be responsible or liable, directly or indirectly, for any damage or loss caused or alleged to be caused by or in connection with use of or reliance on any such content, goods or services available on or through any such web sites or services.
Changes: We reserve the right, at our sole discretion, to modify or replace these Terms at any time. If a revision is material, we will try to provide at least 30 days' notice prior to any new terms taking effect. What constitutes a material change will be determined at our sole discretion.
Contact Us: If you have any questions about these Terms, please contact us.

Part C. Text for the Feature Service

1. Title

Feature Service

2. Summary

Using Citizen Science to Understand the Population Dynamics of the Migratory Sandhill Cranes in Homer, Alaska.

3. Description

This feature service was published from a geodatabase made in ArcGIS Desktop. It is the base for all the other applications and extensions as detailed below. All data from the native application and the web application will be stored in this feature service's database. Access to the database and files below is restricted for non-administrator users.

The applications and extensions include:

1. Native Application: *click here for info page.* (https://umich.maps.arcgis.com/home/item.html?id=5ae8f42bb32947ce897e68805f5e1289).

Download files for the application can be found on the Center for Alaskan Coastal Studies and Kachemak Crane Watch webpages.

2. Two background files for the native application: 1 service definition and 1 web map.
3. Web Application: *click here.* (https://umich.maps.arcgis.com/home/item.html?id=63938e4b3db44121a65a1d649cfad022)
4. One background file for the web application: 1 web map.
5. Dashboard for Administrators: *click here.* (https://umich.maps.arcgis.com/home/item.html?id=f2ac85e5a54b427fb9133edacc605978)
6. Dashboard for Public: *click here*. (https://umich.maps.arcgis.com/home/item.html?id=eac3e3fa923144f380888d610cdd7a03)
7. Two background files for the public dashboard: 1 feature layer and 1 web map.
8. Story Map: *click here for info page* (https://umich.maps.arcgis.com/home/item.html?id=3fbba18347d841bb89fbbc53ba60d2cb) and *click here* (https://umich.maps.arcgis.com/apps/Cascade/index.html?appid=3fbba18347d841bb89fbbc53ba60d2cb) to go directly to the story map.

The Kachemak Crane Watch application project is an extension of the *Center for Alaskan Coastal Studies'* (https://www.akcoastalstudies.org/) monitoring program *Kachemak Crane Watch* (http://cranewatch.org/), a program dedicated to the protection and study of hundreds of migratory sandhill cranes that have frequented Inspiration Ridge Preserve and the greater Homer area since the late 1990s.

Individual observations can only be viewed by creator and database administrators. Specific crane observation locations on private property or detailing nest locations will not be published to ensure privacy and crane safety.

Part D. Text for the Native Application

1. Title

Kachemak Crane Watch Application

2. Summary

Using Citizen Science to Understand the Population Dynamics of the Migratory Sandhill Cranes in Homer, Alaska.

3. Description

This native application is an extension of the *Center for Alaskan Coastal Studies*' (https://www.akcoastalstudies.org/) monitoring program *Kachemak Crane Watch* (http://cranewatch.org/), a program dedicated to the protection and study of hundreds of migratory sandhill cranes that have frequented Inspiration Ridge Preserve and the greater Homer area since the late 1990s.

Download files for the application can be found on the Center for Alaskan Coastal Studies and Kachemak Crane Watch webpages.

To drop a new observation point:

1. Click New (+) button or open a previously saved draft point from the Draft button.
2. Select an Observation Type from the provided menu. Click Next.
3. Let your phone geo-locate or press and hold your location on the map until an address appears to drop pin. Click Next.
4. Attach photos (select the camera icon to take picture or select the album to add existing pictures) and audio files (select the audio icon to add file) as wanted. Click Next.
5. Select best response for each question from drop down menu or enter a number or comment as prompted.
6. Submit your Observation, or save it as a Draft.

For more background information and more explicit directions on how to make an observation, including more images and information on crane identification *click here* (https://umich.maps.arcgis.com/apps/Cascade/index.html?appid=3fbba18347d841bb89fbbc53ba60d2cb).

Individual observations can only be viewed by creator and database administrators. Specific crane observation locations on private property or detailing nest locations will not be published to ensure privacy and crane safety.

Part E. Text for the Web Application

1. Title

Kachemak Crane Watch Web Application

2. Summary

Using Citizen Science to Understand the Population Dynamics of the Migratory Sandhill Cranes in Homer, Alaska.

3. Description

This application is an extension of the *Center for Alaskan Coastal Studies'* (https://www.akcoastalstudies.org/) monitoring program *Kachemak Crane Watch* (https://umich.maps.arcgis.com/home/cranewatch.org), a program dedicated to the protection and study of hundreds of migratory sandhill cranes that have frequented Inspiration Ridge Preserve and the greater Homer area since the late 1990s.

App widgets allow user to return to default extent, find current location, read information, view the legend, drop or edit an observation point, view the data table, or change the base map.

Heat map zoom restrictions have been set for observer and crane privacy. To drop a point, user must zoom out to the visible extent before selecting the editing widget. After the observation type is selected, then user can zoom to the specific location to drop an observation.

To drop a new observation point:

1. Select the Edit icon.
2. Click on the best fitting Observation Type icon.
3. Hover over the map until the location where observation occurred is found. Click to drop the point.
4. Select best response for each question from drop down menu or enter a number or comment as prompted.
5. Attach photos (select the camera icon to take picture or select the album to add existing pictures) and audio files (select the audio icon to add file) as wanted. Click Next.
6. Click Save and close window.

For more background information, including more images and information on crane identification click *here.* (https://umich.maps.arcgis.com/apps/Cascade/index.html?appid=3fbba18347d841bb89fbbc53ba60d2cb)

NOTE: Logged in users can only view and edit data points they created. Anonymous users can only create new points. An ArcGIS account log in can be created on https://www.arcgis.com/home/index.html without purchasing ESRI software.

Part F. Text for Dashboard (Administration)

1. Title

Kachemak Crane Watch – Dashboard (Administration)

2. Summary

Using Citizen Science to Understand the Population Dynamics of the Migratory Sandhill Cranes in Homer, Alaska.

3. Description

This is a summary dashboard of the data from the feature service created for administrators only. All features can be edited or more features can be added.

Includes:

1. Interactive map of observation locations.
2. Legend.
3. Pie chart of observation type counts data.
4. Pie chart of reported crane sex data.
5. Gauge of reported crane injuries out of total.
6. Gauge of reported crane moralities out of total.
7. Bar chart of age demographics.
8. Pie chart of fledging status of reported juvenile cranes.
9. Bar chart comparing frequency of reported confidence in observation accuracy and the correlating observation time frame.

An additional dashboard called Kachemak Crane Watch - Dashboard (Public) has been created with summary statistics CACS and Kachemak Crane Watch have approved appropriate for sharing.

Part G. Text for Dashboard (Public)

1. Title

Kachemak Crane Watch – Dashboard (Public)

2. Summary

Using Citizen Science to Understand the Population Dynamics of the Migratory Sandhill Cranes in Homer, Alaska.

3. Description

Summary information from the Kachemak Crane Watch Application. Heat map zoom restrictions have been set for observer and crane privacy.

NOTE: Logged in users can view dashboard of data points they created. Anonymous users cannot view the dashboard. An ArcGIS account log in can be created on *https://www.arcgis.com/home/index.html* (https://www.arcgis.com/sharing/rest/oauth2/authorize?client_id=arcgisonline&display=default&response_type=token&state=%7B%22useLandingPage%22%3Atrue%7D&expiration=20160&locale=en-us&redirect_uri=https%3A%2F%2Fwww.arcgis.com%2Fhome%2Faccountswitcher-callback.html&force_login=true&showSignupOption=true) without purchasing ESRI software.

Includes:

1. Heat map of observation locations.
2. Gauge of reported crane injuries out of total.
3. Gauge of reported crane moralities out of total.
4. Pie chart of observation type counts.
5. Pie chart of reported cranes' sex.
6. Bar chart of reported cranes' age.
7. Pie chart of fledging status of reported juvenile cranes.

For more information on the background or application *click here* (https://umich.maps.arcgis.com/apps/Cascade/index.html?appid=3fbba18347d841bb89fbbc53ba60d2cb).

Part H. Text for the Story Map

[Heading] Background

This application is an extension of the *Center for Alaskan Coastal Studies*' (https://www.akcoastalstudies.org/) monitoring program *Kachemak Crane Watch* (http://cranewatch.org/), a program dedicated to the protection and study of hundreds of migratory sandhill cranes that have frequented Inspiration Ridge Preserve and the greater Homer area since the late 1990s.

[CACS Logo]

While this population has been the focal point of several formal studies, including several by the *International Crane Foundation* (https://www.savingcranes.org/), and remains a source of interest to the many crane experts, nature videographers, and avid birders that flock to Homer to observe the cranes in this unique setting, the population's main annual tracking has been conducted by local citizen scientists. [*International Crane Foundation Logo* - For more information on the crane study conducted by Dr. Gary Ivey *visit this website*. (https://www.savingcranes.org/wp-content/uploads/2009/01/annual_travels_sh_cranes_homer.pdf)]

Observational data including the population's migration phenology, breeding, survival, and behavior has been historically collected from the Crane Watch hotline or email and filed as a physical paper record.

[Kachemak Crane Watch Logo]

This application provides a uniform platform to collect all current and future crane observation data in order to continue to build a consistent, organized, and scientifically rigorous database from which further population studies can be done.

[Heading] Dropping a New Observation Point in the Native Application

1. Click New (+) button or open a previously saved draft point from the Draft button. *[Picture]*
2. Select an Observation Type from the provided menu. Click Next. *[Picture]*
3. Let your phone geo-locate or press and hold your location on the map until an address appears to drop pin. Click Next. *[Picture]*
4. Attach photos (select the camera icon to take picture or select the album to add existing pictures) and audio files (select the audio icon to add file) as wanted. Click Next. *[Picture]*
5. Select best response for each question from drop down menu or enter a number or comment as prompted. *[Picture]*

6. Number of Observed Adults - Enter the number (1,2,3, etc) observed. Adults sandhill cranes are typically large, around four feet or (120 cm) long, rusty grey plumage, black legs, yellow eyes, and have a noticeable red crown.
   [Picture of adult crane]
7. Number of Observed Juveniles - Enter the number of juveniles or colts observed. Younger colts are typically golden to tan in color and fluffy, but grow quickly to be rusty or gray color and as large as their parents. Juveniles eyes are dark, unlike the yellow eyes of an adult, and they also will not have a red crown.
   [Picture of juvenile crane]
8. Juvenile Fledging Status - If juveniles observed, select from the menu whether the juveniles/colts have fledged (learned to fly) or not or unsure. If no juveniles observed, select the corresponding option.
   [Picture of flying cranes]
9. Sex of the Observed Cranes - Select from the menu if observed cranes were male, female, both, or unsure. Male cranes tend to be larger than females, males have a lower pitch call than females, and throw their heads back all the way while females will throw their head back at a 45 degree angle.
   [Picture of male and female cranes together calling]
10. Crane Injury?- If injured crane observed, select from the menu the best fitting description of the crane(s). If no injured crane, select the corresponding option.
11. Please Provide Details on Observed Injury - If injury reported above, please describe details of observed injury (extend, location, source/type, etc.).
12. Crane Mortality? - If crane mortality observed, select from the menu the best fitting description. If no crane mortality, select the corresponding option.
13. Please Provide Details on Observed Mortality - If crane mortality reported above, please describe details of observed mortality (location details, cause, etc.).
14. Duration of the Crane Observation - Select from the menu the time frame that best fits the duration of your crane observation.
15. Confidence in Accuracy of Observation - Select from the menu the level of confidence you have in the accuracy of above observations details.
16. Additional Comments (Behavior, Vocalizations, Surrounding Habitat, etc.) - Describe any other observations including crane behavior, any vocalizations, the habitat the cranes were observed in, or any additional comments or observations.
17. Submit your Observation, or save it as a Draft. *[Picture]*

[Heading] Dropping a New Observation Point in the Web Application

Open: *this link.*

(https://umich.maps.arcgis.com/apps/webappviewer/index.html?id=63938e4b3db44121a65a1d649cfad022) User may have to zoom out to see heat map due to privacy restrictions.

Note: To drop a point, user must zoom out to the visible extent before selecting the editing widget. After the observation type is selected, then user can zoom to the specific location to drop an observation.

1. Select the Edit icon. *[Picture]*
2. Click on the best fitting Observation Type icon. *[Picture]*
3. Hover over the map until the location where observation occurred is found. Click to drop the point. *[Picture]*
4. Select best response for each question from drop down menu or enter a number or comment as prompted. *[Picture]*
5. Attach photos (select the camera icon to take picture or select the album to add existing pictures) and audio files (select the audio icon to add file) as wanted. Click Next.
6. Click Save and close window.

[Heading] Dashboard

To see summary data from past observations, *check out this link* (https://umich.maps.arcgis.com/apps/opsdashboard/index.html#/f2ac85e5a54b427fb9133edacc605978). Heat map zoom restrictions have been set for observer and crane privacy.

[Picture]

NOTE: Logged in users can view dashboard of data points they created. Anonymous users cannot view the dashboard. An ArcGIS account log in can be created on *https://www.arcgis.com/home/index.html* (https://www.arcgis.com/sharing/rest/oauth2/authorize?client_id=arcgisonline&display=default&response_type=token&state=%7B%22useLandingPage%22%3Atrue%7D&expiration=20160&locale=en-us&redirect_uri=https%3A%2F%2Fwww.arcgis.com%2Fhome%2Faccountswitcher-callback.html&force_login=true&showSignupOption=true) without purchasing ESRI software.

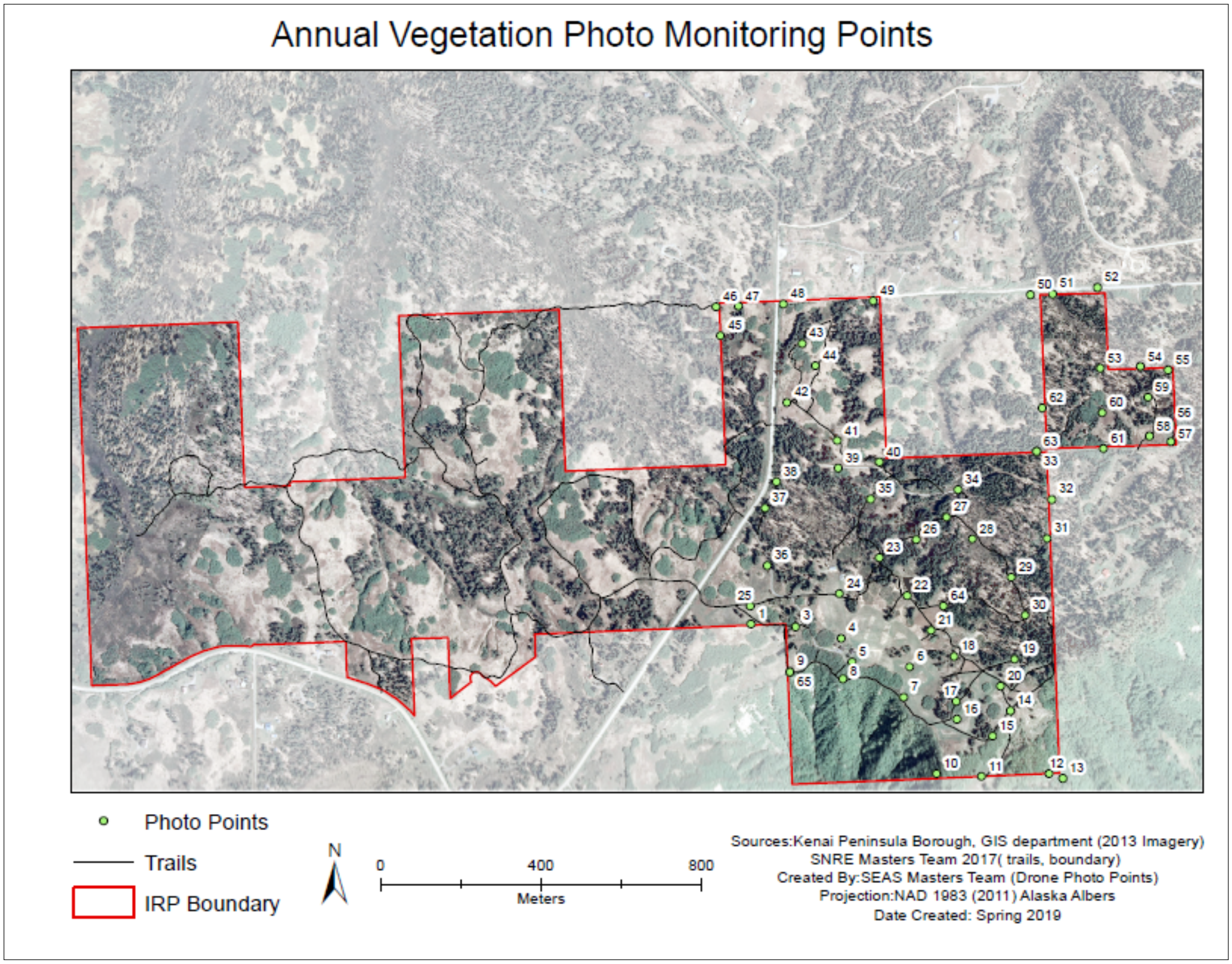
Credits: Application designed and created by Dorthea Leisman. Application created as an extension of the Center for Alaskan Coastal Studies' project Kachemak Crane Watch for the Inspiration Ridge Preserve property and the greater Homer area. All photographs by Nina Faust. Logo designed by Dorthea Leisman.

Additional thanks to Shannon Brines, Ines Ibanez, Beth Trowbridge, Nina Faust, Kelsey Blongewicz, Lorena Cortes, Emily Finch, Lauren Joyal, Liz McLaughlin, and the University of Michigan School for Environment and Sustainability.

Additional crane identification information came from *The Cornell Lab of Ornithology: All about Birds* (https://www.allaboutbirds.org/guide/Sandhill_Crane/id) and *The Cornell Lab of Ornithology: Birds of North America* (https://birdsna.org/Species-Account/bna/species/sancra/introduction).
[Terms & Conditions Same as Others]

Appendix VI: Photo Monitoring

Part A. Photo Points



Part B. 2018 Photo Monitoring Photo Index

Photo Point 1

N: 59.7000999 W: -151.4149933

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	1	339N		23

Photo Point 1

N: 59.7000999 W: -151.4149933

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_1	94E		23

Photo Point 1

N: 59.7000999 W: -151.4149933

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_1	256W		23

Photo Point 2

N: 59.70000 W: -151.4129944

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_2	70E	Near bluff by Alders, just before the bluff trail	22

Photo Point 2

N: 59.70000 W: -151.4129944

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_2	167S	Near bluff by Alders, just before the bluff trail	22

Photo Point 2

N: 59.70000 W: -151.4129944

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_2	58W	Near bluff by Alders, just before the bluff trail	22

Photo Point 3

N: 59.6996994 W: -151.4109955

Date	Point Name	Bearings	Notes	Original Point Number
08/22/2018	IRP_BDR_3	19N	E of Alpaca Pen	20

Photo Point 3

N: 59.6996994 W: -151.4109955

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_3	99E	E of Alpaca Pen	20

Photo Point 3

N: 59.6996994 W: -151.4109955

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_3	319NW	E of Alpaca Pen	20

Photo Point 4

N: 59.69916667 W: -151.4105556

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_4	339N	Trail behind greenhouse	53

Photo Point 4

N: 59.69916667 W: -151.4105556

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_4	69E	Trail behind greenhouse	53

Photo Point 4

N: 59.69916667 W: -151.4105556

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_4	165S	Trail behind greenhouse	53

Photo Point 5

N: 59.6990013 W: -151.4080048

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_5	20N	NW to house	32

Photo Point 5

N: 59.6990013 W: -151.4080048

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_5	129SE	NW to house	32

Photo Point 5

N: 59.6990013 W: -151.4080048

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_5	238SW	NW to house	32

Photo Point 5

N: 59.6990013 W: -151.4080048

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_5	301NW	NW to house	32

Photo Point 6

N: 59.698333333 W: -151.4083333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_6	31NE	On bluff, next to elderberries and broken stump in path	38

Photo Point 6

N: 59.698333333 W: -151.4083333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_6	103E	On bluff, next to elderberries and broken stump in path	38

Photo Point 7

N: 59.6987991 W: -151.4109955

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_7	52NE	Bluff Trail near bench	21

Photo Point 7

N: 59.6987991 W: -151.4109955

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_7	161S	Bluff Trail near bench	21

Photo Point 7

N: 59.6987991 W: -151.4109955

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_7	270W	Bluff Trail near bench	21

Photo Point 8

N: 59.699000 W: -151.4133333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_8	72E	Nearby first camera trap	39

Photo Point 8

N: 59.699000 W: -151.4133333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_8	150SE	Nearby first camera trap	39

Photo Point 8

N: 59.699000 W: -151.4133333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_8	256W	Nearby first camera trap	39

Photo Point 9

N: 59.6966019 W: -151.4069977

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_9	6N	Along S property line	27

Photo Point 9

N: 59.6966019 W: -151.4069977

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_9	92E	Along S property line	27

Photo Point 9

N: 59.6966019 W: -151.4069977

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_9	139SE	Along S property line	27

Photo Point 9

N: 59.6966019 W: -151.4069977

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_9	267W	Along S property line	27

Photo Point 10

N: 59.6964989 W: -151.4049988

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_10	87E	Photo point on trail/property line below	25

Photo Point 10

N: 59.6964989 W: -151.4049988

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_10	160SE	Photo point on trail/property line below	25

Photo Point 10

N: 59.6964989 W: -151.4049988

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_10	175S	Photo point on trail/property line below	25

Photo Point 10

N: 59.6964989 W: -151.4049988

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_10	256W	Photo point on trail/property line below	25

Photo Point 10

N: 59.6964989 W: -151.4049988

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_10	310NW	Photo point on trail/property line below	25

Photo Point 11

N: 59.6964989 W: -151.4019928

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_11	349N	Get to property corner	26

Photo Point 11

N: 59.6964989 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_11	75E	Get to property corner	26

Photo Point 11

N: 59.6964989 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_11	178S	Get to property corner	26

Photo Point 11

N: 59.6964989 W: -151.4019928

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_11	249W	Get to property corner	26

Photo Point 12

N: 59.69638889 W: -151.4013889

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_12	111E		35

Photo Point 12

N: 59.69638889 W: -151.4013889

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_12	225SW		35

Photo Point 13

N: 59.69794444 W: -151.4036111

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_13	33NE		36

Photo Point 13

N: 59.69794444 W: -151.4036111

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_13	122SE		36

Photo Point 13

N: 59.69794444 W: -151.4036111

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_13	209S		36

Photo Point 13

N: 59.69794444 W: -151.4036111

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_13	291W		36

Photo Point 14

N: 59.69738889 W: -151.40444444

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_14	107E	Dead tree stump, above cottonwood forest, low point in field trail	37

Photo Point 15

N: 59.6977997 W: -151.4060059

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_15	112SE	Bench	9

Photo Point 16

N: 59.6982002 W: -151.4060059

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_16	92E	E of lower field; back on trail	8

Photo Point 17

N: 59.6991997 W: -151.4060059

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_17	22NE	Mallard pond	31

Photo Point 17

N: 59.6991997 W: -151.4060059

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_17	115SE	Mallard pond	31

Photo Point 17

N: 59.6991997 W: -151.4060059

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_17	289W	Mallard pond	31

Photo Point 18

N: 59.99083333 W: -151.40333333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_18	34N	Parking pad in front of rental cabin	62

Photo Point 18

N: 59.99083333 W: -151.40333333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_18	135SE	Parking pad in front of rental cabin	62

Photo Point 18

N: 59.99083333 W: -151.40333333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_18	238SW	Parking pad in front of rental cabin	62

Photo Point 19

N: 59.6985016 W: -151.404007

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_19	75E	Snipe Pond	30

Photo Point 19

N: 59.6985016 W: -151.404007

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_19	158S	Snipe Pond	30

Photo Point 19

N: 59.6985016 W: -151.404007

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_19	282W	Snipe Pond	30

Photo Point 20

N: 59.6997986 W: -151.4069977

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_20	88E	Frog Pond	34

Photo Point 20

N: 59.6997986 W: -151.4069977

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_20	215SW	Frog Pond	34

Photo Point 21

N: 59.7005997 W: -151.4080048

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_21	352N	Goose Pond	33

Photo Point 21

N: 59.7005997 W: -151.4080048

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_21	111E	Goose Pond	33

Photo Point 21

N: 59.7005997 W: -151.4080048

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_21	235S	Goose Pond	33

Photo Point 22

N: 59.70147222 W: -151.4091667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_22	30NE	Gozzie Trail junction with Jeff Oils Bus Trail	66

Photo Point 22

N: 59.70147222 W: -151.4091667

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_22	112SE	Gozzie Trail junction with Jeff Oils Bus Trail	66

Photo Point 22

N: 59.70147222 W: -151.4091667

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_22	257W	Gozzie Trail junction with Jeff Oils Bus Trail	66

Photo Point 23

N: 59.706986 W: -151.4109955

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_23	25NE	Goose Pond	28

Photo Point 23

N: 59.706986 W: -151.4109955

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_23	155SE	Goose Pond	28

Photo Point 23

N: 59.706986 W: -151.4109955

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_23	245W	Goose Pond	28

Photo Point 23

N: 59.706986 W: -151.4109955

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_23	311NW	Goose Pond	28

Photo Point 24

N: 59.7005005 W: -151.4149933

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_24	18N	Bottom of field	24

Photo Point 24

N: 59.7005005 W: -151.4149933

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_24	265W	Bottom of field	24

Photo Point 25

N: 59.70183333 W: -151.4075

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_25	25NE	Gozzie Trail, loop opening	67

Photo Point 25

N: 59.70183333 W: -151.4075

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_25	121SE	Gozzie Trail, loop opening	67

Photo Point 25

N: 59.70183333 W: -151.4075

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_25	241SW	Gozzie Trail, loop opening	67

Photo Point 26

N: 59.70230556 W: -151.4061111

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_26	32NE	Gozzie Trail junction N of bog	68

Photo Point 26

N: 59.70230556 W: -151.4061111

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_26	110E	Gozzie Trail junction N of bog	68

Photo Point 26

N: 59.70230556 W: -151.4061111

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_26	260W	Gozzie Trail junction N of bog	68

Photo Point 27

N: 59.7018013 W: -151.4049988

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_27	1N	Bog	29

Photo Point 27

N: 59.7018013 W: -151.4049988

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_27	95E	Bog	69

Photo Point 27

N: 59.7018013 W: -151.4049988

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_27	187S	Bog	69

Photo Point 27

N: 59.7018013 W: -151.4049988

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_27	271W	Bog	69

Photo Point 28

N: 59.70091667 W: -151.4033333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_28	8N	South of bog on Gozzie Trail in riparian zone	69

Photo Point 28

N: 59.70091667 W: -151.4033333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_28	105E	South of bog on Gozzie Trail in riparian zone	69

Photo Point 28

N: 59.70091667 W: -151.4033333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_28	278W	South of bog on Gozzie Trail in riparian zone	69

Photo Point 29

N: 59.7005556 W: -151.4027778

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_29	90E	On Gozzie Trail	63

Photo Point 29

N: 59.7005556 W: -151.4027778

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_29	210SW	On Gozzie Trail	63

Photo Point 29

N: 59.7005556 W: -151.4027778

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_29	310NW	On Gozzie Trail	63

Photo Point 30

N: 59.70175 W: -151.4016667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_30	156SE	Halfway back to gate on major ravine	61

Photo Point 30

N: 59.70175 W: -151.4016667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_30	224SW	Halfway back to gate on major ravine	61

Photo Point 31

N: 59.70261111 W: -151.4013889

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_31	340N	S of old road	60

Photo Point 31

N: 59.70261111 W: -151.4013889

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_31	51NE	S of old road	60

Photo Point 31

N: 59.70261111 W: -151.4013889

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_31	52SE	S of old road	60

Photo Point 32

N: 59.703701 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_32	57NE	Driveway corner	7

Photo Point 32

N: 59.703701 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_32	129SE	Driveway corner	7

Photo Point 32

N: 59.703701 W: -151.4019928

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_32	213SW	Driveway corner	7

Photo Point 32

N: 59.703701 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_32	258W	Driveway corner	7

Photo Point 33

N: 59.70291667 W: -151.4055556

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_33	353N	Off alder ridge connects road to Gozzie Trail	57

Photo Point 33

N: 59.70291667 W: -151.4055556

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_33	78E	Off alder ridge connects road to Gozzie Trail	57

Photo Point 33

N: 59.70291667 W: -151.4055556

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_33	265W	Off alder ridge , connects road to Gozzie Trail	57

Photo Point 34

N: 59.70277778 W: -151.4094444

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_34	2N	Halfway to dip on the Greenhouse Trail	58

Photo Point 34

N: 59.70277778 W: -151.4094444

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_34	122SE	Halfway to dip on the Greenhouse Trail	58

Photo Point 34

N: 59.70277778 W: -151.4094444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_34	213SW	Halfway to dip on the Greenhouse Trail	58

Photo Point 35

N: 59.70138889 W: -151.414667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_35	157S	Trail behind the cabin	58

Photo Point 35

N: 59.70138889 W: -151.414667

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_35	228SW	Trail behind the cabin	58

Photo Point 35

N: 59.70138889 W: -151.414667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_35	319NW	Trail behind the cabin	58

Photo Point 36

N: 59.7026667 W: -151.4141667

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_36	43NE	Halfway on Bypass Trail	55

Photo Point 36

N: 59.7026667 W: -151.4141667

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_36	186S	Halfway on Bypass Trail	55

Photo Point 36

N: 59.7026667 W: -151.4141667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_36	302NW	Halfway on Bypass Trail	55

Photo Point 37

N: 59.70325 W: -151.4136111

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_37	160S	Road on Bypass Trail	56

Photo Point 37

N: 59.70325 W: -151.4136111

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_37	76E	Road on Bypass Trail	56

Photo Point 37

N: 59.70325 W: -151.4136111

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_37	270W	Road on Bypass Trail	56

Photo Point 38

N: 59.7035 W: -151.41083333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_38	353N	Alder Ridge Road driveway	57

Photo Point 38

N: 59.7035 W: -151.41083333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_38	78E	Alder Ridge Road driveway	57

Photo Point 38

N: 59.7035 W: -151.41083333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_38	265W	Alder Ridge Road driveway	58

Photo Point 39

N: 59.7036018 W: -151.4089966

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_39	4N	1996 property mark	6

Photo Point 39

N: 59.7036018 W: -151.4089966

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_39	200S	1996 property mark	6

Photo Point 39

N: 59.7036018 W: -151.4089966

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_39	277W	1996 property mark	6

Photo Point 40

N: 59.704111111 W: -151.4108333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_40	21N	Pinch point of 3 trails next to spruce	46

Photo Point 40

N: 59.704111111 W: -151.4108333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_40	155SE	Pinch point of 3 trails next to spruce	46

Photo Point 40

N: 59.704111111 W: -151.4108333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_40	297NW	Pinch point of 3 trails next to spruce	46

Photo Point 41

N: 59.7050018 W: -151.4129944

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_41	340N	Over the fireweed field towards to road. Top of the knoll of the elderberry cluster in center	1

Photo Point 41

N: 59.7050018 W: -151.4129944

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_41	199S	Over the fireweed field towards to road. Top of the knoll of the elderberry cluster in center	1

Photo Point 41

N: 59.7050018 W: -151.4129944

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_41	270W	Over the fireweed field towards to road. Top of the knoll of the elderberry cluster in center	1

Photo Point 42

N: 59.70630556 W: -151.4122222

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_42	15N	Second clearing from turn point in front of the spruce	47

Photo Point 42

N: 59.70630556 W: -151.4122222

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_42	113SE	Second clearing from turn point in front of the spruce	47

Photo Point 42

N: 59.70630556 W: -151.4122222

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_42	238SW	Second clearing from turn point in front of the spruce	47

Photo Point 43

N: 59.7080556 W: -151.411667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_43	26NE	Below knoll loop and field	45

Photo Point 43

N: 59.7080556 W: -151.411667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_43	169	Below knoll loop and field	45

Photo Point 43

N: 59.7080556 W: -151.411667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_43	330NW	Below knoll loop and field	45

Photo Point 44

N: 59.70580556 W: -151.410000

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_44	9N	Spruce forest and open meadow	43

Photo Point 44

N: 59.70580556 W: -151.410000

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_44	266W	Spruce forest and open meadow	43

Photo Point 45

N: 59.7071991 W: -151.4160004

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_45	159SE	Top western corner of property	3

Photo Point 45

N: 59.7071991 W: -151.4160004

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_45	28SW	Top western corner of property	3

Photo Point 46

N: 59.7071991 W: -151.4149933

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_46	70E	Fireweed meadow with alder along road	4

Photo Point 47

N: 59.7071991 W: -151.4129944

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_47	208SW	Edge of Eagle Aerie and Skyline	2

Photo Point 48

N: 59.7071991 W: -151.4089966

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_48	165S	NE property corner	5

Photo Point 49

N: 59.7071991 W: -151.4019928

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_49	99	NW property corner	17

Photo Point 49

N: 59.7071991 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_49	157SE	NW property corner	17

Photo Point 49

N: 59.7071991 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_49	250W	NW property corner	17

Photo Point 50

N: 59.7071991 W: -151.401001

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_50	162SE	Riparian habitat from road (cottonwoods coming in)	18

Photo Point 51

N: 59.7072983 W: -151.3990021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_51	103E	NE property corner of 15, S down property line	19

Photo Point 51

N: 59.7072983 W: -151.3990021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_51	168S	NE property corner of 15, S down property line	19

Photo Point 51

N: 59.7072983 W: -151.3990021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_51	233SW	NE property corner of 15, S down property line	19

Photo Point 52

N: 59.7055016 W: -151.399021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_52	345N	NW corner 7.5	13

Photo Point 52

N: 59.7055016 W: -151.399021

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_52	75E	NW corner 7.5	13

Photo Point 52

N: 59.705501 W: -151.399021

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_52	189S	NW corner 7.5	13

Photo Point 53

N: 59.70551 W: -151.3972222

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_53	351N	Property corner of 2 north parcels, Defibaugh	52

Photo Point 53

N: 59.7055 W: -151.3972222

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_53	80E	Property corner of 2 north parcels, Defibaugh	52

Photo Point 53

N: 59.7055 W: -151.3972222

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_53	261W	Property corner of 2 north parcels, Defibaugh	52

Photo Point 54

N: 59.7053986 W: -151.3957778

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_54	359N	NE corner 2.5, property line	12

Photo Point 54

N: 59.7053986 W: -151.3957778

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_54	156S	NE corner 2.5, property corner	12

Photo Point 54

N: 59.7053986 W: -151.3957778

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_54	271W	NE corner 2.5, property line	12

Photo Point 55

N: 59.7042007 W: -151.3959961

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_55	350N	Back to property line (patch of spruce)	11

Photo Point 55

N: 59.7042007 W: -151.3959961

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_55	158S	Back to property line (patch of spruce)	11

Photo Point 56

N: 59.7038002 W: -151.3959961

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_56	18N	SE corner of 2.5	10

Photo Point 56

N: 59.7038002 W: -151.3959961

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_56	264W	SE corner of 2.5	10

Photo Point 57

N: 59.70394444 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_57	356N	First clearing	50

Photo Point 57

N: 59.70394444 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_57	91E	First clearing	50

Photo Point 57

N: 59.70394444 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_57	218SW	First clearing	50

Photo Point 57

N: 59.70394444 W: -151.3969444

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_57	288W	First clearing	50

Photo Point 58

N: 59.7040556 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_58	342N	Old junk clearing	51

Photo Point 58

N: 59.7040556 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_58	61NE	Old junk clearing	51

Photo Point 58

N: 59.7040556 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_58	135SE	Old junk clearing	51

Photo Point 58

N: 59.7040556 W: -151.3969444

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_58	205SW	Old junk clearing	51

Photo Point 59

N: 59.7044983 W: -151.3990021

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_59	15N	Fireweed meadow/propery, moose trail?	14

Photo Point 59

N: 59.7044983 W: -151.3990021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_59	62NE	Fireweed meadow/property , moose trail?	14

Photo Point 59

N: 59.7044983 W: -151.3990021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_59	110E	Fireweed meadow/property, moose trail?	14

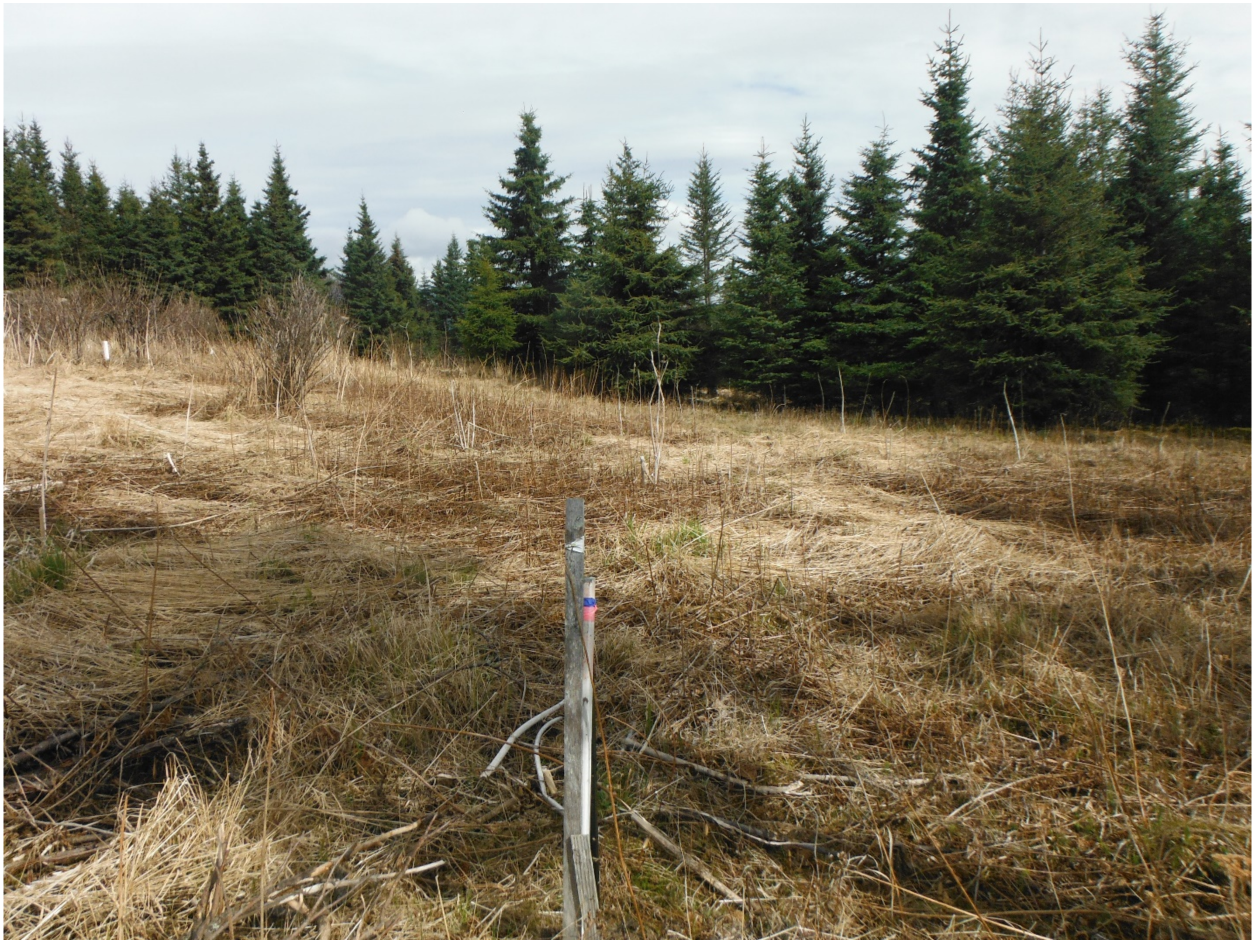
Photo Point 59

N: 59.7044983 W: -151.3990021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_59	165S	Fireweed meadow/propert y, moose trail?	14

Photo Point 60

N: 59.703701 W: -151.399021



Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_60	358N	SE corner of 15, SW of 2.5	16

Photo Point 60

N: 59.703701 W: -151.399021

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_60	84E	SE corner of 15, SW of 2.5	16

Photo Point 60

N: 59.703701 W: -151.399021

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_60	262W	SE corner of 15, SW of 2.5	16

Photo Point 61

N: 59.70466667 W: -151.4016667

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_61	100E		49

Photo Point 61

N: 59.70466667 W: -151.4016667

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_61	175S		49

Photo Point 62

N: 59.703701 W: -151.4019928

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_62	345N	S corner and W boundary of parcel	15

Photo Point 63

N: 59.70033333 W: -151.4133333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_63	114SE	End of Gozzie Trail Intersect with U Trail along the NE side of Frog Pond	65

Photo Point 63

N: 59.70033333 W: -151.4133333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_63	222SW	End of Gozzie Trail Intersect with U Trail along the NE side of Frog Pond	65

Photo Point 63

N: 59.70033333 W: -151.4133333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_63	325NW	End of Gozzie Trail Intersect with U Trail along the NE side of Frog Pond	65

Photo Point 64

N: 59.699 W: -151.4133333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_64	93E	Directly above Sklyline Rd where trails intersect	40

Photo Point 64

N: 59.699 W: -151.4133333

Date	**Point Name**	**Bearings**	**Notes**	**Original Point Number**
05/22/2018	IRP_BDR_64	210SW	Directly above Sklyline Rd where trails intersect	40

Photo Point 64

N: 59.699 W: -151.4133333

Date	Point Name	Bearings	Notes	Original Point Number
05/22/2018	IRP_BDR_64	299NW	Directly above Sklyline Rd where trails intersect	40

Appendix VII: Maps

Part A. Sound Mapping

Part B. Fish Trapping

Part C. Vegetation Monitoring

Part D. Wildlife Assessment

Part E. Sandhill Crane Monitoring

Part F. Photo Monitoring

Part G. Trail Maps

Part H. Invasive Species Monitoring

Sound Monitoring Points 2018

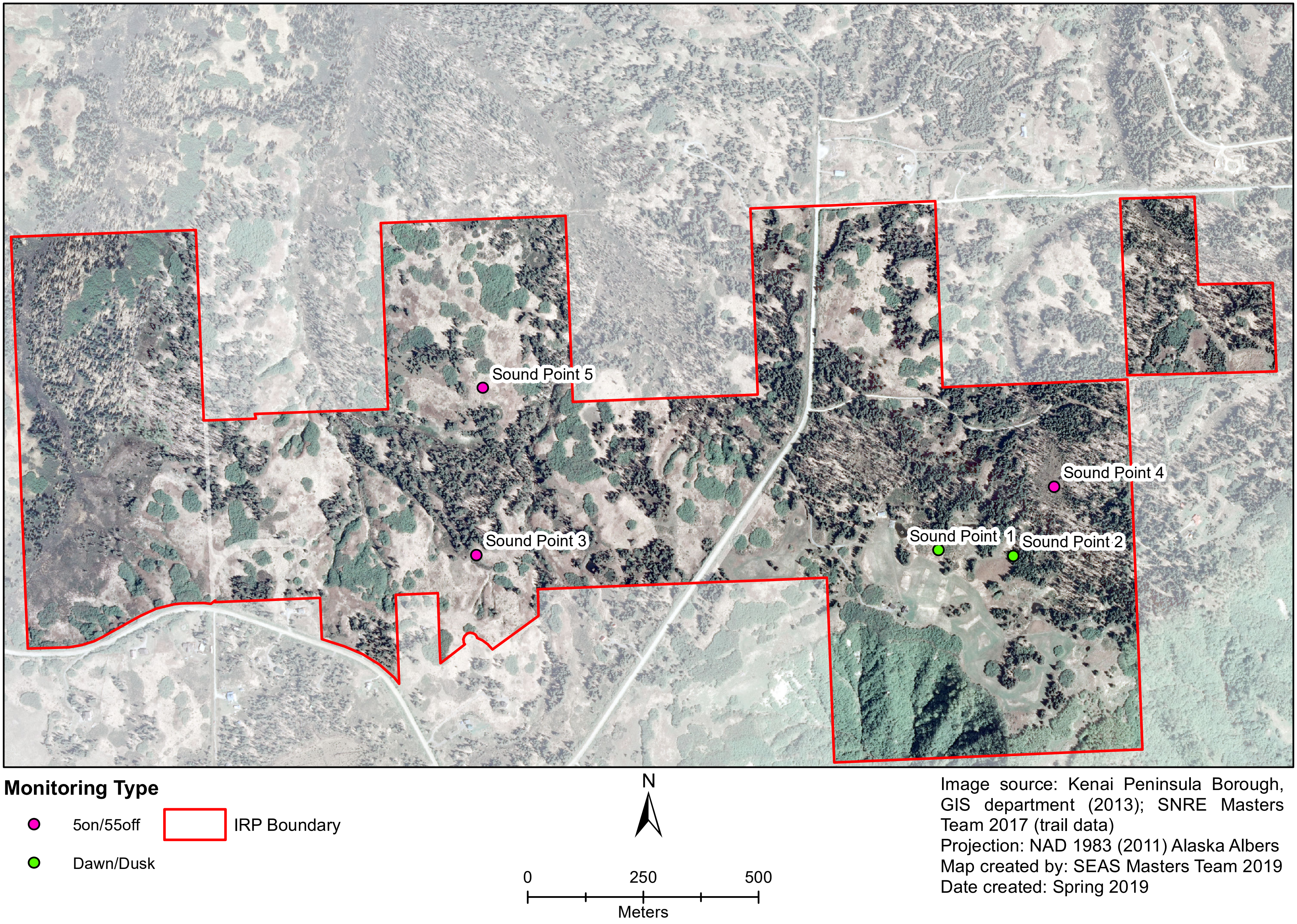
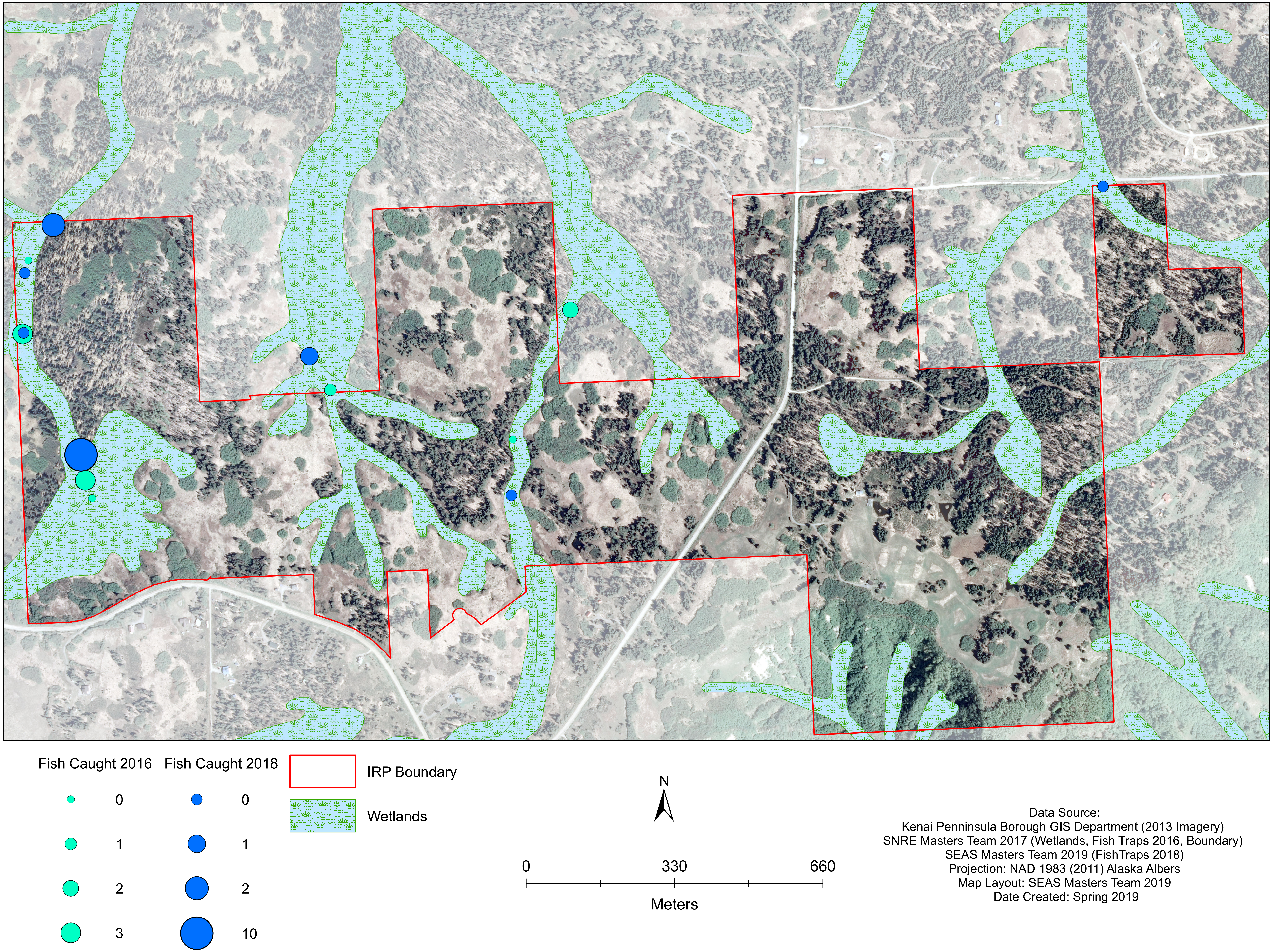


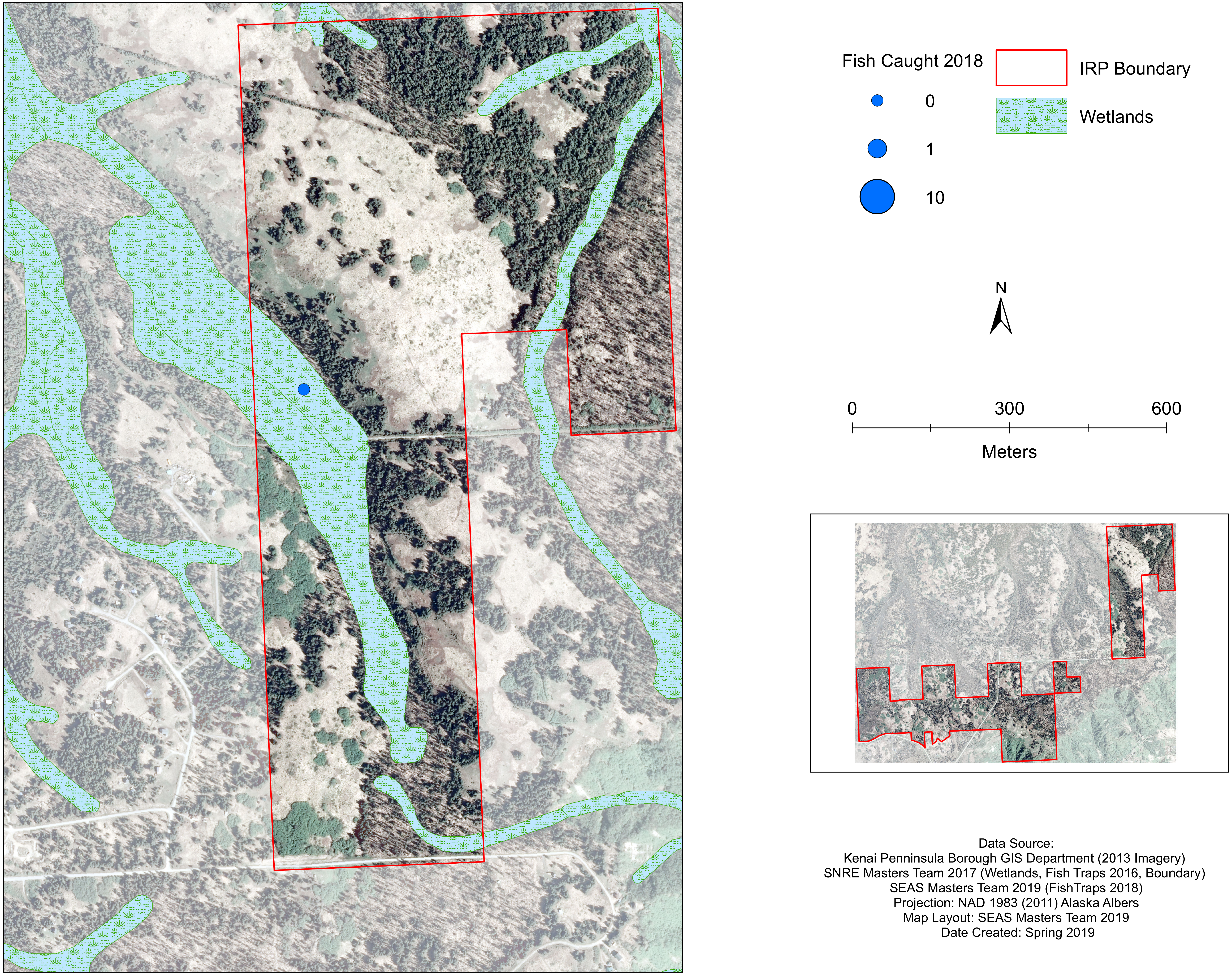
Image source: Kenai Peninsula Borough, GIS department (2013); SNRE Masters Team 2017 (trail data)
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

IRP Fish Trap Locations



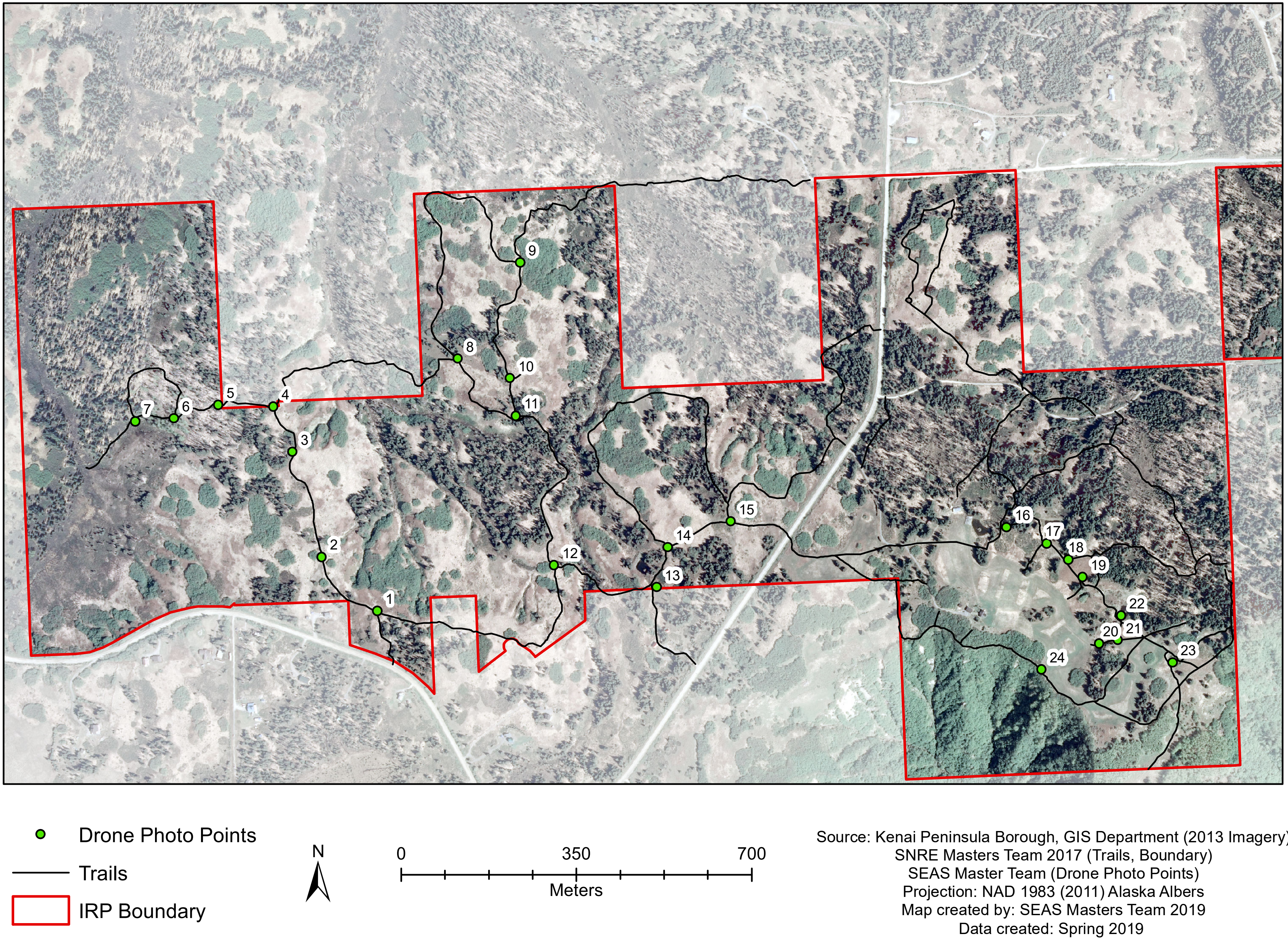
Data Source:
Kenai Penninsula Borough GIS Department (2013 Imagery)
SNRE Masters Team 2017 (Wetlands, Fish Traps 2016, Boundary)
SEAS Masters Team 2019 (FishTraps 2018)
Projection: NAD 1983 (2011) Alaska Albers
Map Layout: SEAS Masters Team 2019
Date Created: Spring 2019

Hogback Fish Trap Locations



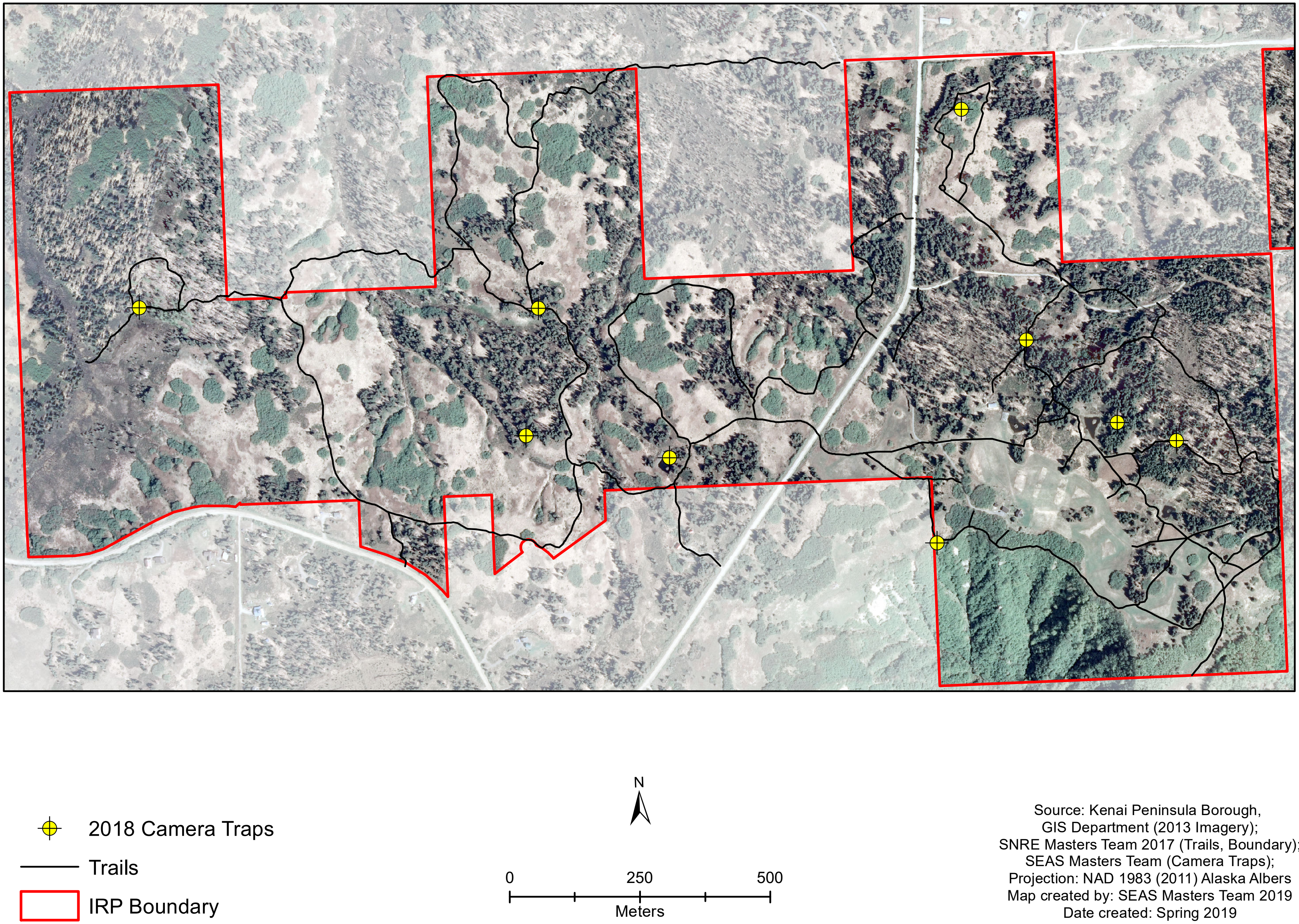
Data Source:
Kenai Penninsula Borough GIS Department (2013 Imagery)
SNRE Masters Team 2017 (Wetlands, Fish Traps 2016, Boundary)
SEAS Masters Team 2019 (FishTraps 2018)
Projection: NAD 1983 (2011) Alaska Albers
Map Layout: SEAS Masters Team 2019
Date Created: Spring 2019

Drone Vegetation Photo Capture Points

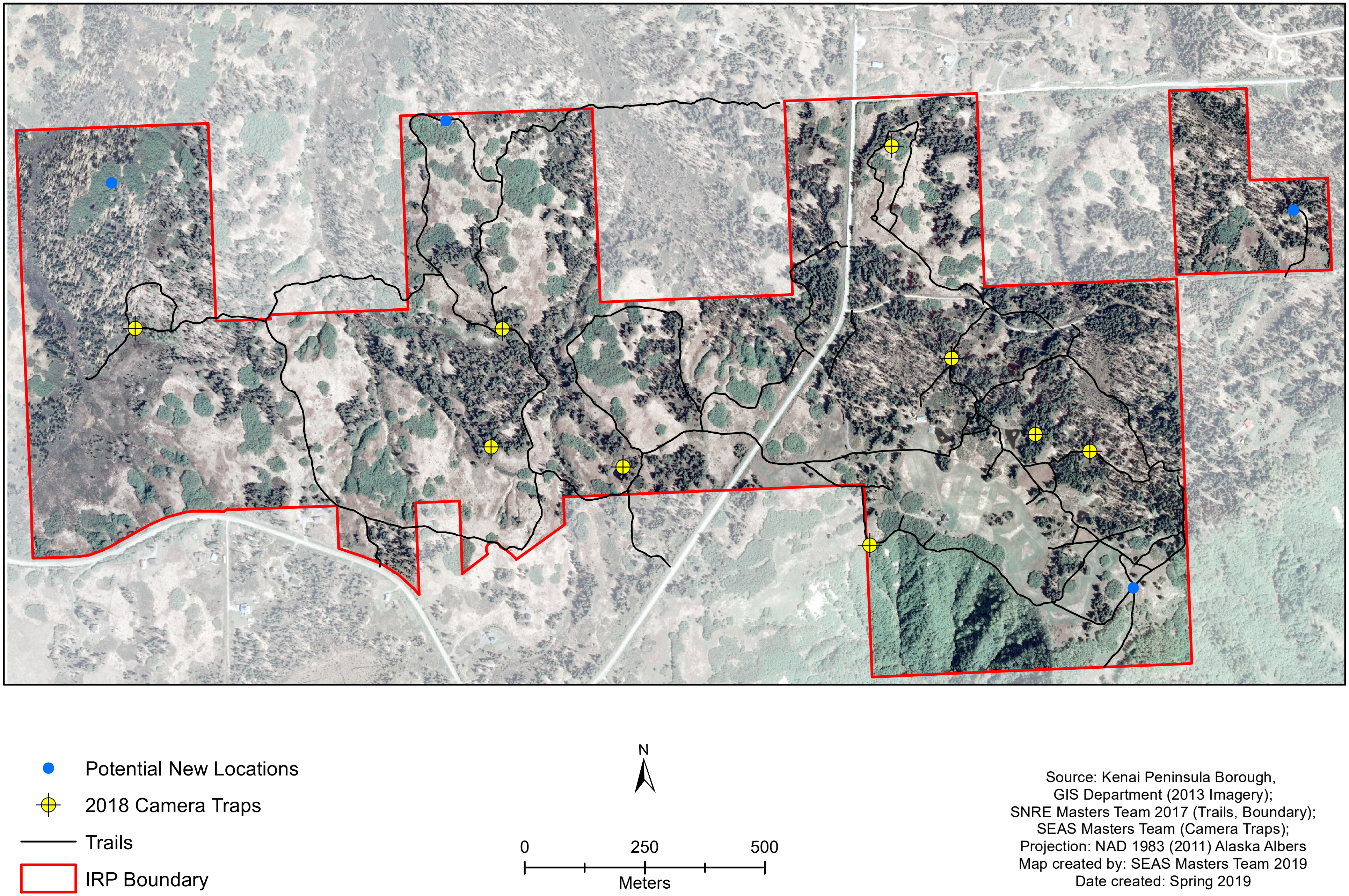


Source: Kenai Peninsula Borough, GIS Department (2013 Imagery)
SNRE Masters Team 2017 (Trails, Boundary)
SEAS Master Team (Drone Photo Points)
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Data created: Spring 2019

Camera Trap Locations 2018



Suggested New Camera Trap Locations
1 of 2 (Main Lots)



Suggestest New Camera Trap Locations
2 of 2 (Hogback Lot)

Potential New Locations

Trails

IRP Boundary

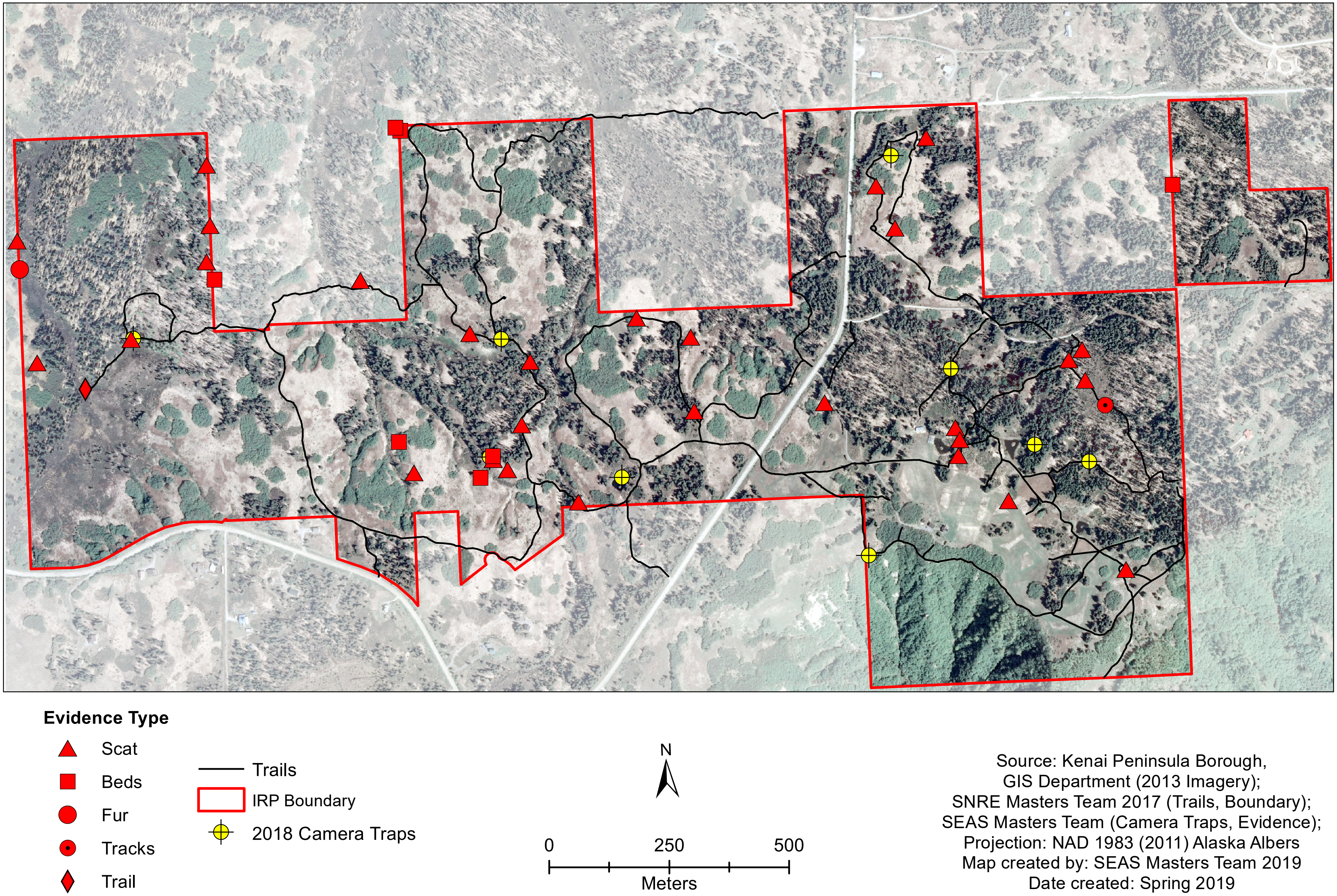
N

0 150 300

Meters

Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Camera Traps);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Moose Evidence on IRP - May to August 2018
1 of 2 (Main Lots)



Moose Evidence on IRP - May to August 2018
2 of 2 (Hogback Lot)

Evidence Type

- Scat
- Beds
- Fur
- Tracks
- Trail

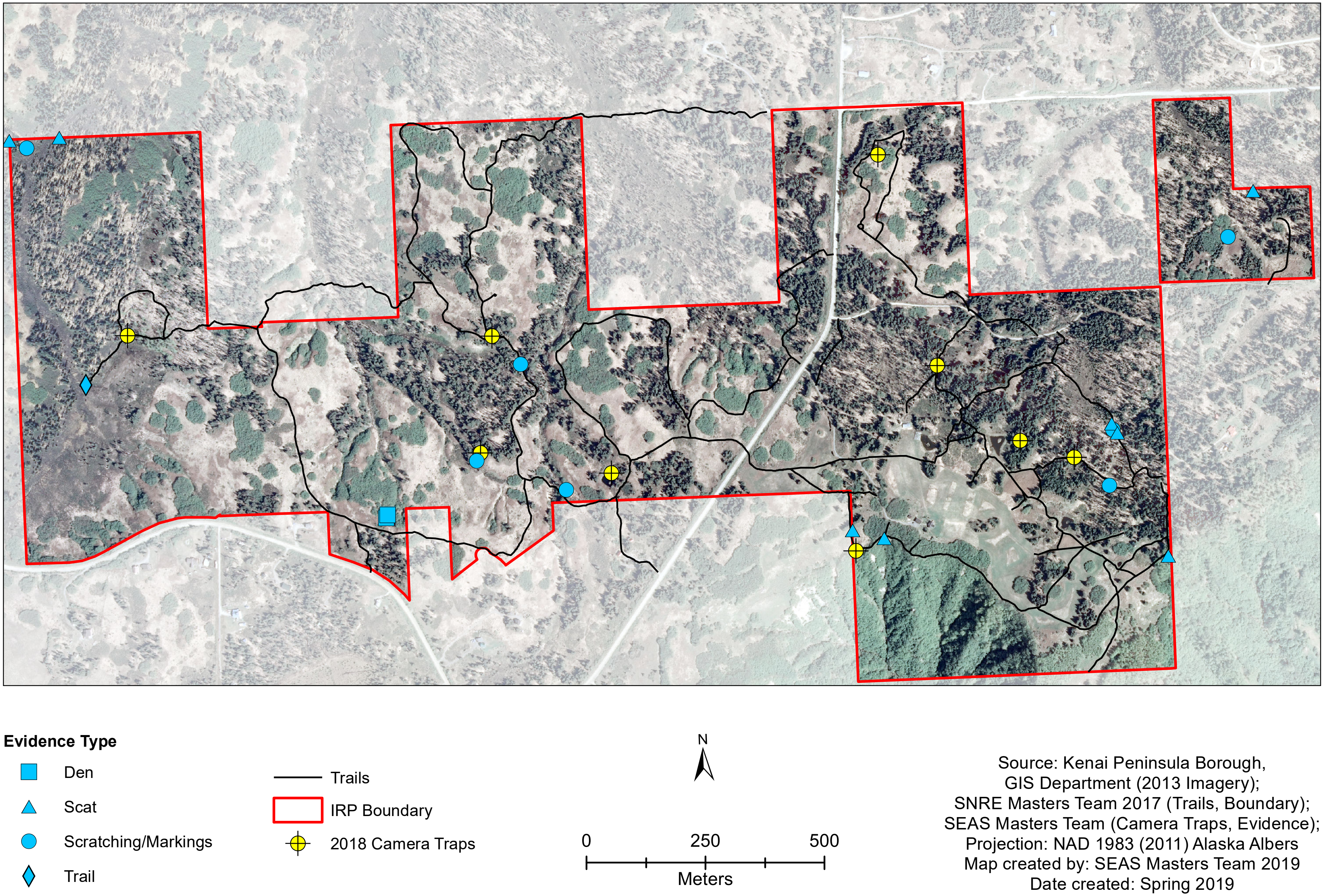
- Trails
- IRP Boundary

N

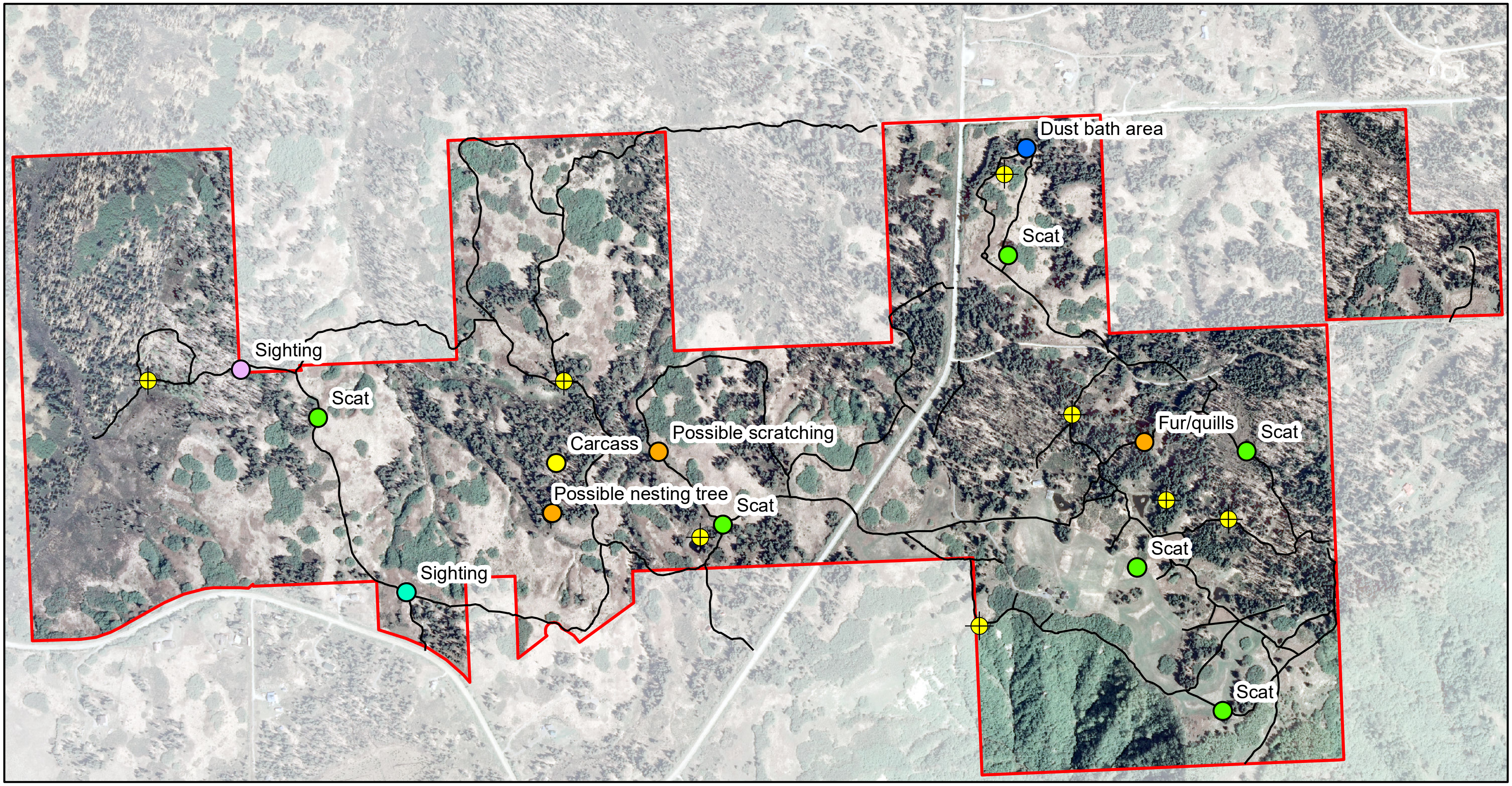
0 150 300
Meters

Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Evidence);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Bear Evidence on IRP - May to August 2018



Wildlife Evidence (Excluding Moose & Bear) on IRP
May to August 2018



Species

- Coyote
- North American beaver
- North American porcupine
- Red-tailed hawk
- Sharpshinned hawk
- Snowshoe hare
- Spruce grouse

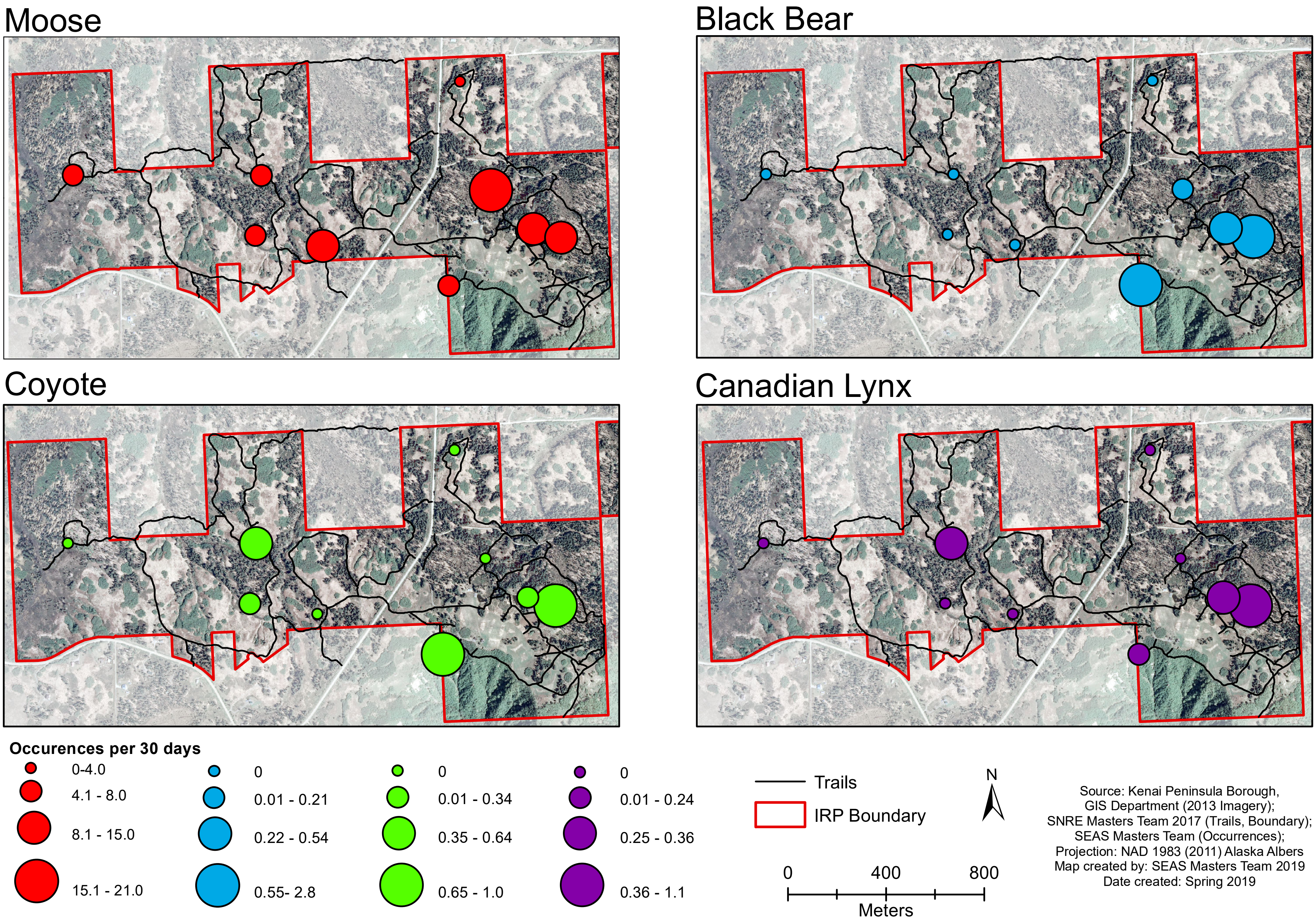
Trails
IRP Boundary
2018 Camera Traps

N

0 250 500
Meters

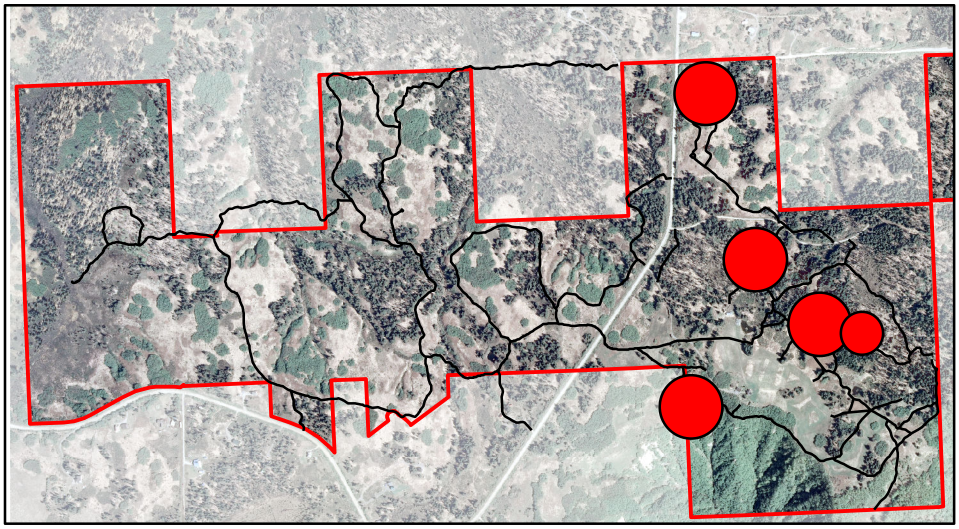
Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Camera Traps, Evidence);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Standardized Occurrences (Occ. per 30 Days) - 2018

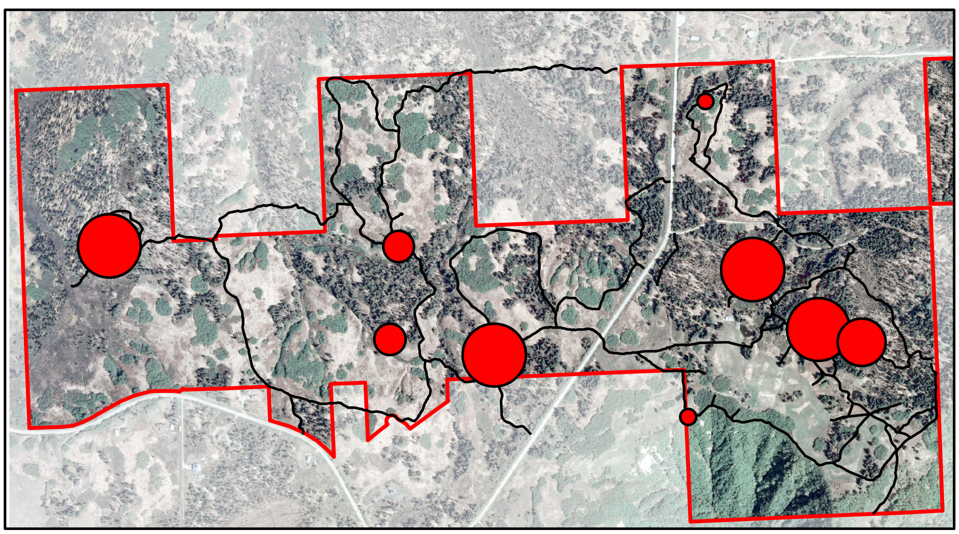


Moose Occurrences on IRP by Season - 2018

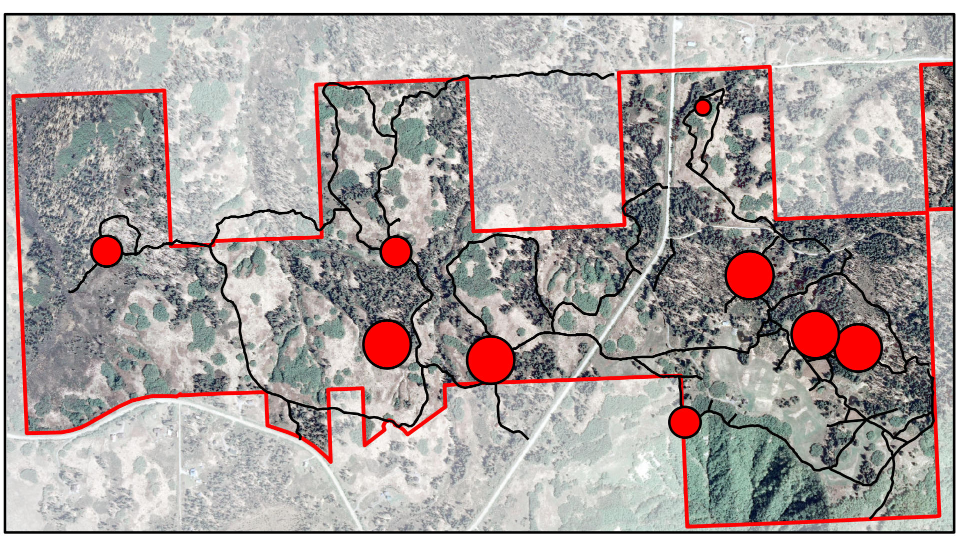
Spring

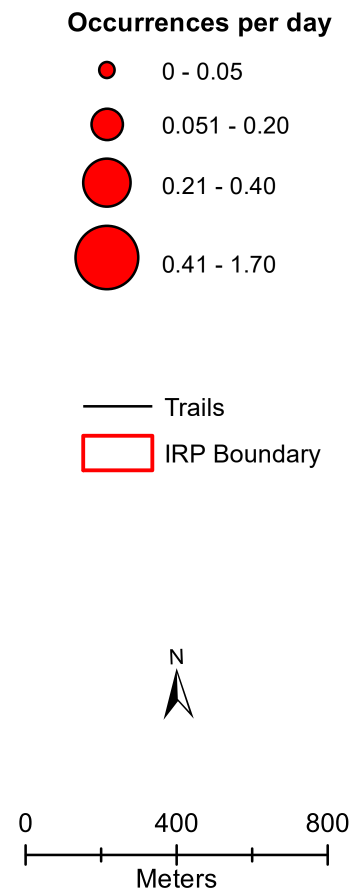


Summer



Fall

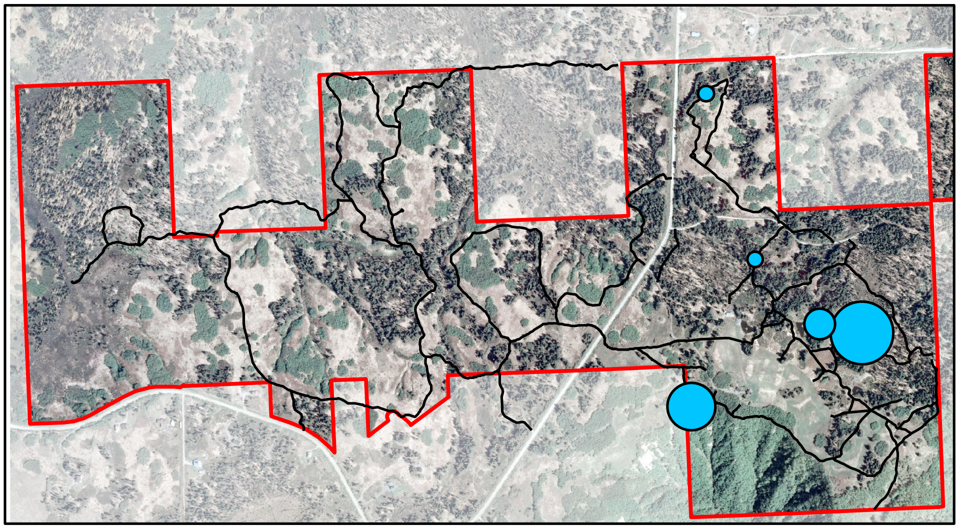




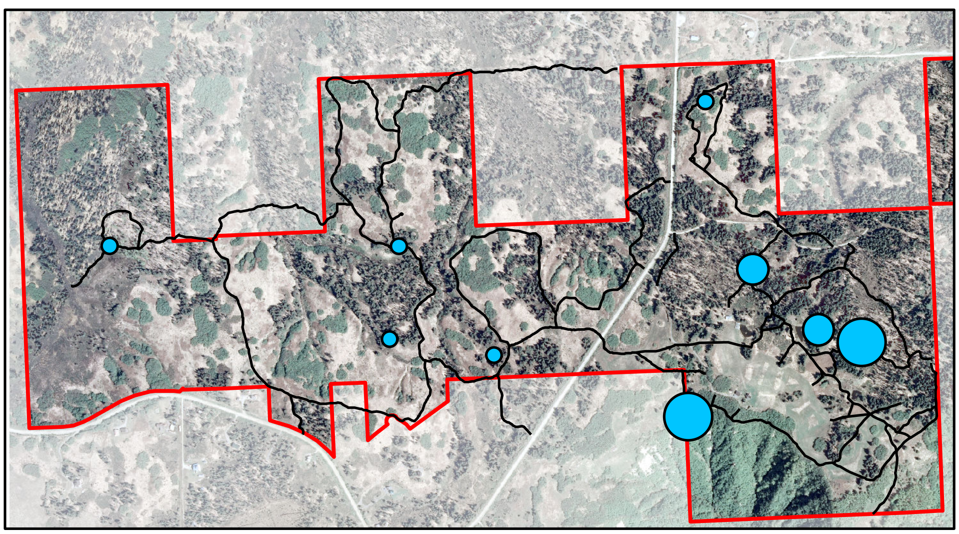
Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Occurrences);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Black Bear Occurrences on IRP by Season - 2018

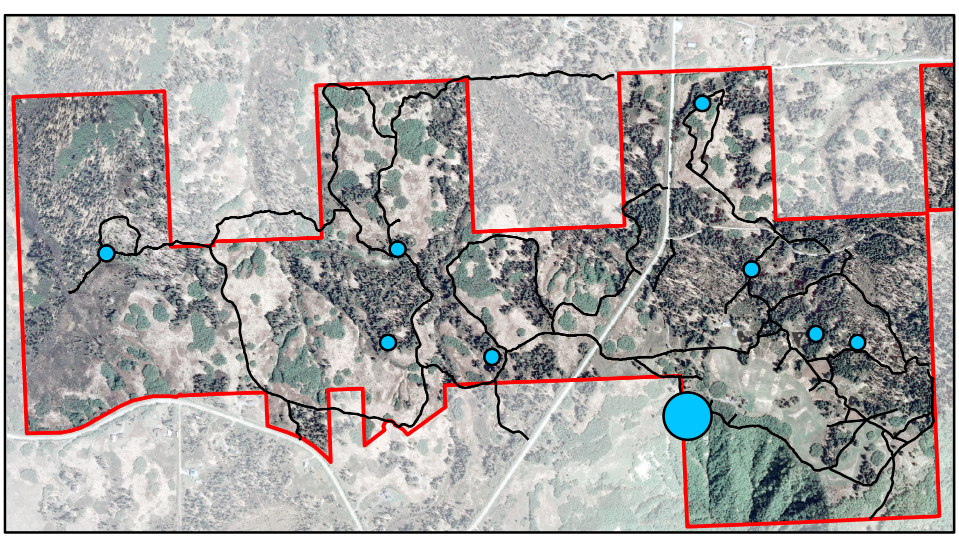
Spring

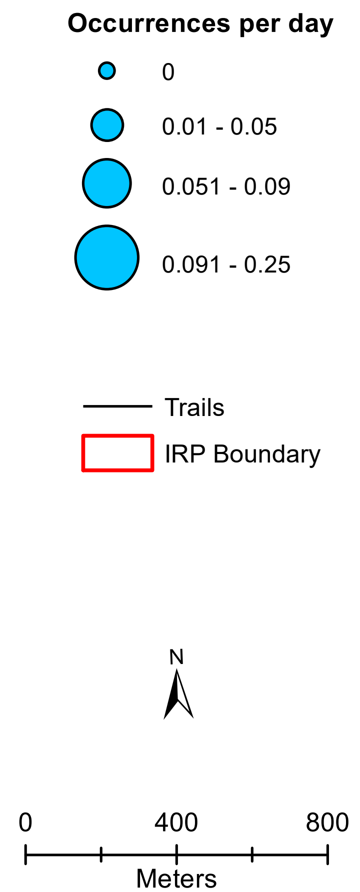


Summer



Fall

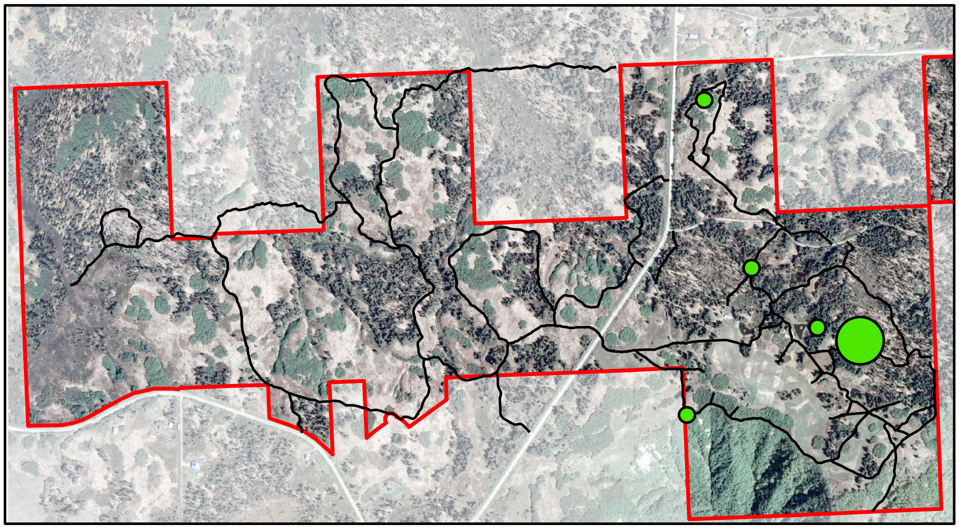




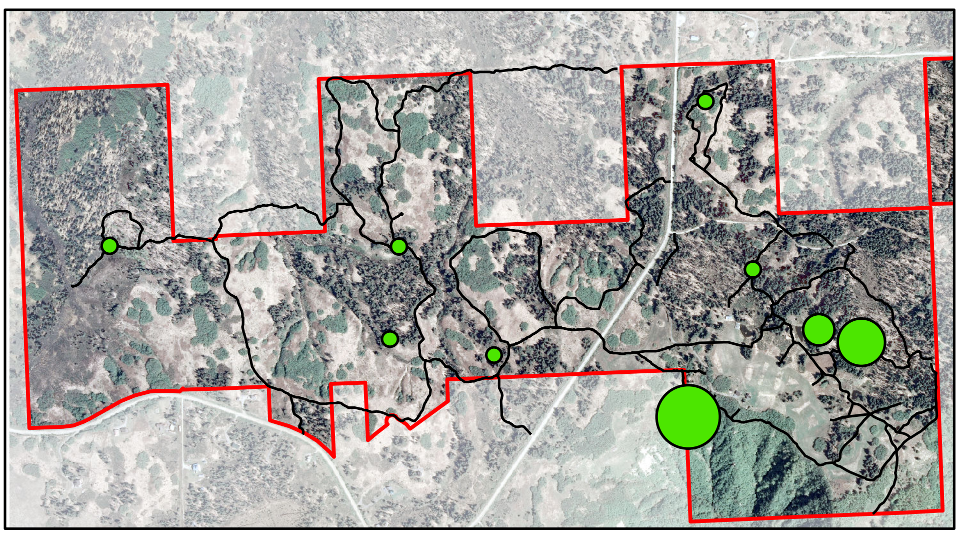
Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Occurrences);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Coyote Occurrences on IRP by Season - 2018

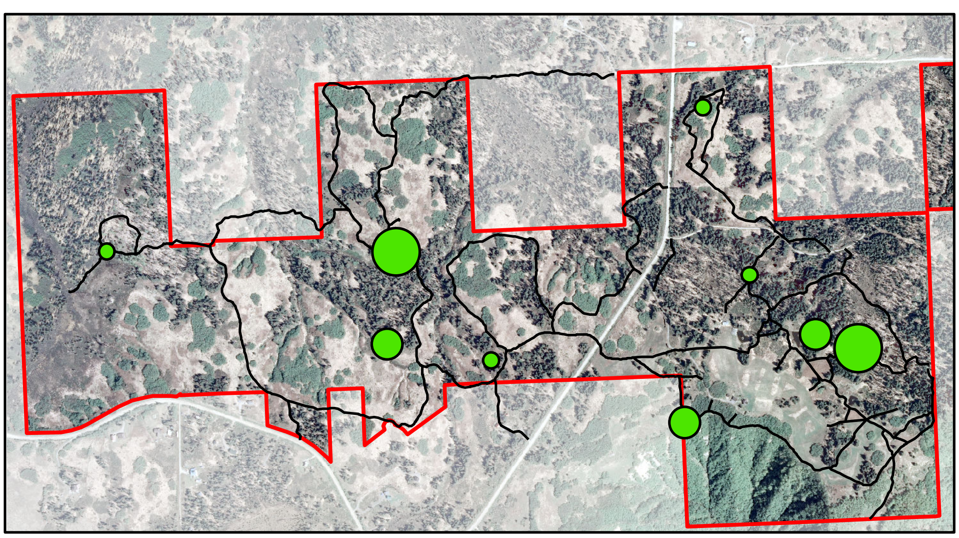
Spring

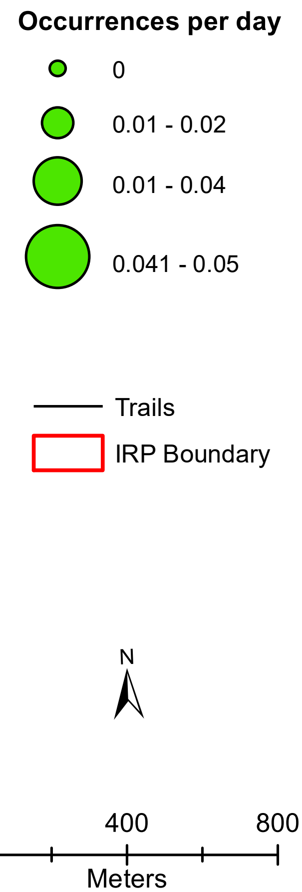


Summer



Fall

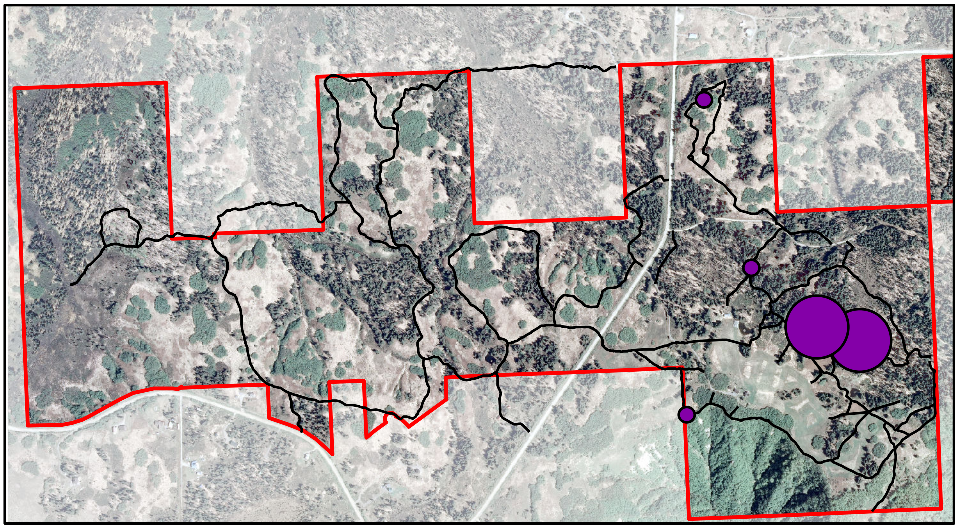




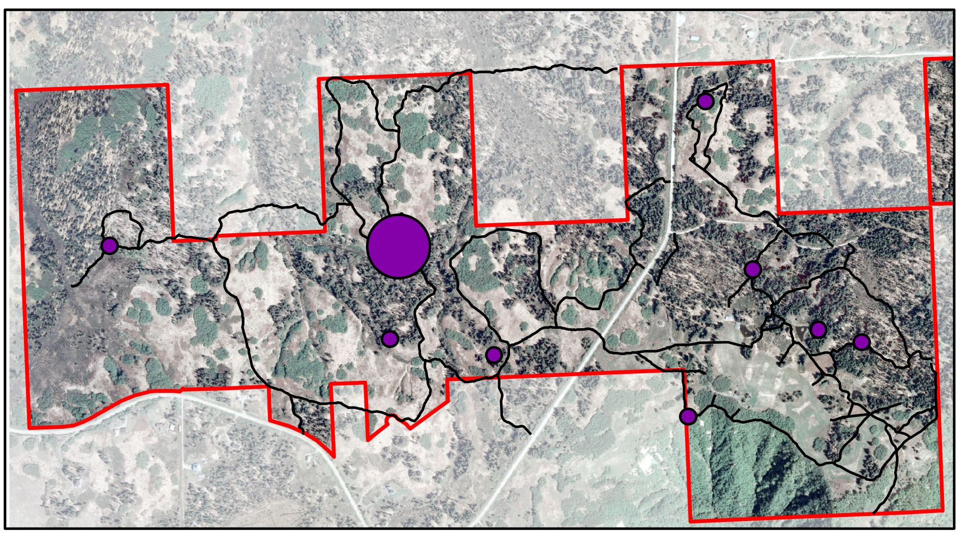
Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Occurrences);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Canandian Lynx Occurrences on IRP by Season - 2018

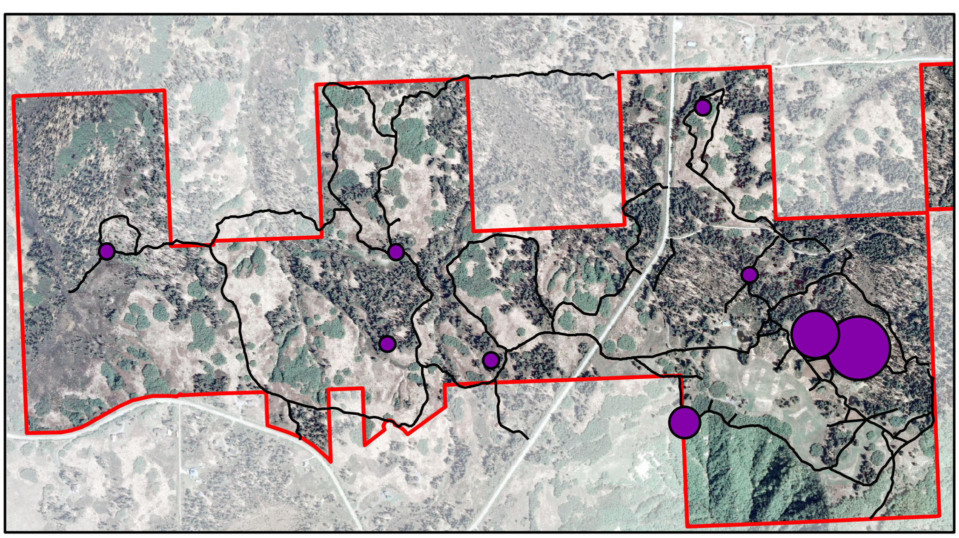
Spring

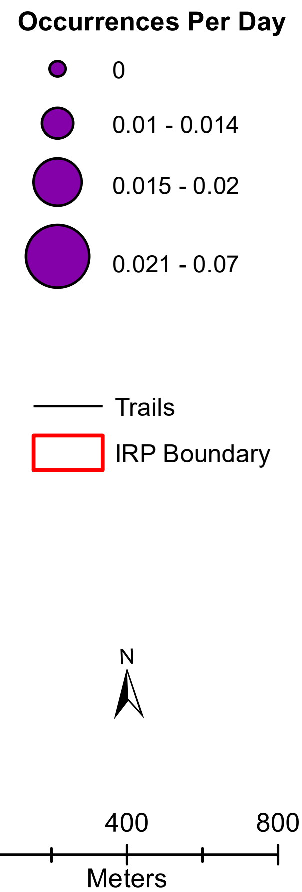


Summer



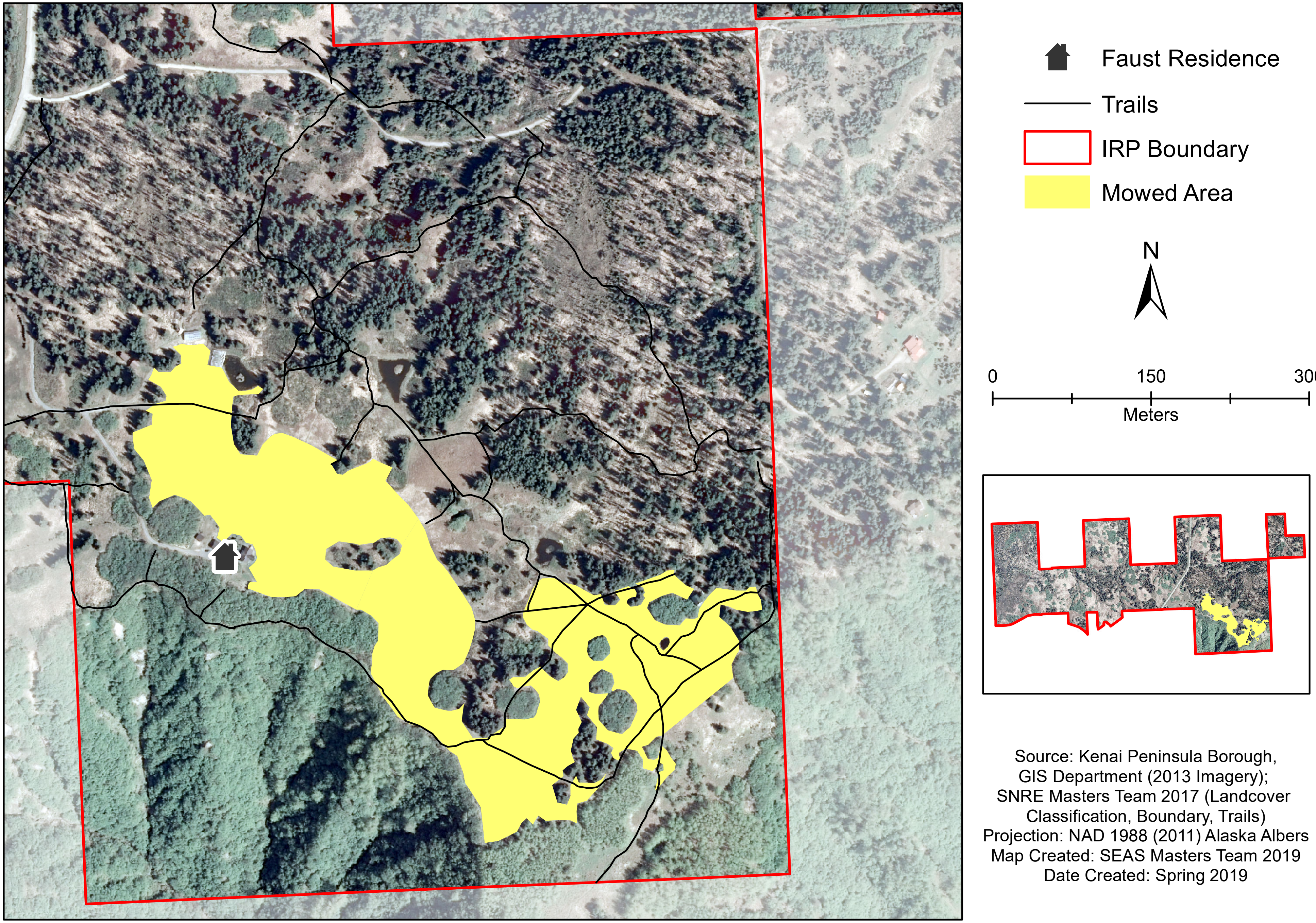
Fall





Source: Kenai Peninsula Borough, GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Trails, Boundary);
SEAS Masters Team (Occurrences);
Projection: NAD 1983 (2011) Alaska Albers
Map created by: SEAS Masters Team 2019
Date created: Spring 2019

Annually Mowed Crane Habitat



Source: Kenai Peninsula Borough,
GIS Department (2013 Imagery);
SNRE Masters Team 2017 (Landcover
Classification, Boundary, Trails)
Projection: NAD 1988 (2011) Alaska Albers
Map Created: SEAS Masters Team 2019
Date Created: Spring 2019

Annual Vegetation Photo Monitoring Points

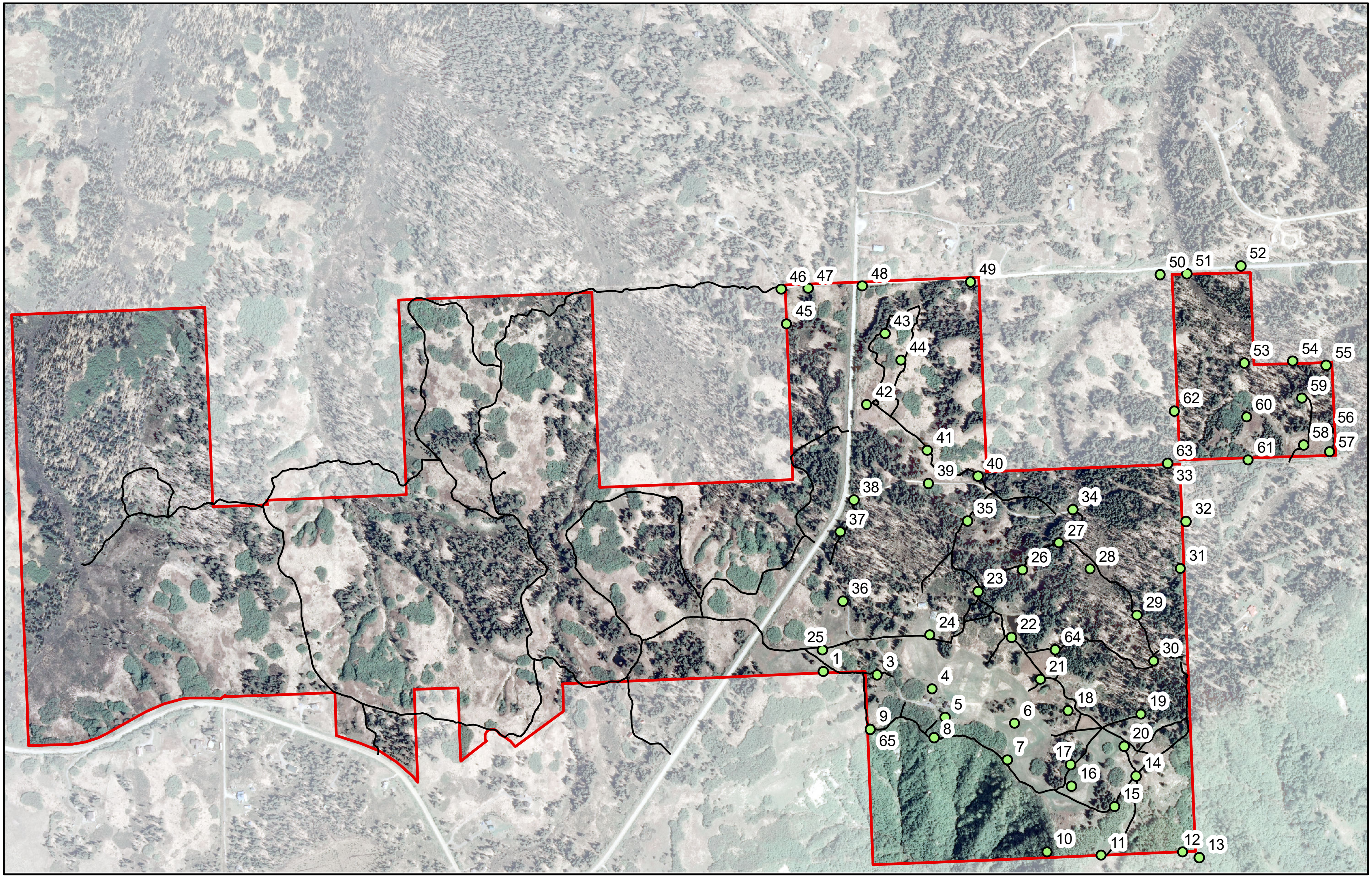


Photo Points

Trails

IRP Boundary

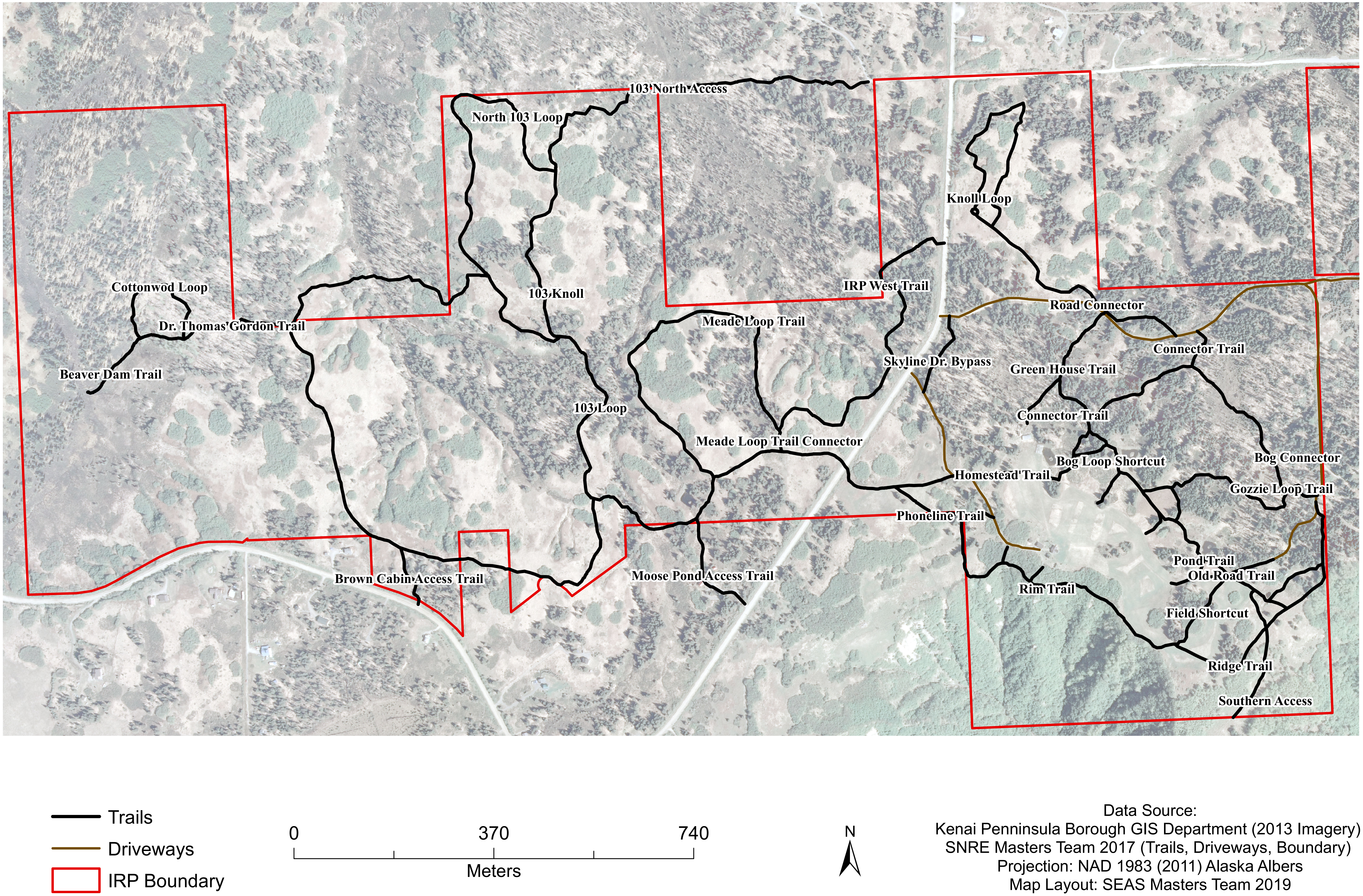
N

0 400 800

Meters

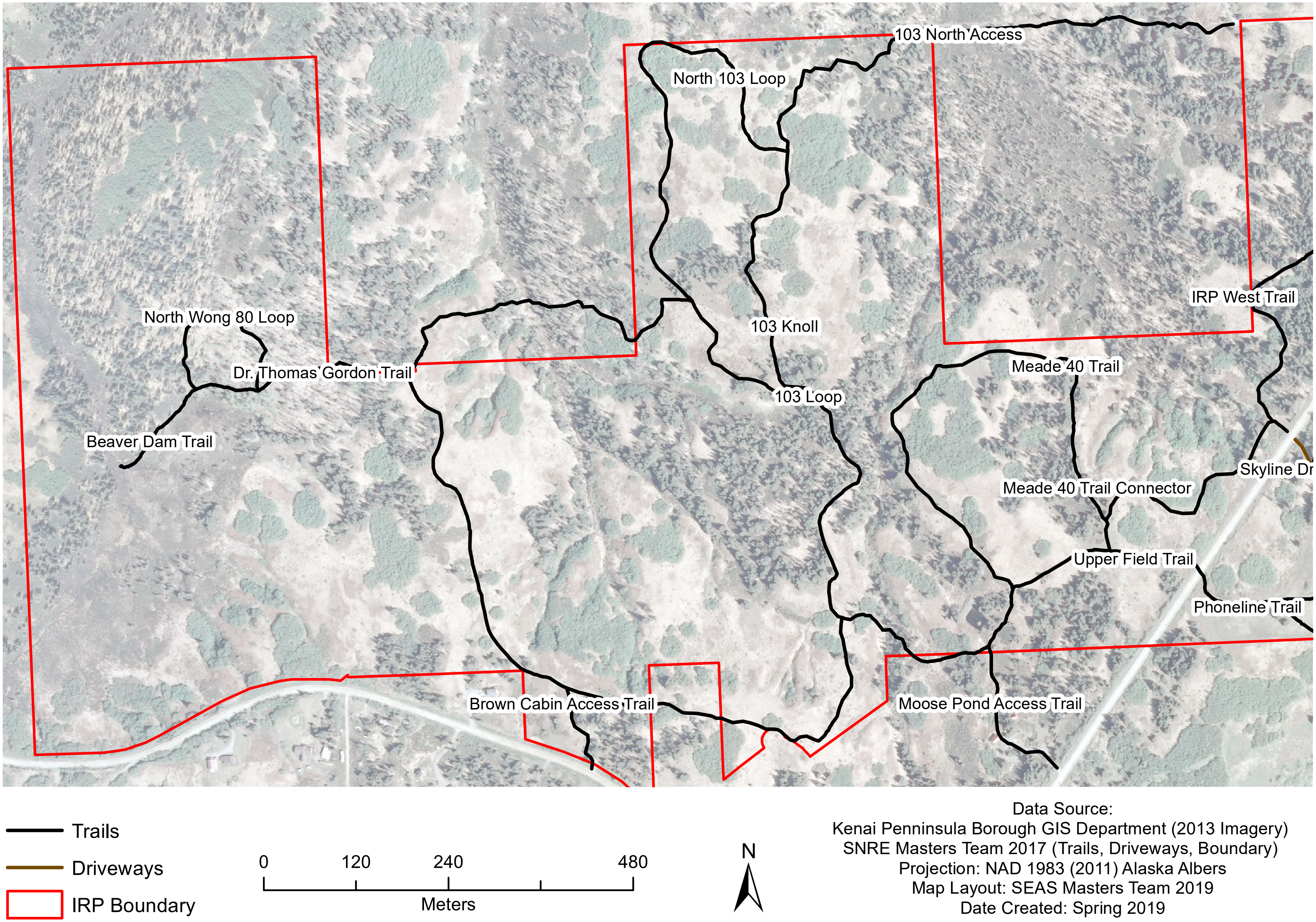
Sources:Kenai Peninsula Borough, GIS department (2013 Imagery)
SNRE Masters Team 2017(trails, boundary)
Created By:SEAS Masters Team (Drone Photo Points)
Projection:NAD 1983 (2011) Alaska Albers
Date Created: Spring 2019

IRP Trails



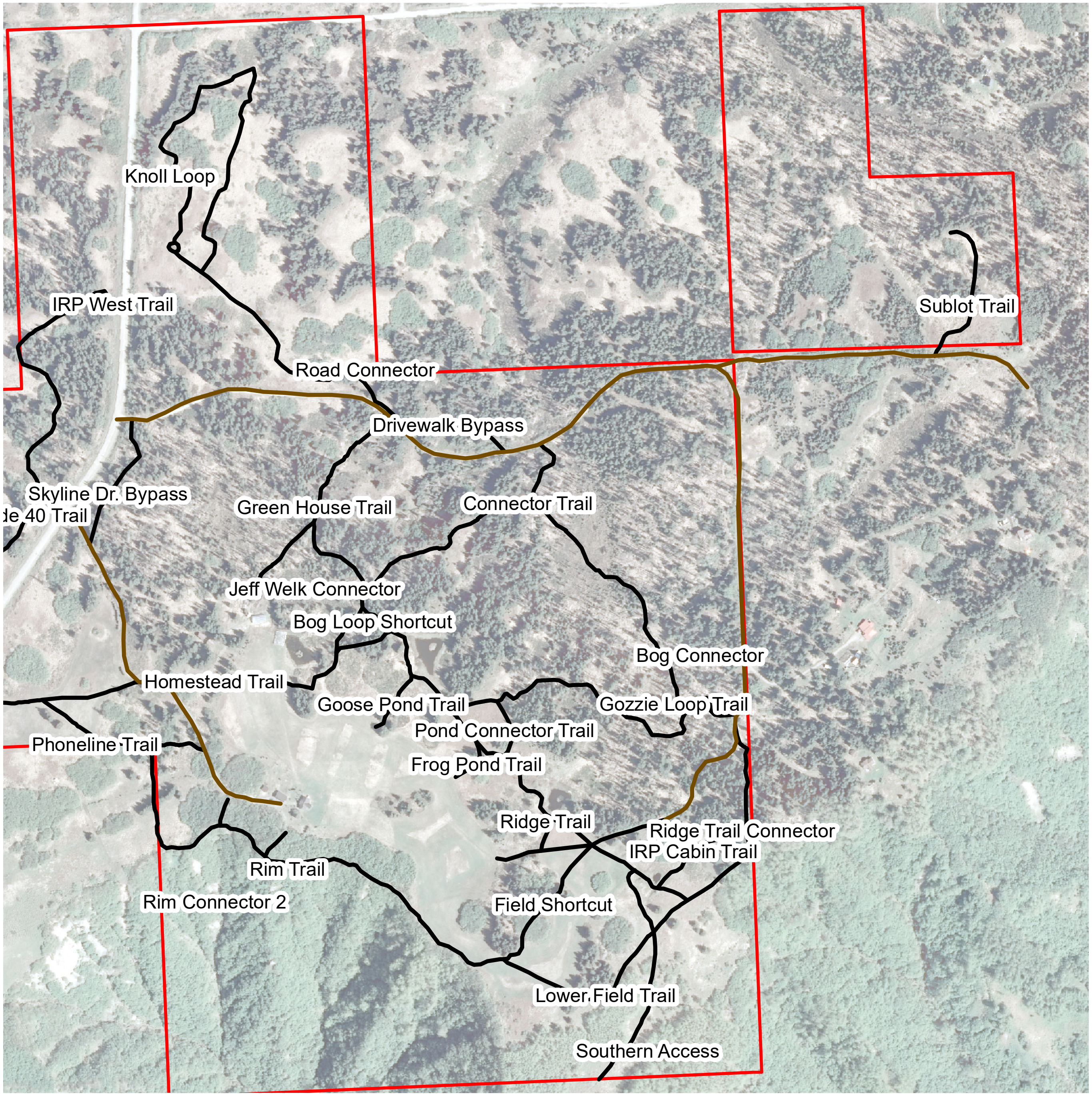
Data Source:
Kenai Penninsula Borough GIS Department (2013 Imagery)
SNRE Masters Team 2017 (Trails, Driveways, Boundary)
Projection: NAD 1983 (2011) Alaska Albers
Map Layout: SEAS Masters Team 2019
Date Created: Spring 2019

West Side of IRP Trails



Data Source:
Kenai Penninsula Borough GIS Department (2013 Imagery)
SNRE Masters Team 2017 (Trails, Driveways, Boundary)
Projection: NAD 1983 (2011) Alaska Albers
Map Layout: SEAS Masters Team 2019
Date Created: Spring 2019

East Side of IRP Trails



Trails

Driveways

IRP Boundary

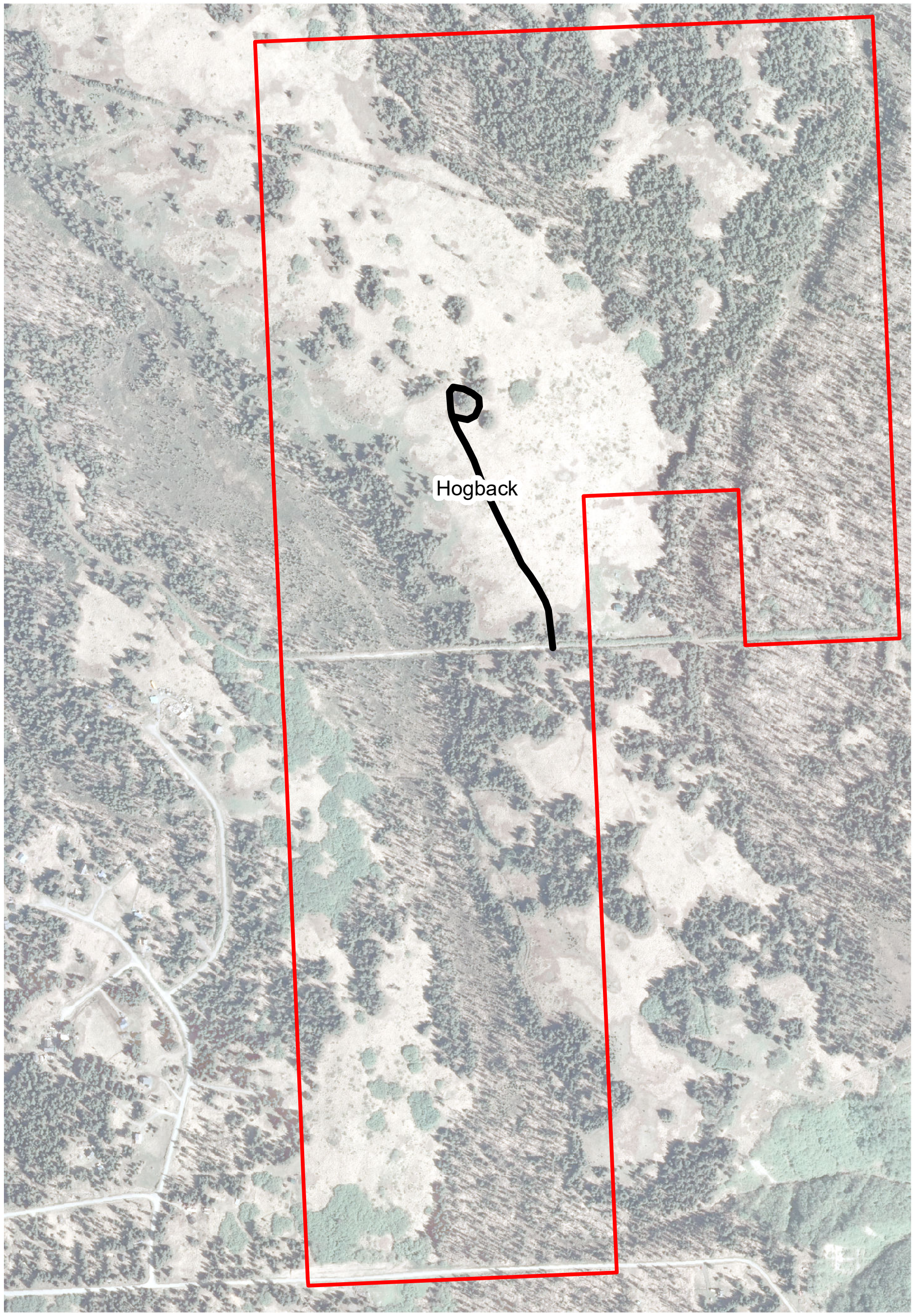
N

0 105 210 420

Meters

Data Source:
Kenai Penninsula Borough GIS
Department (2013 Imagery)
SNRE Masters Team 2017 (Trails, Driveways,
Boundary); Projection: NAD 1983 (2011)
Alaska Albers; Map Layout: SEAS Masters
Team 2019; Date Created: Spring 2019

IRP Hogback Trails



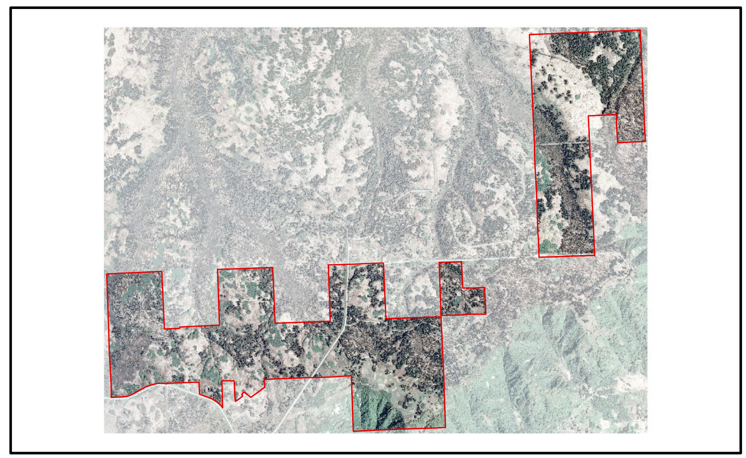
N

Trails

IRP Boundary

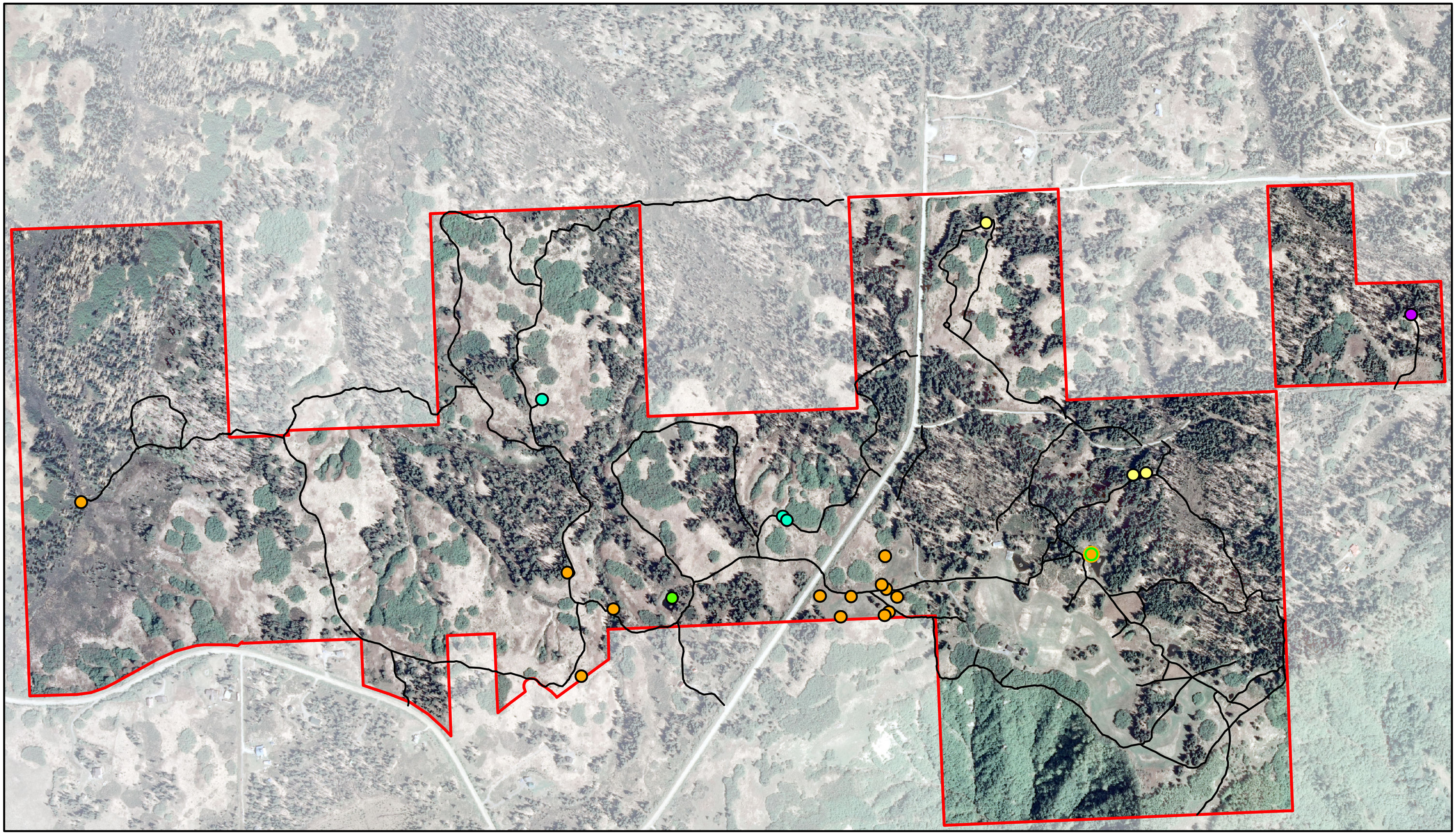
0 212.5 425 850

Meters



Data Source:
Kenai Penninsula Borough GIS Department (2013 Imagery)
SNRE Masters Team 2017 (Trails, Boundary)
Projection: NAD 1983 (2011) Alaska Albers
Map Layout: SEAS Masters Team 2019
Date Created: Spring 2019

Invasive Species Monitoring Points 2018



Galeopsis tetrahit (Brittlestem Hemp-Nettle)
Pilosella caespitosa (Yellow Hawkweed)
Unspecified Species
Birdsfoot Trefoil (Lotus corniclatus)
Pilosella aurantiaca (Orange Hawkweed)
P. aurantiaca and L. corniclatus
Trails
IRP Boundary

N

0 250 500
Meters

Source: Kenai Peninsula Borough, GIS Department (2013 Imagery); SNRE Masters Team 2017 (Landcover Classification, Boundary, Trails)
Projection: NAD 1988 (2011) Alaska Albers
Map Created: SEAS Masters Team 2019
Date Created: Spring 2019