Interdisciplinary Ecological Baseline Assessment Contributing to the Understanding of the Health and Value of Watersheds Protected by the Center for Alaskan Coastal Studies

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Abstract

Not only do watersheds act as critical habitat for various species of flora and fauna, they provide numerous important ecosystem services to humans. These services include water and air filtration, carbon storage, flood protection, and nutrient cycling. Monitoring and managing watersheds appropriately is important in order to maintain healthy and intact ecosystems that may continue to provide for plants, animals, and humans. However, watersheds around the world are threatened by climate change impacts and increasinging development. Due to this, the Center for Alaskan Coastal Studies (CACS) in Homer, Alaska recruited our Masters Project team to aid in conducting an interdisciplinary analysis of watershed properties that their organization stewards. This involved creating protocols that were subsequently used to conduct ecological baseline data collection on CACS' Wynn Nature Center (140 acres), Inspiration Ridge Preserve (693 acres), and Peterson Bay Field Station properties. Ecological data collection involved fish trapping, macroinvertebrate sampling, breeding bird surveying, peat depth probing, and vegetation assessments.

Through our ecological sampling we observed a diversity of flora and fauna present on CACS properties, habitat diversity and connectivity, and pristine headwater stream ecosystems. These data can function as part of a baseline that CACS can compare to future sampling so they may continue to monitor how these ecosystems respond to anthropogenic threats. Further, information and results shared in this report may be used to aid in land management decision making, and to inform the public and policymakers regarding the importance of conserving and protecting these watershed ecosystems.

Acknowledgements

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In addition, we'd like to thank all University of Michigan staff who assisted us during our writing process including Dr. Bill Currie, Shannon Brines, and the staff at CSCAR.

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Our team would also like to thank Inspiration Ridge Property Manager Nina Faust. We are deeply grateful for all of her direction on sampling locations, understanding the ecology of the IRP, and for our many nature walks with Chipper.

We would also like to send thanks to the many researchers, artists, and naturalists who helped us during our stay in Homer and with creating our protocols. Special thanks to ecologist Ed Berg, artist and naturalist Kim McNett, watershed ecologist Coowe Walker, avid birder George Matz, and Alaska Songbird Institute Executive Director Tricia Blake.

Thank you also to the Alaska Department of Fish and Game for signing our permits and reviewing our protocols prior to data collection.

Thank you to the University of Michigan School for Environment and Sustainability and Rackham Graduate School for funding our project.

Finally thank you to the land, vegetation, and fish and wildlife whom we spent many hours learning from.

Land Acknowledgement

We would like to acknowledge the land the majority of our project has taken place on, at the University of Michigan, was originally known as Michigami. These are the ancestral lands of the Wyandot and Anishinaabek, who are also known as the Three Fires People: Ojibwe, Odawa, and Bodewadmi.

We would also like to acknowledge that our field work in the southern Kenai Peninsula took place on traditional lands of the Dena’ina and Sugpaq peoples. For thousands of years the Dena’ina and Sugpaq peoples have and continue to care for these lands in which settlers and our project have benefited from. Without their stewardship and continued resilience to colonial powers and systems, the ecological community of the Kenai would not have the integrity it does today.

Our project, alongside past and future projects, have and will continue to benefit from the hurtful dispossession and exploitation of Indigenous Peoples. We honor the Indigenous Peoples which have shaped the land that we learn from and upon. We acknowledge the sovereignty and self-determination of all Indigenous peoples and denounce the societal and state-sanctioned violence, theft, and genoice perpetrated against Indigenous peoples for settler benefit. We know these words are not enough. However, in environmental science and sustainability as we continue to seek understanding from land we must also continue to stand in solidarity with all Indigenous peoples as they seek visibility and sovereignty of Native Geographies.

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Introduction

The Center for Alaskan Coastal Studies (CACS) is a 501-c-3 non-profit organization located in Homer, Alaska. Homer is located in the South Central region of the state, on the southern tip of the Kenai Peninsula and on the Kachemak Bay. (See Fig. 1)

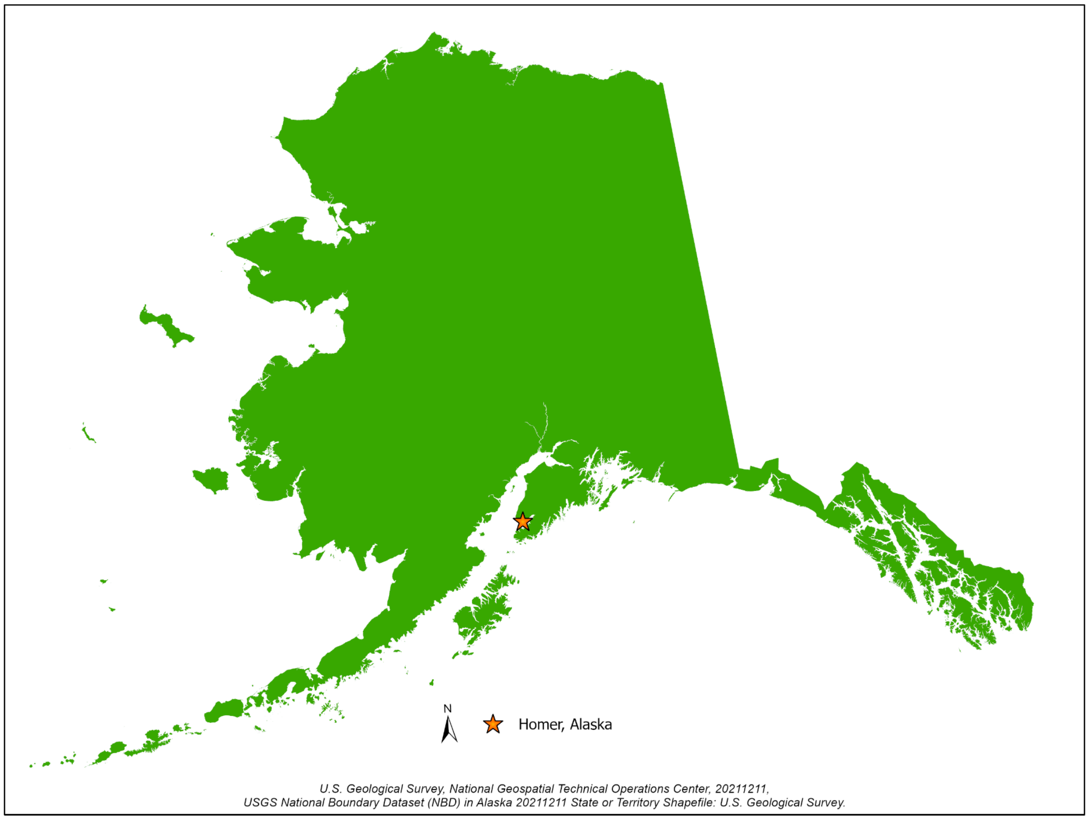


Figure 1. Map depicting location of Homer, Alaska

Prior to the 1800's and colonialist Russian and European settlement, the Dena'ina and Sugpaq peoples had, and continue today, stewarded their traditional lands for thousands of years. The Dena'ina peoples had permanent coastal settlements in the Kenai with rich economies based on sophisticated and sustainable ocean harvest (Ninilchik Village Tribe, n.d.). The Sugpaq peoples economies were based around connection to land and tied to seasonal changes (NPS, 2020). Despite disease, culture erasure, and conflict from settlers, these Indigenous groups have remained resilient and are sovereign nations with commitment to the health of their people and the land (Ninilchik Village tribe and Kenaitze Indian Tribe, n.d.).

Today, the city of Homer has a population size of roughly 6,000 permanent residents. However, it attracts tourists from around the world who come to experience its natural beauty. Described by residents as "where the land ends and the sea begins," and "the Cosmic Hamlet by the Sea" there are enchanting views of Kachemak Bay, the Kenai Mountains, and snow dotted volcanoes across the Cook Inlet (City of Homer, n.d.). This region provides numerous opportunities for birders, anglers, artists, hunters, wildlife photographers, and more to experience a place that is so closely tied to the natural world. Alaska is also visited regularly by researchers from around the world, including climate scientists. One reason, among many, that the arctic region is a hub of scientific research is due to its high rate of warming in recent decades, warming roughly 2x faster than any other region on Earth (Coggin, 2019). The small coastal town's economy is based on a mixture of tourism, art, marine sectors, and fishing, with Homer being hailed the "Halibut Capital of the World." Homer continues to develop and increase in population size, growing 27% between 2000 and 2019. The community hopes to grow and develop responsibly, as is indicated by it being the first city in Alaska to develop a Climate Action Plan in 2017 (City of Homer, n.d.).

The Center for Alaskan Coastal studies has been operating out of Homer since its creation in 1982. CACS focuses on environmental stewardship and education, with their mission statement highlighting their goal to "foster responsible interaction with our natural surroundings and to generate knowledge of the unique marine and coastal ecosystems of Kachemak Bay through science-based environmental education and stewardship." This is accomplished through providing a science-based education to visitors of all ages. In addition, CACS owns and manages land properties for conservation and environmental education purposes. Three of these properties are the Wynn Nature Center (Wynn), the Peterson Bay Field Station (PBFS), and the Inspiration Ridge Preserve (IRP).

The Wynn Nature Center is a 140-acre property that lies on the bluff overlooking Homer. It was donated to CACS in 1990. At the Wynn, CACS provides numerous guided hikes and interpretive programs for all age groups. While there are trails on the property, much of the land is managed as essential wildlife corridors and habitat for wildlife including black bear and moose. The diverse habitat on the property supports a variety of vegetation communities, such as those that can be found on their peatlands and in the boreal forest. Notably, this protected property contains headwaters of the Anchor River Watershed. The Peterson Bay Field Station is located across the bay from the IRP and Wynn and serves as a living laboratory, supporting day and overnight trips for groups of all ages. This involves hiking in the lush vegetation and tide pooling at the nearby beach.

The Inspiration Ridge Preserve is also located on the bluffs overlooking Homer, a few miles from the Wynn. The IRP is a 693-acre property with diverse habitats, including beautiful open meadows, riparian habitat including creeks and ponds, peatlands, and boreal forests. These habitats support a variety of wildlife, vegetation, and essential natural processes that provide ecosystem services to the community of Homer. Edgar Bailey and Nina Faust purchased the first 32 acres of the IRP in 1986 and over the years the couple continued to purchase adjacent land. The IRP parcels that were purchased by the couple over the years are connected to surrounding state and private lands in a way that creates essential wildlife corridors and habitat (Whiting, 2020). In Fig. 1.1a you can see the IRP (upper right) and Wynn property (lower left) in purple. Adjacent to the IRP are land parcels owned by the Alaska DNR and Moose Inc. Fig. 1.1b highlights the watershed basins that the IRP and Wynn are located within and streams that flow through these properties.

Kenai/Homer Conservation Parcels

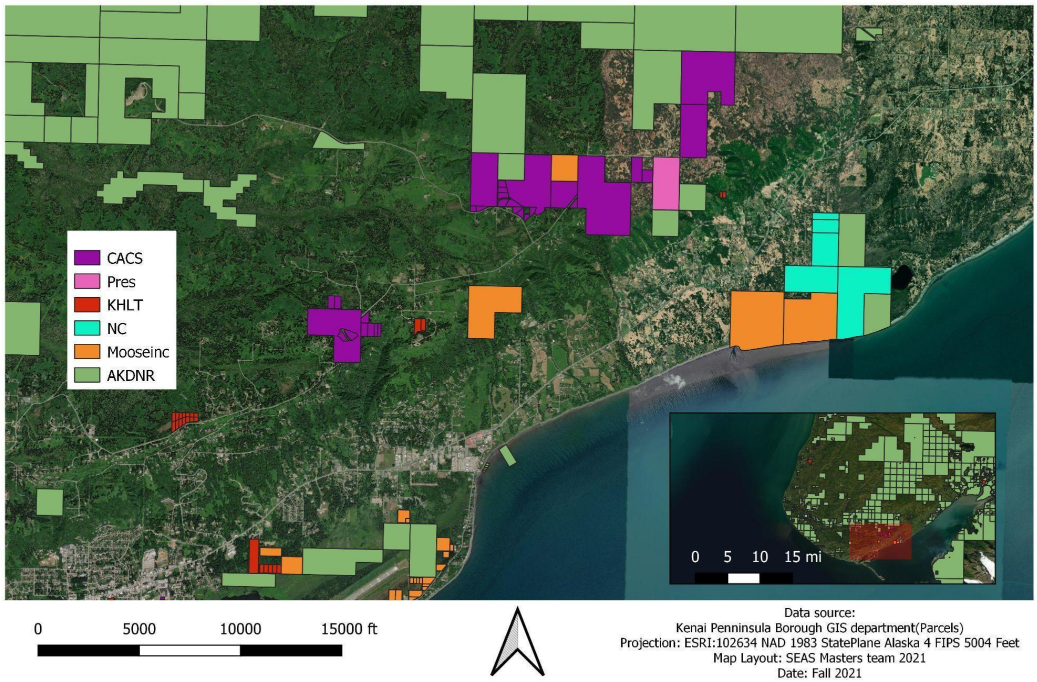


Figure. 1.1a Map showcasing land parcels highlighting those owned by conservation organizations in the Homer, Alaska region. CACS(Center for Alaskan Coastal Studies), Pres(Preserved parcels),KHLT(Kachemak Heritage land trust), NC(Nature conservancy), Moose inc(Moose inc non-profit), AKDNR(Alaska Department of Natural resources).

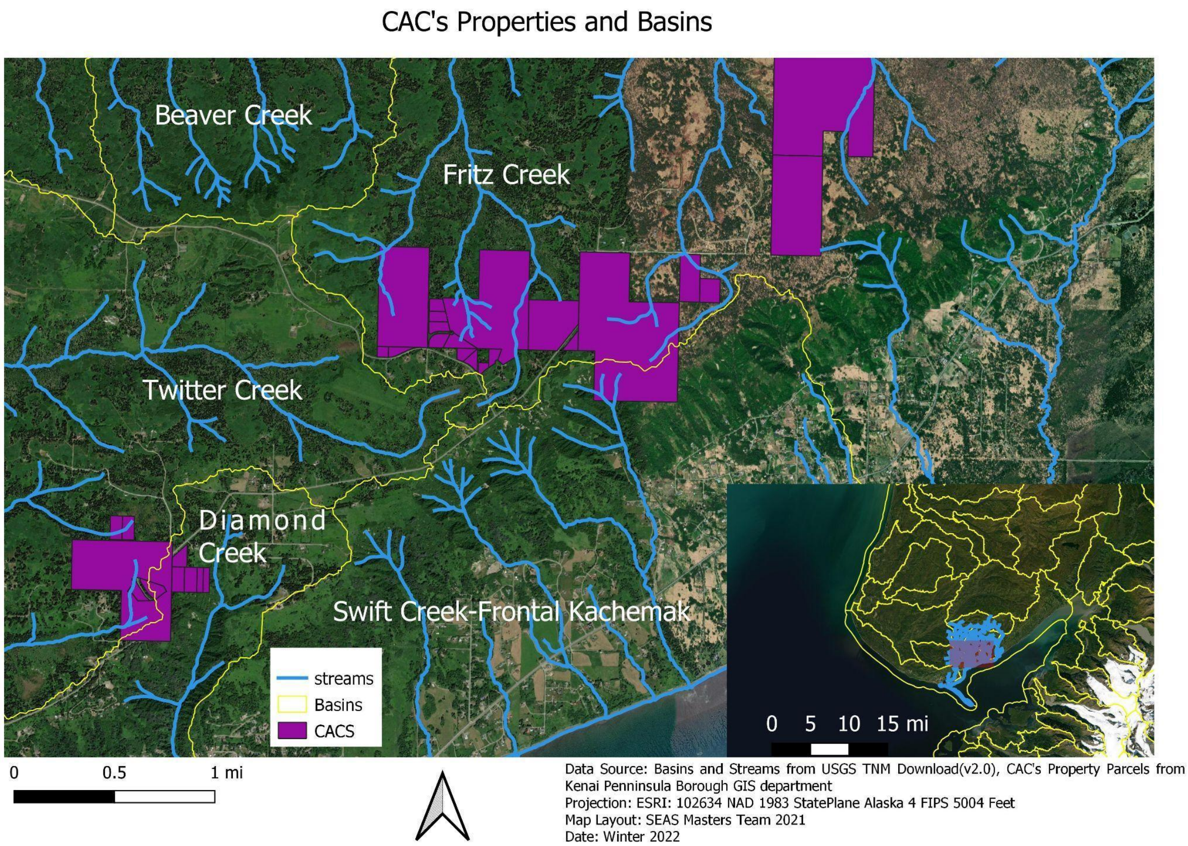


Figure 1.1b Map showcasing CACS property Parcels (purple) with watershed extents/boundaries (yellow) and streams.

Nina and Ed have stewarded the IRP over the years, working with surrounding local, state, and federal organizations and agencies. An essential component of the IRP property is nesting and staging areas for sandhill crane populations during their migration to the Kenai in the spring and fall (Whiting, 2020). Nina and Ed set up a monitoring program for the local crane populations, the Kachemak Crane Watch, to encourage local residents to share sightings in order to record long-term changes in their populations; including their arriving and departure times and number of colts.

Of the 19 properties that make up the 693-acres of the IRP, 12 are protected conservation easements with Kachemak Heritage Land Trust and in 2016 CACS was gifted these lands by Nina and Ed in partnership with the Kachemak Heritage Land Trust (Whiting, 2020). While Ed Bailey passed away in 2018, Nina continues to act as property manager. Residing on and managing the property, alongside managing the caretakers residing on the land. Nina continues to be dedicated to her and Ed's dream of creating their own wildlife preserve. The IRP will continue to be managed by CACS and the Kachemak Heritage Land Trust for wildlife habitat, corridors, and as a place for people to connect to the land through educational programming; truly a lasting testament to the conservation efforts of Ed and Nina. Detailed information regarding the ecology of the IRP and Wynn has been documented by previous SEAS master's project teams. For this reason, this report will not go into extensive detail regarding the specific ecology of these properties.

As environmental educators and land managers, CACS takes part in ecological research, applying field data to land management decisions, monitoring how these decisions impact the landscape, changing their approaches based on monitoring, and communicating ecology-based curriculum with the public. Their holistic approach to stewardship, science, and education plays an important role in the land they manage, the communities they work with, and the greater environmental science community.

Ecological Context and Project Scope

The Anchor River/Fritz Creek Watershed

The Anchor River/Fritz Creek Watershed (hereafter referred to as the Anchor River Watershed) lies in the southern part of the Kenai Peninsula and is part of the greater Cook Inlet watershed (Fig. 1.2).

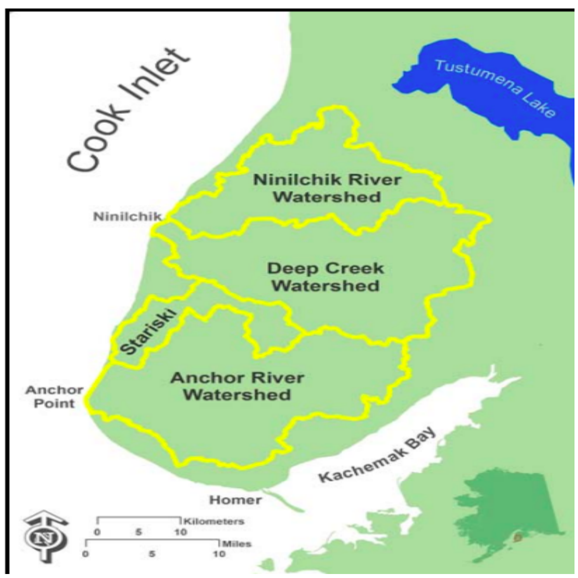


Figure 1.2: Greater Cook Inlet Watershed detailing subwatersheds, including the Anchor River Watershed, which contains our study sites, the IRP and Wynn. Source of image: (Cook Inlet Keeper, 2007)

The IRP is within the Anchor River Watershed and contains wetlands and unnamed headwater streams. The Wynn is in the Bridge Creek Watershed, which is nestled in the Twitter Creek watershed and ultimately also the Anchor River watershed. The Wynn contains a tributary to Bridge Creek, ultimately being a part of the Bridge Creek Watershed which provides Homer their drinking water through the Bridge Creek Reservoir.

The Anchor River watershed includes diverse habitat that supports wildlife including seabirds, black and brown bears, and a variety of fish species such as coho salmon (*Oncorhynchus tshawytscha*). Additionally, it includes around 164 miles of anadromous streams for fish and wetlands occupy 48.2% of the watershed landscape (Cook Inlet Keeper, 2007). Within the Anchor River Watershed is the Anchor River/Fritz Creek Critical Habitat Area (Fig. 1.3). In 1985 this land was protected for fish and wildlife and is the main source of overwintering habitat for moose in the southern Kenai (Alaska Department of Fish and Game, n.d.).

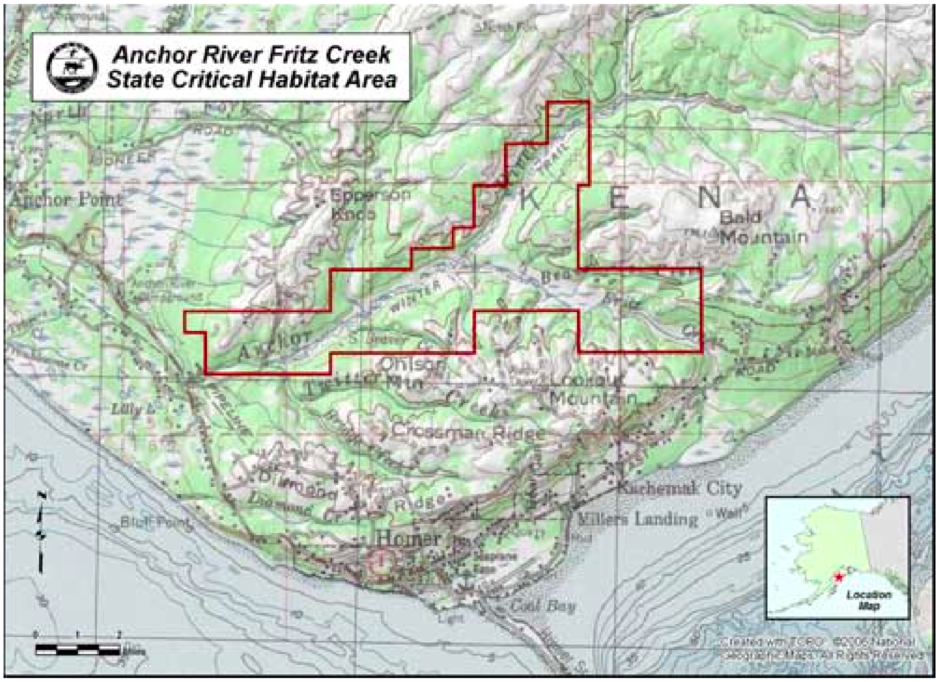


Figure 1.3: Anchor River/Fritz Creek State Critical Habitat area refuge boundary. (Alaska Department of Fish and Game, n.d.).

Recognizing the ecological, societal, and environmental benefits of a healthy watershed and the importance of ecosystem monitoring, the Anchor River Watershed Action Plan was developed in 2007 by the Homer Soil and Water Conservation District in partnership with the Cook Inlet Keeper (Cook Inlet Keeper, 2007). In the action plan these organizations used 5 years of monitoring data to pinpoint main threats and concerns within the watershed in order to develop a management plan. Overall, they concluded that currently the Anchor River Watershed is of high quality, however there were concerns around water temperatures, turbidity, and loss of habitat. Specific threats leading to these concerns include point-source pollution such as road building and gravel mining, alongside non-point source pollution through logging, sedimentation, and increased urbanization (Cook Inlet Keeper, 2007). Land in the watershed has developed significantly in recent years and development is projected to continue.

Between 2004 to 2005, monitoring showed that summer water temperatures were violating water quality standards based on the Alaska Clean Water Actions in the middle and upper Anchor River. High water temperatures in the Anchor River, particularly during the summer months, are impacted by a variety of natural and human influences (Cook Inlet Keeper, 2007). Natural influences on water temperature include precipitation, flow rate, and channel depth. Human influences can include removal of vegetation leading to loss of shade for cooling and increased sedimentation, lower stream flows from water withdrawal, channel straightening that leads to lower floodplain connectivity, and draining of wetlands that leads to less water storage (Cook Inlet Keeper, 2007).

Monitoring done on turbidity in the Anchor River Watershed displayed that general development, primarily through culverts and resource extraction related to gravel, were decreasing water quality through increased turbidity (Cook Inlet Keeper, 2007). Turbidity relates to the cloudy or murkiness of the water through particles that scatter light (Minnesota Pollution Control Agency, 2008). High turbidity can impact ecological functioning of the aquatic system, decrease recreation value, and impact sources for drinking water. Main impacts to fish and aquatic life include change in food supply and structure, degradation of spawning beds, and impacting gill functioning (Minnesota Pollution Control Agency, 2008). The other major concern is stream bank degradation related to erosion, degradation of riparian zones, and bank alternation through a mix of natural and human causes. Human impacts on stream bank degradation include development and ATV usage (Cook Inlet Keeper, 2007).

In addition to development concerns, climate change is impacting and will continue to impact watershed ecosystems in the Anchor River Watershed in various ways. Table 1 depicts a comprehensive list of climate change impacts on watershed health and delivery services developed by the Intergovernmental Panel on Climate Change in 2007 (IPCC, 2007, as cited by the USDA/USFS, 2008).

Table 1: Climate change impacts on watersheds developed by the Intergovernmental Panel on Climate Change (IPCC) in 2007.

↑ = probable increase, ↓ = probable decrease, ▲ = change

Climatic Changes	Location	Ecosystem Effects	Consequences for Watershed Services
Warmer air temperatures	Widespread Greatest change in mountains and northern latitudes	↓ Precipitation as snow; faster and earlier snowmelt ↑ Evapotranspiration and primary productivity ↑ Water temperatures ↑ Sea level; coastal erosion and saltwater intrusion into freshwater supplies	▲ Amount, type, quality, and distribution of aquatic habitat and biota ▲ Water availability and recreational and cultural experiences ↓ Water quality and timing ↓ Function and operation of existing water infrastructure in coastal areas
Changes in precipitation patterns (projected changes vary by location and have substantial uncertainty)	Less winter precipitation at lower latitudes (Southwest, Intermountain West)	↓ Snow; changes in streamflow timing ↑ Risk of disturbance, e.g., drought, wildfires, insects, disease ↓ Vegetation growth; changes in composition	↓ Water supplies for people, agriculture, energy, and other uses ↑ Water demand, ground water withdrawals, and consumptive use of surface waters ↓ Fisheries and water-based tourism
	More precipitation at higher latitudes (Pacific Northwest, New England)	↑ Streamflow ▲ Vegetation growth and composition ↑ Soil erosion and landslides	↑ Freshwater supplies ↑ Improvements in warm water fisheries
Greater variability in precipitation from year to year More extreme floods and droughts	Everywhere	↑ Variability in stream, lake, and riparian habitats ↑ Risk of aquatic and riparian species extirpation ↑ Soil erosion, stream and lake sedimentation, and landslides	↑ Uncertainty in water supply ↑ Uncertainty for reservoir operations ↑ Risk to aquatic habitat and water supply infrastructure

While these impacts vary by geographic region, those that are particularly concerning to watersheds in the Homer area, and waterways in the Kenai Peninsula as a whole, are those that impact essential stream function such as temperature and flow regimes (Leppi et al. 2014, as cited by Walker et al., 2021).

The climate impacts of warmer stream temperatures and changes in precipitation are of particular concern to these coastal Alaskan watersheds and their fish populations (Bryant, 2009). In coastal southeast Alaska, predicted changes in precipitation that will have an impact on stream ecosystem functioning include changes in snowpack, timing of melting, and increased amount and intensity of rainfall (Stewart et al., 2004 & Trenberth, 1999 as cited by Bryant, 2009). Changes in precipitation impact stream hydrology and river discharge. While these changes will impact the overall watershed in Homer in several ways, salmonid populations in particular will be impacted as much of their life history is tied to river discharge timing and stream flows (Byrant, 2009).

Warming stream temperatures will impact various levels of freshwater stream ecosystems in the Kenai. Water temperature increase will not only impact fish during their life history stages but also other aquatic animals and plants. Warming water temperatures will increase metabolic costs for fish species including salmonids. With increasing metabolism comes an increased need for food to meet energy demands. However, if other aquatic organisms and plants aren't abundant enough to meet increase in metabolic demands then populations will have increased mortality rates (Bisson, 2008). In addition, with increasing water temperatures coldwater fish populations such as trout and salmon will seek thermal refugia. However, these coldwater streams which typically have provided refuge, may be reduced due to reduced snowpack and changes in streamflow (Bisson, 2008). Concern over climate change impacts to watersheds is further heightened when considering how habitat degradation and biodiversity loss through development and pollution may intensify climate change impacts and ecosystem consequences.

Another emerging concern in the Kenai Peninsula is how an increase in the frequency and intensity of wildfires may impact these watersheds for years to come. While wildfires are a natural occurrence in most forested ecosystems, due to climate change and increased fuel loads from settler-colonialism fire suppression practices, wildfires now pose a greater threat (Hohner et al., 2019). Severe wildfires can have a number of impacts on watershed functioning. When fires are of high-severity they can burn up much of the vegetation and soil layers on the landscape (Keely, 2009 as cited by Hohner et al., 2019). This loss of vegetation and soils can lead to altering of essential watershed functions such as stream flow, erosion control, and water chemistry (Hohner et al., 2019). The loss of vegetation will not only decrease natural filtration, but will also be a loss of food source for various animals that rely on these riparian ecosystems. In addition, ash from these wildfires blows and washes into streams and is transported downstream, leading to decreased water quality and negatively impacting wildlife and human drinking sources (Hohner et al., 2019).

Even in the face of climate change impacts and overharvesting, these Alaskan ecosystems are one of the few places in the world where sustainable management practices for salmon are possible (Walker et al., 2021) The watersheds in the southern Kenai are incredibly unique ecosystems due to the abundance of peatland fens. The relationship between alder cover, peatland fens, and groundwater provides excellent habitat for rearing-salmon (Walker et. al., 2021). Coowe Walker and her colleagues at the Kachemak Bay National Estuarine Research Reserve (KBNERR) have been studying the relationship between these landscape elements in the watershed and how they relate to stream productivity for salmon.

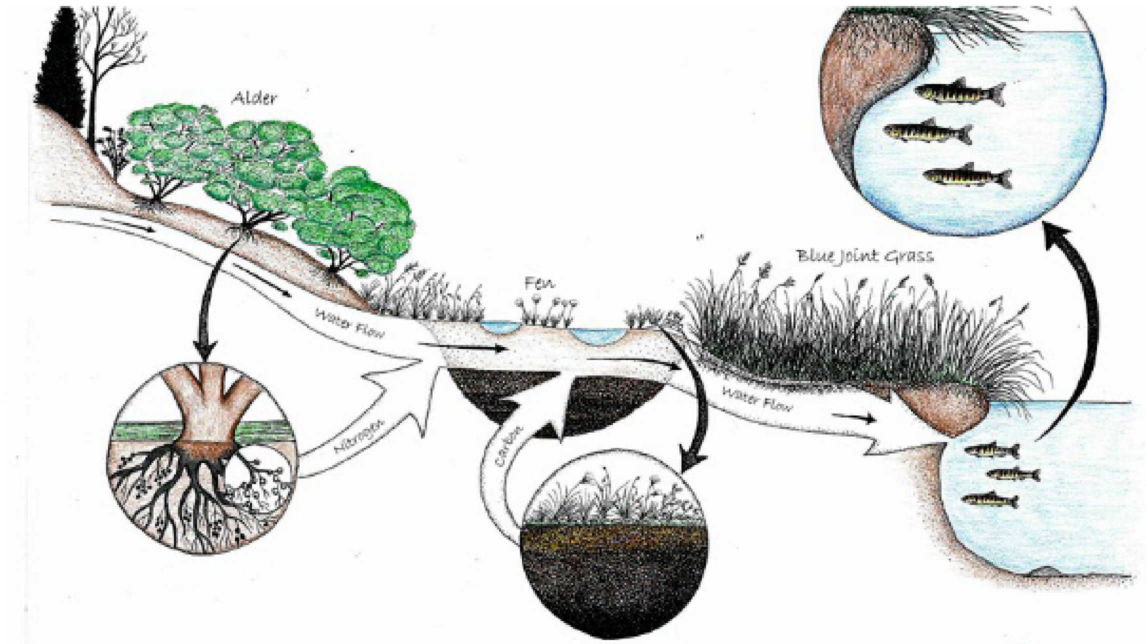


Figure 1.4: Illustration depicting the nutrient flows via groundwater of nitrogen and carbon from alder trees and fens, ultimately deposing into streams. These nutrients result in productive stream habitats for fish populations (Conrad Field, 2021 as cited by Walker et al., 2021).

Beautifully illustrated by naturalist, biologist, and artist Conrad Field, thoroughly described in KBNERR's numerous published ecological research papers, and shared with us during our stay was the importance of this relationship (Fig. 1.4). In the Homer area, there is high alder cover. Alder roots have nodules that can fix atmospheric nitrogen and make it available to the plant. As alder roots and leaves senesce, the nitrogen can then be taken up by hydraulic flow paths through ground water. This nitrogen is joined by both dissolved and particulate carbon inputs from peatland fens, which also aid in regulating groundwater temperatures, and is transported through groundwater into headwater streams (Walker et al., 2021). In addition to delivering the nutrients from these alder and peatland landscapes, the groundwater within these streams also supports refugia for juvenile fish in winter since the water does freeze. Together these attributes enhance the primary productivity of stream ecosystems for rearing-salmon (Walker et al., 2021). As mentioned previously, the IRP and Wynn properties contain headwater streams to the greater Anchor River Watershed, alongside both alder and peatland fen landscape elements. Therefore, these landscape elements on their properties potentially play a role in supporting higher production and densities of macroinvertebrates and juvenile fish (Walker et al., 2021).

The Wynn Nature Center contains the headwaters of Bridge Creek. Bridge Creek originates in and then flows through the Wynn Nature Center wetlands before flowing into Twitter Creek, which meets up with the larger Anchor River, a major fish spawning river in the Kenai (Center for Alaskan Coastal Studies, n.d.). Through protection and conservation of these headwaters and their associated wetland landscapes at the IRP and Wynn Properties, CACS is providing benefits for the entire community through maintaining healthy and naturally functioning watersheds. These benefits include, as mentioned above, contributing valuable nutrients to spawning salmon in the Anchor River, which is both economically and culturally important to the Homer region. Additionally, CACS plays an important role in providing Homer residents with healthy and safe drinking water. As mentioned, the Wynn contains the headwaters of Bridge Creek, which flows into the Bridge Creek Reservoir which is the source of Homer's drinking water.

Due to the immense ecological and community benefits that a healthy watershed provides to the Homer area, there is collaborative effort between numerous organizations and community members to study and conserve these watersheds. These efforts involve establishing baseline data, monitoring how landscape elements might be changing to stressors, better pinpointing the value (economically, socially, and ecologically) of these watersheds, and connecting and communicating findings to the public and policy makers. CACS continues to play a key role in this greater effort through conservation, implementing watershed science and outreach programs, and conducting baseline ecological assessments and monitoring to inform land management decisions. We are honored to work with CACS and play a small role in this ongoing effort through a multidisciplinary analysis on the value of these watersheds.

SEAS 2021 Masters Project Scope

SEAS Master's Project teams from the University of Michigan have had the opportunity to work with and learn from CACS in past years on various projects (Hebert et al., 2015; Turner et al., 2017; Blongewicz et al., 2019). Our 2021 team was the fourth group from SEAS to work with CACS on a masters project. The overarching goal of this project was to conduct a multidisciplinary analysis to contribute to the understanding of the value and health of the two watersheds that the Wynn and IRP properties reside within. As well as conducting some ecological data collection at the PBFS property. According to the Environmental Protection Agency (EPA) a healthy watershed is one in which natural land cover supports hydrological and geomorphic processes, has sufficient habitat and connectivity to support native aquatic and riparian species, and has physical and chemical water quality conditions that can support biological communities. Other key components of a healthy watershed are intact and functioning headwater streams, riparian corridors, biotic refugia, and having natural vegetation in the landscape, the latter of which helps maintain natural stream flows and connectivity of aquatic and riparian habitats (EPA, 2021). Watersheds that are ecologically healthy with intact floodplains and riparian landscapes, enabling them to maintain natural processes, are also more resilient to threats such as climate change and invasive species (EPA, 2021). As discussed above, not only do watersheds act as critical habitat for various species of flora and fauna, they also provide numerous important ecosystem services to humans, including water and air filtration, carbon storage, recreation, cultural significance, and nutrient cycling. Therefore, protecting watershed health and integrity is beneficial ecologically, socially, culturally, and economically. Additionally, studying the ecological interactions within a watershed may better allow for the implementation of land management strategies that maintain natural processes.

This is essential to supporting and maintaining a resilient watershed in the face of anthropogenic impacts.

More specifically, this project involved conducting ecological data collection, creating monitoring protocols for future use by staff and citizen scientists, creating GIS maps to visualize data results and sampling locations, and communicating our findings to CACS and the public. Ecological monitoring included fish trapping, macroinvertebrate sampling, water quality testing, bird surveying, and vegetation and depth assessments on peatlands. This monitoring was done to establish baseline data, contribute to existing data, and to aid in the creation of monitoring protocols. We hope our data will allow and incentivize long term monitoring of these properties to further address changes their flora and fauna are undergoing in the face of development and climate change. In addition, we hope documentation of ecological data can aid in illustrating how important CACS conservation efforts have been and will continue to be for generations to come.

Continuing to conserve high levels of species biodiversity and protecting wildlife migratory corridors and headwater streams are essential to watershed health. This data and this report may aid CACS communication to the public and policy makers. Additionally, we hope that with the support of long-term monitoring data, CACS can pursue additional resource protections and funding. Further, as the IRP is a newly acquired land that CACS is beginning to manage, documenting baseline data of the pristine habitat may be able to serve as an ecological reference for naturalists and researchers to study impacts from climate change and habitat loss. Based on our assessment data, we aim to draw conclusions to address the larger questions of what value these watersheds hold, what threats they face, and what management strategies are essential for protection of ecosystem services.

Objectives:

1. Conduct ecological monitoring in the form of fish trapping, macroinvertebrate sampling, water quality testing, bird surveying, and peatland assessments on the IRP, Wynn, and PBFS properties.
    a. Utilize this information to determine flora and fauna present in the watersheds.
    b. Analyze data and determine species' abundance, diversity, and distribution.
    c. Use the information to make inferences regarding stream and ecosystem health on properties.
    d. Determine if anadromous fish are utilizing the property as this may lead to further stream protections.
2. Create GIS maps and shapefiles that may be shared with CACS that showcase:
    a. Sampling locations on the properties
    b. Visualization of data results
3. Creating protocols for future ecological monitoring that may be used by staff and citizen scientists
4. Suggest recommendations for future monitoring and management strategies.
5. Share the information with CACS that may be ultimately shared with the public and policy makers. This includes:

a. A document that will include information that CACS may include in future education outreach materials.
b. A Story Map sharing information regarding CACS and the properties they own that may be shared on their website.

Ecological Monitoring

I. Fish Surveys

A. Introduction

Homer, Alaska on the coast of the Kachemak Bay is widely regarded as a pristine fishery, home to a healthy Halibut fishery as well as renown pacific salmon fisheries. Pacific Salmon and Trout species are known for their Anadromous lifestyle, meaning they migrate from the ocean to freshwater rivers to spawn and then subsequently die fertilizing their spawn's habitat in the process otherwise known as semelparity. This is the most common pacific salmon (*Oncorhynchus* sp.) life history, however some species do demonstrate repeated spawning otherwise known as iteroparous reproduction, such as *Oncorhynchus mykiss* the Anadromous form of Rainbow trout, more commonly known as *Steelhead*. In southeast Alaska there are seven anadromous Oncorhynchus sp, and one Anadromous Char (Salvelinus sp.) species, all locally known for their important commercial, sport and subsistence values to native and local peoples (Mecklenburg et al, 2002).

Anadromous Pacific Salmon and Char have been deemed "keystone species" (Willson & Halupka, 1995) in Southeast Alaska due to their imperative position in the food web serving as a link between terrestrial and aquatic ecosystems. Others such as (Willson et al, 1998) describe these anadromous species as "cornerstone species" because they are the foundation on which much of the southeast coastal ecosystems rely upon. However, in light of climate change, habitat alteration/degradation, increased anthropogenic stressors such as fishing pressure, and chemicals and logging, anadromous species have significantly declined in some fisheries (Harding and Jones 1993, Glynn and Elliott 1993, Harding and Jones 1992, Murphy, 1995, Willson and Halupka 1995).

The decline of Anadromous fishes in Southeast Alaska is detrimental to the food web as a whole, and peoples who rely upon these fishes and the ecosystem services they directly and indirectly provide. Currently the Alaska Department of Fish and Game has a running list of *waters important for the spawning, rearing or migration of anadromous fishes.* However, they believe their list is far from complete with many streams supporting anadromous fishes not yet receiving an anadromous designation (AS 16.05.871), which grants these streams special protections under Alaska State Law if anadromous species are proven to inhabit said waters. With this in mind, aquatic localities such as Fritz creek and Bridge creek on the IRP and the Wynn managed by CACS, were further investigated.

B. Rationale

Fish trapping was conducted in accordance with previous scientific and management advice on both the IRP and the Wynn. Based on previous fish trapping conducted by SEAS Masters Project groups and preliminary research, anadromous fishes were not to be expected to be caught in either of these headwater tributaries. Our fish trapping attempted to expand upon the 2018 SEAS team fish trapping locations. In total, 24 traps were placed on the IRP and Wynn properties at 12 different locations in July of 2021. No fish were collected from the Wynn and trapping efforts on this property ceased after multiple failed attempts. Water depths were not ideal for hard minnow traps, and locations in which the minnow traps could be fully submerged were difficult to find. Temporal variability in discharge and natural stream processes made trapping the exact same locations as previous researchers difficult. However, efforts were made to trap similar locations regardless of ideal trapping conditions to varying degrees of success.

C. Study Design

Permitting and Reporting

The fish trapping method was developed and successfully used by previous SEAS masters teams. The methodology followed falls in line with ADFG regulations regarding fish trapping. A fish trapping permit must be acquired from the ADFG for properties one wishes to trap. Fish trapping permits were acquired for the Wynn and IRP roughly one month prior to data collection. Subsequent reports on activities are also required by the ADFG.

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

Trapping method

Fish trapping method summary below (more detailed protocol in Appendix B.1)

o Record the latitude and longitude GPS coordinates.
o Anchor the trap to the bank either tying them off to branches or tied off to a stake in the ground.
o Mark trapping locations with surveying tape for easier collection.
o Obtain pre-cured Salmon Skein or free eggs from local sources (Ulmer's), keep frozen until roughly 1 hour before use.

- o Place a quarter sized chunk of skein or a dozen eggs and a few pebbles into a sandwich bag. Use a small stick to perforate said sandwich bag
- o Place bait in the minnow trap secure the trap shut
- o Submerge the trap fully if able, if not be SURE to submerge at least the trap's entrance holes.
- o Secure the traps with cordage or chain to either vegetation on the bank or to a user placed stake well above the water level.
- o Label the traps (using a piece of tape on cordage or chain) with the Permit holder’s name, phone number, and permit number.
- o Leave traps for approximately 24 hours before retrieval.
- o Check the traps approximately 24 hours after they were placed.
- o Remove fish and place them in a bucket of stream water.
- o Take a quick digital picture of the fish on a “Write in the Rain” notebook for later identification if needed
- o Release back into the stream.

Replication

Based on previous master’s teams suggestions regarding fish trapping, trapping should be replicated approximately every three years, on the IRP property at locations denoted by Fig. 2, as well as any new locations on CACS properties with sufficient depth. Fish trapping should be carried out during the summer months when stream flow and accessibility are ideal.

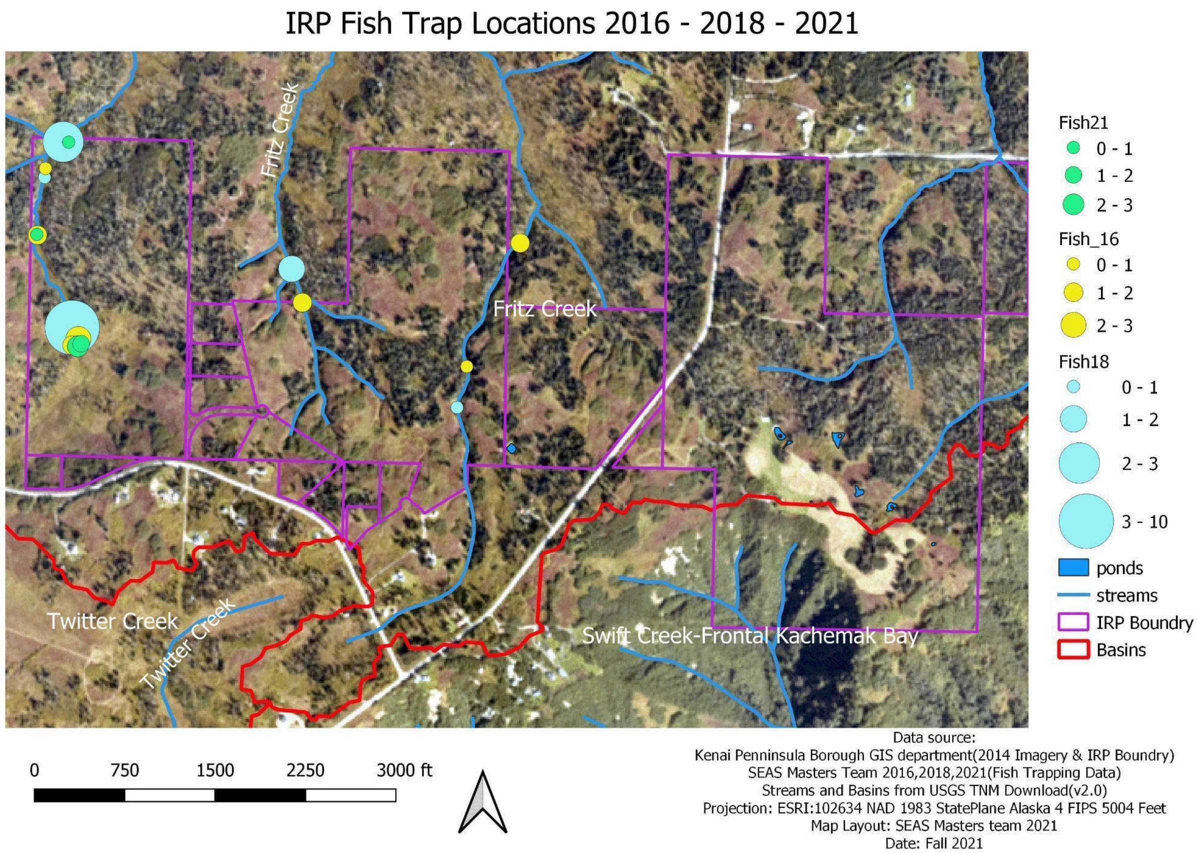


Figure 2: Successful fish trapping locations used by the three SEAS teams from 2016-2021 on the Inspiration Ridge Preserve, Homer, AK.

D. Results

During July of 2021 fish surveys resulted in 7 Dolly Varden (*Salvelinus malma*) from 4 different localities within the IRP. All of the fish came from the western most tributary of Fritz creek on the IRP property. Additionally, the majority of the fish collected during this season came from localities successfully surveyed in the past. Traps on the eastern tributaries and at the Wynn did not result in any fish; however, this does not prove their absence and further sampling in these tributaries is warranted. Although Dolly Varden can have various life history strategies (Armstrong and Hermans, 1991) The Dolly Varden sampled on the IRP were likely resident individuals, given an anadromous fish barrier in the form of waterfalls that block fish passage upstream. This suggests Fritz creek likely does not warrant special anadromous protection.

Table 2: Fish sampling summary statistics for 2016, 2018 and 2021 masters project groups, Homer, AK.

2016	Overall (N=7)
Fish Caught	
Mean (SD)	1.86 (0.690)
Median [Min, Max]	2.00 [1.00, 3.00]

2018	Overall (N=6)
Fish Caught	
Mean (SD)	3.00 (3.52)
Median [Min, Max]	1.50 [1.00, 10.0]

2021	Overall (N=4)
Fish Caught	
Mean (SD)	1.75 (0.957)
Median [Min, Max]	1.50 [1.00, 3.00]

Considering previous fish surveys, these results could be expected. Fritz creek has never been reported to have natural anadromous fishes due to natural barriers in the form of waterfalls at the mouth of the stream blocking upstream migration. From an anecdotal perspective Dolly Varden, up to 6.5”, were trapped in 1st/2nd order headwater tributaries which points towards a healthy, mature population of resident Dolly Varden in the headwaters of Fritz Creek. This also falls in line with the pristine water quality conditions and abundance of macroinvertebrate assemblages that will be discussed further below.

E. Recommendations

In order to monitor long term trends and determine fish species, we recommend CACS repeat fish trapping at least every three years (Blongewicz et al. 2019*)*. Given what the 2021 masters group discovered regarding the pristine health of these streams, fishes are likely not threatened and fish trapping should not be the highest priority in future research unless hydrological alterations occur. Sampling should be conducted at locations sampled in 2016, 2018, and 2021, based on Fig. 2 and Nina Faust’s recommendations. We also recommend performing observational redd (spawning nest) surveys during the fall resident Dolly varden spawning season. This will confirm the presence of the resident spawning population and of spawning redds. Macroinvertebrate sampling should be performed in conjunction and proximity to fish surveying locations. Lastly, we recommend new fish trapping locations that are easily accessible and of adequate thalweg depth (~12 in) to increase CACS’ knowledge of fisheries on their properties and monitor quality for any changes in light of human or natural hydrological/climatic alterations.

II. Macroinvertebrate Surveys

A. Introduction

Stream macroinvertebrates can often be overlooked with relation to the food web and their ecological functions, which are most often only discovered once their ecosystem services have been degraded. It would be inappropriate to call a specific stream macroinvertebrate a “keystone” species; however, as a community of species they perform essential roles to the functional integrity of a stream (Wallace & Webster, 1996), from a bottom-up perspective. Although we most often think of stream macroinvertebrates in the community sense, species with varying degrees of susceptibility to pollution and habitat degradation can tell us a lot about the health of a given stream. Benthic macroinvertebrate sampling has been used for decades to assess water and habitat quality and used for environmental protection by States and the U.S. EPA (Barbour et al, 1999).

Using these benthic assessment approaches are well validated over decades, as a way to assess the general health of a water body by looking at some of the most sensitive inhabitants: macroinvertebrates. They are good indicators of biological health for several reasons. They have a wide range of pollution tolerance in flowing streams and provide a long time water quality indicator (throughout their life cycle of months to years). They are an essential lower trophic level providing food for fish, and are relatively sessile, not moving away from a site like fish. These characteristics increase their diagnostic ability to identify site stressors that occurred within the past months.

Some of the most studied and sensitive stream macroinvertebrates belong under the EPT label which stands for Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Species such as gastropods, oligochaetes, and Diptera(flies) are much more tolerant of higher pollutant levels and habitat degradation. This difference in habitat quality tolerance allows for standardized sampling and surveying of stream macroinvertebrates to generate comparable index values which allow one to compare habitat quality as a proxy of macroinvertebrate community structure and richness.

High EPT index values, denoting a strong richness in EPT, usually come from pristine, pollution and disturbance free stream habitats. These are most common in flowing water with larger grain-sized sediments (e.g., gravel and cobble) as opposed to large slow moving streams, and rivers and lakes where substrates are comprised of silts and clays. A high EPT index value throughout the stream's gradient would suggest a holistically pristine system, of which Alaska has many. One aspect of benthic macroinvertebrate sampling that should be considered is populations can vary dramatically over space (meters to km) and time (seasonal); but, serve as a good long-term indicator of disturbance.

B. Rationale

Macroinvertebrate sampling was conducted on both the IRP and the Wynn properties, in accordance with modified sampling protocols to determine species diversity and richness. These data were used to compute standardized index scores (metrics) which allow for comparisons between streams and stream stations. Previous macroinvertebrate sampling has been conducted through CACS' in a more non-formal educational context; however, the sampling conducted in 2021 was completed in a standardized manner to allow for future sampling and trends analyses of ecosystem quality and degradation. Since all streams sampled have healthy macroinvertebrate communities, any future changes in EPT metrics will indicate disturbances.

C. Study design

More detailed protocol in Appendix B.2

Figure 3 Benthic macroinvertebrate collection and field identification picture, post survey

MACROINVERTEBRATE COUNT

Please consult biological monitoring instructions on how to conduct the macroinvertebrate count. Use the attached tally sheet to track numbers of each macroinvertebrate found. Once sampling and identification are complete, place a check mark next to each type of macroinvertebrate identified and list the total number found. Add up the number of check-marks in each category (sensitive, less sensitive, tolerant) and multiply those numbers by the indicated index value.

Sensitive (Ex: ☑ 10 Caddisflies)	**Less Sensitive** (Ex: ☑ 2 Dobsonflies)		**Tolerant** (Ex: ☑ 3 Leeches)
☐ ________ Caddisflies (except net spinners)	☐ __ Dobsonflies	☐ __ Crayfish	☐ ________ Aquatic worms
☐ ________ Mayflies	☐ __ Fishflies	☐ __ Scuds	☐ ________ Black flies
☐ ________ Stoneflies	☐ __ Crane flies	☐ __ Aquatic sowbugs	☐ ________ Midge flies
☐ ________ Watersnipe flies	☐ __ Damselflies		☐ ________ Leeches
☐ ________ Riffle beetles	☐ __ Dragonflies	☐ __ Clams	☐ ________ Lunged snails
☐ ________ Water pennies	☐ __ Alderflies	☐ __ Mussels	
☐ ________ Gilled snails	☐ __ Common net spinning Caddisflies		
___# of check marks multiplied by 3 = ___	___# of check marks multiplied by 2 = ___		___# of check marks multiplied by 1 = ___

Now add the three totals from each column for your stream's index value. Total index value = ______________________
Total number of macroinvertebrates in sample: ______________________

Compare the final index value to the following ranges of numbers to determine the water quality of the stream sample site.

WATER QUALITY RATING

_________ Excellent (> 22) _________ Good (17-22) _________ Fair (11-16) _________ Poor (< 11)

Figure 3.1 Save our streams Izaak walton league of America Biological monitoring data form for stream monitors, Macroinvertebrate counts and scoring metrics.

Figure 3.2 Sampling site BEVMD, a prime example of benthic macroinvertebrate riffle habitat.

D. Results

Macroinvertebrate surveying was conducted at 4 locations on 3 separate tributaries of Fritz creek in the IRP as well two locations on Bridge Creek in the Wynn (Fig's 3.3, 3.4). All sampling sites resulted in index value >22, which indicates excellent water quality (Izaak Walton, Stream monitor sensitivity metrics, Fig 3.1). More information regarding index values is shown in the figures below. A Correspondence Analysis (Fig. 3.5) was conducted to identify any relationships between macroinvertebrate families and sampling sites. Overall, 13 different taxa were counted with the vast majority of richness related to species of EPT.

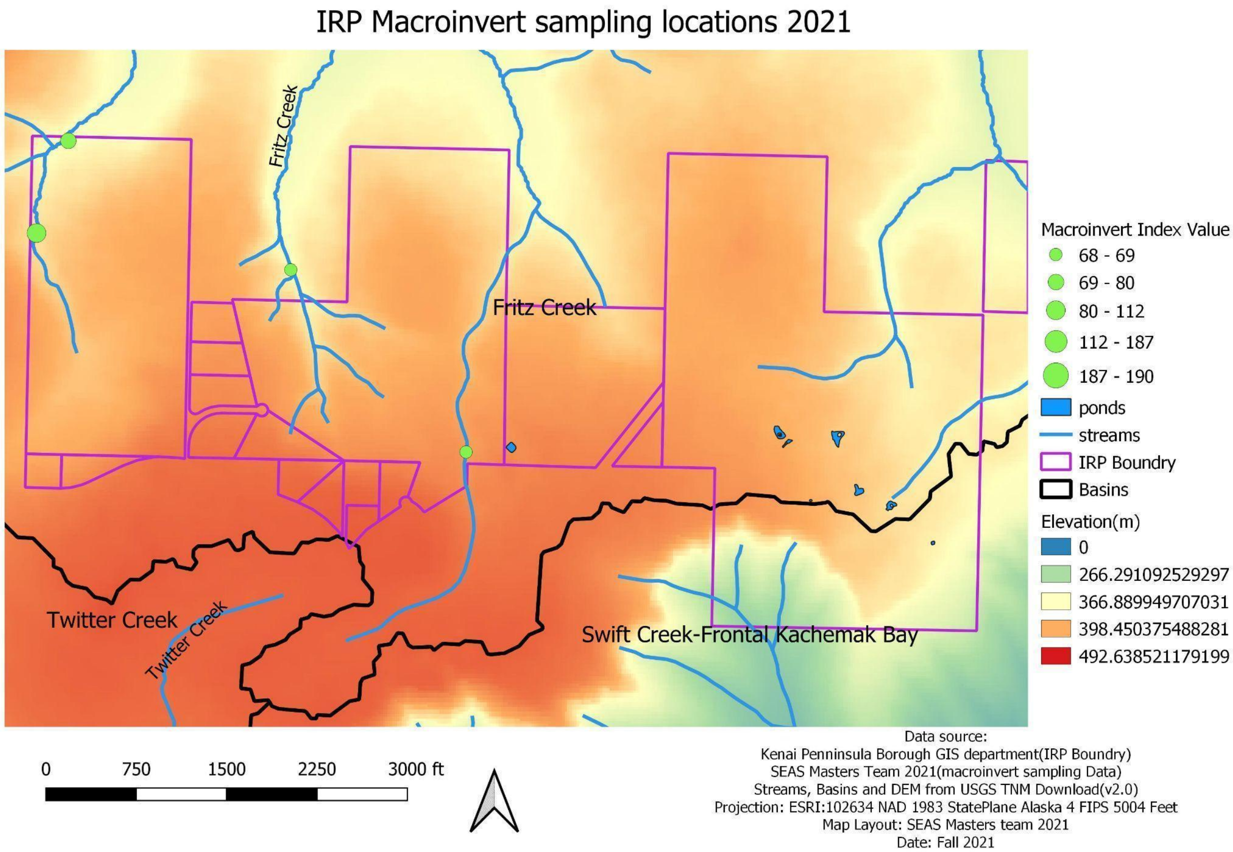


Figure 3.3 DEM map of Inspiration Ridge Preserve (IRP) showing the macroinvert sampling sites with size of circle corresponding to the magnitude of the index value, Homer, AK.

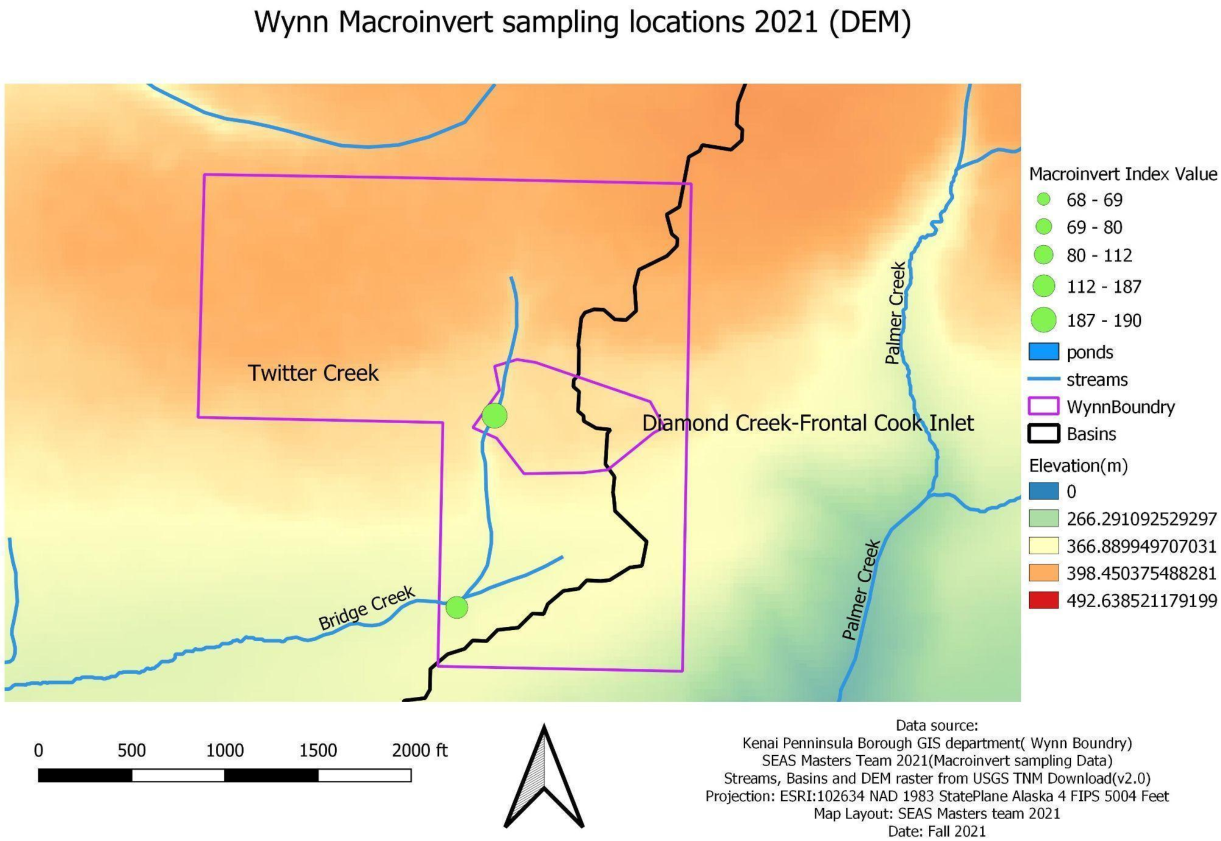


Figure 3.4 Digital Elevation Model(DEM, from Kenai GIS data Portal) map of Wynn Nature Center showing the macroinvertebrate sampling sites with size of circle corresponding to magnitude of the index value, Homer, AK.

Table 3 Summary statistics for benthic macroinvertebrate sampling at Wynn Nature Center and Inspiration Ridge Preserve (IRP), Homer, AK.

	Overall (N=6)
Index Value	
Mean (SD)	118 (57.1)
Median [Min, Max]	96.0 [68.0, 190]
Watershed	
Bridge Creek	2 (33.3%)
Fritz Creek	3 (50.0%)
Twitter Creek	1 (16.7%)
Diversity(#taxa)	
Mean (SD)	6.50 (1.97)
Median [Min, Max]	7.00 [3.00, 8.00]
Quality Index	
Excellent	6 (100%)

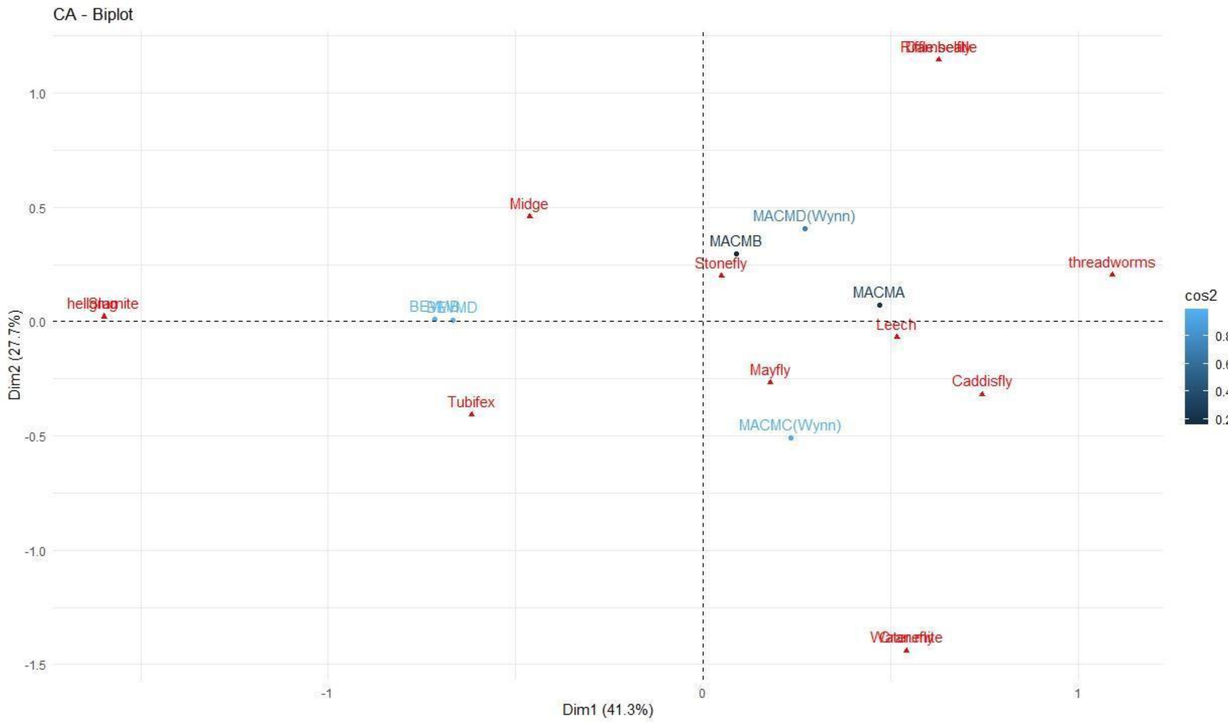


Figure 3.5 Correspondence Analysis biplot depicting Taxa in red and Sites in blue.

The Correspondence Analysis (Fig 3.5) depicts relationships between taxa and sites. It appears both Wynn locations are associated with EPT; However, Caddisflies are not grouped with any site, which could be attributed to their low numbers or the abundance of mayflies and stoneflies. Some taxa were uncommon, such as the hellgrammites and fish flies (left Dimension 1). It is hard to extrapolate what this means for the stream without macroinvertebrate context through the gradient of the entire stream, for now we can only make associative observations. Future macroinvert research would be needed to draw any broader scientifically relevant conclusions. In short this correspondence analysis falls in line with what we discovered, which is that the headwaters are in pristine condition and regular monitoring at these sites and others would highlight any temporal trends and shifts in macroinvertebrate communities, potentially earlier than would be visually apparent.

E. Recommendations

We recommend CACS resample and index similar sites in future years to get an idea of temporal variability and stability. As noted above this could be conducted in conjunction with fish trapping at least every three years; however, it could be conducted yearly time and resource permitting. These benthic indicators provide a powerful approach for monitoring the high quality of area streams. Changes in benthic indices can influence fish communities and thereby assists in interpreting fish monitoring results. Bridge Creek sampling is prioritized, as this is the source of Homer's drinking water. As CACS' is an organization focused on environmental education and land stewardship, these protocols may be followed in a citizen science format for groups of various ages to facilitate greater understanding of stream ecosystems and the roles of macroinvertebrates. However, for more detailed data and trend analyses, aquatic entomologists familiar with Southeast Alaskan diversity could verify volunteer identifications.

III. Water Quality

A. Introduction

In terms of necessity, there are few resources as essential to life as water. Human connections to water are not just for health, as water availability and quality is interrelated with societal components, known as social-ecological systems (SES). Conventional resource management has become increasingly complicated as our understanding of anthropogenic impacts on the world has developed over the last century. These systems are typically characterized by interactions both spatially and temporally between both natural and societal components (Schlüter *et al.*, 2012).

Our impact on water bodies, across the globe, is closely tied to population growth. In our meetings with the team at CACS, one of the trends happening in and around Homer, AK is increasing development. In riverine watersheds, human population growth tends to coincide with extensive modification of stream and river networks. These impacts range from channelization and bank erosion of streams and rivers, construction of dams, removal of beavers, increased nutrient and chemical loads from runoff, flashy flows resulting in higher erosion, decreased shading of waters thus elevating stream temperatures and UV irradiation, and alteration of macroinvertebrate and fish communities from a more diverse and pollution sensitive community towards more pollution tolerant species (Burton and Pitt, 2002; Wohl, 2006). On the IRP, beavers have been extirpated and on Bridge Creek, a large reservoir has been constructed to supplement the supply of Homer's drinking water. The latter modification is necessary for human health as the groundwater in the area is known to sometimes be contaminated with impurities from natural gas or other contaminants making it unsuitable for human consumption.

The headwaters of Bridge Creek begin on the Wynn Nature Center. The headwaters serve a critical role for fish and benthos lifecycles, including spawning habitat, and affects on downstream water quality. As water moves through the watershed, it carries with it organisms (including pathogens), suspended solids from erosion, and any chemicals stemming from the inputs due to human activities. This aspect of water connects distant reaches to downstream water quality and must be monitored to protect human health, property values and aesthetics, provide adequate resources for irrigation and drinking, and the welfare of aquatic organisms. Establishing a water quality baseline (physicochemical and biological) to use for comparison as time progresses allows residents in the watershed to detect any degradation and pinpoint potential pollution sources in the watershed. One of the aims of this project is to establish a baseline that can be added to over time– something that also lends itself to analysis as it increases reliability of our conclusions.

B. Rationale

CACS has an explicit goal to provide environmental education and stewardship through monitoring of water quality, aquatic biota and other wildlife. With the increasing development, especially in the outskirts of Homer near CACS two largest properties, the Wynn Nature Center and IRP, monitoring water quality is becoming increasingly important. This is particularly important for Wynn Nature Center, since it serves as the Bridge Creek headwaters, supplying Homer's drinking water supply: The Bridge Creek Reservoir.

These aquatic sampling approaches are not an exhaustive compilation of methods or site data; but, serve as a baseline that CACS can build upon to increase reliability and potentially build predictive models. This modeling is important as these watersheds support human health and quality of life and animal welfare– including benthos, fish, birds and several charismatic megafauna like moose and black bear. This aquatic monitoring and potential modeling, while important, can be supplemented by other important aspects of the CACS ecosystem, as described below in the following sections.

C. Study Design

Site Selection

In selecting sites to sample at, it is best to identify stations that can be routinely revisited on a seasonal basis, meaning they should be as accessible as possible year round. Sites should be distinct from each other in both the reaches being sampled as well as the stream segment– samples should be taken with enough distance to ensure that the same waters are not being resampled on the same mission. This also helps with minimizing spatial-autocorrelation as well.

In selecting sites, it is good to sample sites that have previous records as these locations will benefit most from continued monitoring. The SEAS team worked with Nina Faust to select sites on the IRP that would be best for sampling in addition to sampling all ponds on the property. On the Wynn, sites were selected to be distinct spatially as there were less streams present. At the Peterson Bay Field Station, only the kettle pond was sampled for water quality to begin monitoring efforts in this area as well.

Sampling Protocol

When conducting water quality monitoring, there should be standard equipment used for all sites. CACS provided Vernier digital sensors for pH and DO to be used. Prior to field work, these should be recalibrated if supplies are available to do so as reads may be inaccurate for some of the measurements these sensors can take otherwise. When collecting data in the companion app, the data is collected in a time series and the initial reads will not reflect the true value of the water quality parameters, so samplers should wait until a distinct plateau is reached in the data– the SEAS team found that 150 seconds was sufficient to reach a distinct plateau for all sites under all conditions. In the post-processing of sampling, data will need to be compiled from the multiple files that are created into a master spreadsheet to record all data points for future analysis.

D. Results

The results of our water quality monitoring come with several caveats. Our monitoring begins a limited baseline, meaning that interpretation of data can be statistically unreliable. That said, some preliminary analysis is necessary to provide at least some context to the current state of the watersheds under CACS' stewardship.

Since this dataset has a relatively small number of values, nonparametric testing is preferred to avoid violating statistical assumptions. The nonparametric Spearman's Rank Correlation test is useful as it measures the strength of relationships between water quality variables. This test allows us to discern if the relationships between physicochemical water parameters are behaving as expected. If deviations from relationships between parameters occur (described below), then there may be an ecosystem stressor present.

By utilizing a non-parametric test, analysis of data with non-normal distributions is possible. After performing the Shapiro-Wilk test, only the dissolved oxygen has a normal distribution, hence the need for the nonparametric method. It is important to note that correlation does not indicate causation. The correlation coefficient, ρ, ranges from -1 to +1 indicating the directionality and strength of the relationship in a simple and elegant way. The p-value used to determine significance is 0.05 yielding a 95% confidence interval. The results of the analysis can be seen below in Table 4.

Table 4: A table of the water quality data correlation results.

	Dissolved Oxygen (mg/L)	pH
pH	ρ = 0.57 p-value = 0.004	not assessed
Temperature (ºC)	ρ = -0.75 p-value = 0.000	ρ = -0.63 p-value = 0.001

This correlation analysis is useful to assess how these variables are fluctuating or deviating from their known relationships. In the correlation matrix above (*Table 4*) the directionality of the relationships between environmental parameters is shown in a pairwise manner.

This analysis suggests the sampled waters do not have any significant contamination. The waters in the higher portions of the watershed are pristine. This is reflected in both the correlation test that was done as well as the macrobenthos sampling done (see macroinvertebrate survey section). This is also reflective of the lack of development and preservation of lands at and around our study area.

Moreover, much of the water on the properties are headwaters or very near headwaters with little time to develop differences, especially if stream waters are influenced by groundwater discharge. As noted above, there has been an increase in development in the area; but, it is mostly confined to lower areas of the watershed.

Three statistically significant relationships were observed between: pH and dissolved oxygen, pH and temperature, and temperature and dissolved oxygen. These parameter relationships are well understood, either directly or indirectly, and may influence the other metrics.

Temperature and dissolved oxygen are known to have a strong negative relationship (USGS, n.d.; Muigui *et al.*, 2010). Here the correlation is only moderately negative though, meaning other factors should be considered here. Other factors influencing stream oxygenation are photosynthesis, biological oxygen demand, and groundwater discharge. Given that most the streams sampled were first- or second-order streams, there is an understanding that waters in this region are consequently lower in overall productivity under the river continuum concept. A more likely reason for the weak correlation is oxygen diffusion through physical mixing with the atmosphere. There was enough flow and hydraulic turbulence to allow for rifles which enhance this process. It is important to note that the capacity of cold water to absorb dissolved oxygen is higher than warm water systems. This means that the acceptable threshold for dissolved oxygen (DO) in cold water systems is higher than warm water systems. In Alaska, the Alaska Department of Environmental Conservation (ADEC) has different standards for waters that hold fish stocks and those that do not. For waters with fish stocks, the DO should remain above 7 mg/L; however, waters without fish should have more than 4 mg/L of dissolved oxygen (Water Quality Standards 18 AAC 70, 2003). See Table 4.1 for further information.

The relationship between pH and dissolved oxygen is ambiguous. There was a significant correlation between oxygen and pH. There are relationships between carbonates and pH in aquatic environments through photosynthesis (Zang *et al.*, 2011). The low biological productivity of streams in this area do not provide conditions supporting the growth of algae (phytoplankton) and abundant submerged aquatic macrophytes, thus photosynthesis likely has a minor role in DO levels.

Figure 4: A typical sampling site on the IRP with narrow stream width and dense riparian vegetation.

The relationship between pH and temperature is not the ultimate driving factor for pH. The presence of an anticipated relationship between the two measured by the correlation serves to underline the lack of stressors in the headwaters on CACS' properties as changes in pH are carbonate concentrations, alkalinity, and photosynthesis which are better observed through other parameters.

All parameters fall within expected ranges and are quite consistent across sites with a relatively small range of values. As you can see in Table 4.1, all sites are well within the State's standards per Water Quality Standards 18 AAC 70 as amended in March of 2020. This, along with the assessment of benthos (see the previous section on macroinvertebrate sampling for more), shows that water flowing through CACS' steward lands is quite clean with little contamination due to anthropogenic activities.

Table 4.1: This table shows the average water quality measurements taken across all sites as well as the standard deviation for each parameter. The standards used are pursuant to those defined for growth and propagation of fish, shellfish, other aquatic life, and wildlife which exceed those for consumption or other uses for the selected parameters.

Parameter	State Standard	Average Water Quality	Standard Deviation	Standard Met?
Dissolved Oxygen (mg/L)	7 mg/L	10.913	1.81	Yes
pH	between 6.5 and 8.5	6.846	0.237	Yes
Temperature (°C)	>25°C	9.358	3.548	Yes

E. Recommendations

It is this team's recommendation that long term monitoring of physicochemical parameters for water bodies under CACS' stewardship should be conducted at least on seasonal intervals when feasible for as many stations as possible. The largest sources of water quality changes in this area are from storm water inputs and snowmelt inputs– both in the form of runoff or leaching. In these headwater streams, the major annual loadings of nutrients, organic carbon and suspended solids is derived during runoff events.

In the Spring snow melts, the pH may drop due to acid snow melt (from acid precipitation), which can have negative consequences for fish populations. Too high a pH during hatching or early life stages (e.g. young-of-year, year-1, *etc.*) can have higher mortality rates with implications for long term persistence of populations. Flow measurements (possibly using an acoustic doppler velocimeter) could assist in determining loading rates of different pollutants since they can be tied to seasonality.

Our teams sees the following metrics as being of importance for long term monitoring:

- Dissolved Oxygen
- Temperature
- pH
- Conductivity

The ability to record conductivity has been reported as a method for rapid assessment of general water quality as there are strong correlations between conductivity and several environmental water quality metrics including pH, CO_2, water hardness, calcium, total dissolved solids, total solids, and sulfate concentration (Kumar, 2010). This makes conductivity a quick method for rapid monitoring activities and should be added to future monitoring efforts. To establish more complete baselines, quantitative analysis of water quality on these metrics would be good. This strong correlation between conductivity and components listed above could also allow for predictive model development to give a rough estimate of concentrations for these other metrics between thorough monitoring periods.

In assessing water quality, nutrient pollution often coincides with development and air pollution. This type of monitoring is relatively inexpensive (e.g., total phosphorus, soluble reactive phosphorus, total kjeldahl nitrogen, nitrite/nitrate and ammonia) but can be useful as these tests are reflective of the nutrients that lead to algal blooms. This would provide a useful baseline for reference as urban development continues in the area.

VI. Breeding Bird Surveying

A. Introduction

There are many nationwide efforts to monitor and survey bird species, from those done by backyard bird enthusiasts, to large-scale efforts such as those conducted by Audubon societies or the North American Breeding Bird Survey. Bird surveys can be used to determine species abundance, diversity, migration patterns, and population trends which can have important implications for conservation, policy, and advocacy efforts. Additionally, birds have been described as an indicator species, meaning they can serve as a measure of existing environmental conditions. Both resident and migratory birds are strong indicators of environmental health, because they are high in the food chain and are sensitive to changing environmental conditions, particularly changes in climate (Gregory and Strien, 2010). Therefore, studying birds can aid in monitoring environmental changes, the effectiveness of management strategies, and can act as a warning system for ecological shifts (Siddig et al., 2016).

While birding surveys have primarily been conducted by local volunteer birding groups, recently wide scale databases have been used to identify major losses in bird species abundance and diversity. A 2019 study reported that since 1970, bird populations have declined by 3 billion, which is 29% of 1970 bird abundance values (Rosenberg et al., 2019). These losses highlight the increasingly critical need for increased monitoring and habitat conservation efforts. Additionally, while conservation efforts are important for all bird species, more expansive conservation efforts may be required for migratory species, as they rely on multiple habitats, often in distant locations (Horns & ŞEkercioğlu, 2018).

The expansiveness and popularity of citizen science and volunteer bird monitoring efforts, such as the online database eBird in which users can submit birding observations, speaks not only to their ecological importance, but also to their cultural, economic, and social importance to humans (Greogry and Strein, 2010). Birds can provide recreation and educational opportunities as novices and expert bird watchers alike can observe birds in their natural habitats, assess their behavior, and appreciate their intrinsic value. In addition, as noted above, since migratory birds travel between nearby habitats or across the globe, conservation efforts can benefit other species who utilize these same habitats. This can lead to protections for a wide variety of ecosystems functions and services that are essential for other forms of wildlife, and human health.

B. Rationale

CACS currently conducts a daily morning bird survey at the Wynn Nature Center property. However, to track long-term population changes in birds and gather additional quantitative data, CACS requested our SEAS Masters Project team to develop protocols for a more robust bird survey. These protocols will be used to conduct annual bird surveys each breeding season by staff and citizen scientists. These surveys will be conducted at both the Wynn Nature Center, building upon their currently daily surveys, and at the newly acquired IRP property.

As noted above, breeding bird surveys can be used to track species long-term population trends. Therefore, data collected by CACS will allow them to monitor changes in total bird abundance and in species diversity on their properties. This information will be increasingly important as the Homer area continues to be impacted by climate change and increasing development. While the watershed properties on these landscapes provide essential habitat for year-round species such as moose, bear, and resident birds, they also provide critical habitat for migratory species of birds. Many of the bird species arrive in Alaska in early spring to breed, relying on healthy and intact ecosystems to find mates, build nests, and provide for their young. Climate change impacts such as changes in temperature and precipitation will lead to additional hazards for migratory birds such as wildfire smoke, intensity in the loss of habitat, and changes in food supply from insects and vegetation. Habitats such as the IRP with low disturbance and protected habitat can serve as a study site for changes in abundance and diversity of species, impacts on reproduction, and changes in arrival and departure patterns since there are few interactions between stressors. Surveys can also be used to monitor habitat use and distribution of species. As bird surveying has never been conducted on the IRP property, surveys may provide particularly insightful information into the species utilizing this property. Additionally, as migratory species rely on habitats on a wider geographic scale, surveys can provide data that may be utilized to inform conservation efforts at a global scale.

Data from our survey conducted in summer 2021 can be used to provide baseline data that will be built upon by surveys conducted in future years by CACS staff and citizen scientists. In addition to the uses highlighted above, we hope birding data may ultimately be used to inform land management decisions and be used to inform policy makers of the importance of protecting watershed properties. These surveys may also be used as a tool for community education. Bird surveys can create opportunities for additional educational outreach programs, allowing youth groups and citizen scientists to have increased experience with bird monitoring. This opportunity to get out in nature and learn about local bird populations and diversity in the area through direct observation may aid in fulfilling CACS mission of increasing land stewardship.

C. Study Design

Site Selection

Specific survey sites were chosen by walking the property with Nina Faust to determine areas that covered a wide range of habitats and that would be feasible for staff and citizen scientists to monitor. We established one survey site on the Wynn property and two sites on the IRP property, the IRP Pond Side and IRP Ridge Side. This is due to the IRP's significantly larger size and variation in habitat types across this property. After selecting our sites, two of our team members walked the trail to choose specific point count stations. We used the app GAIA as our GPS tool to mark the coordinates of the bird count stations and track our trail. Survey points were at least 200-250 meters apart as recommended by protocol established by the US Forest Service (Huff et. al, 2000). This is to help lessen the chance that surveyors count the same bird individual twice at different surveying stations. This process resulted in 6 count stations at the IRP Pond Side, 8 at the IRP Ridge Side, and 7 at the Wynn Nature Center. See Appendix A.3 for maps depicting our birding survey sites and point count stations.

Monitoring Protocols

Our protocols were developed largely based on key scientific recommendations from the North American Breeding Bird Survey and on a habitat-based protocol for terrestrial developed by Mark H. Huff et al. through the USDA/U.S. Forest Service. We also pulled information from Alaska Landbird Monitoring Survey (ALMS) for insights into general good practices and to aid in determining what data metrics should be collected. We also sought guidance from George Matz, an avid birder in the southcentral Alaska region who is on the board of Kachemak Bay Research Reserve Community Council and Kachemak Bay Birders.

One survey at each site was conducted by members of our SEAS team. Surveyors first noted the dominant habitat type at each survey point count station. The following habitat structures: Riparian, Bog/Fen, Open Meadow, Mixed Forest, Spruce Dominated, Shrub Dominated Meadow, were included as options to choose from. These were determined based on consultation with CACS and the USDA/USFS protocols. Surveyors then counted all species of individual birds that were seen or heard at each point count station for five minutes. If observed rather than only heard, bird behavior was also noted. Protocols were repeated at each point count station. Additionally, a drone image was taken at 30 and/or 60 meters height at each survey point count station on the IRP, unfortunately we were unable to fly the drone at the Wynn Nature Center. These drone images will be supplemented to CACS in a separate document. For step-by-step protocols please see appendix B.4.

D. Results

In order to test the feasibility of the protocols, two members of our team conducted a bird point-count survey at each of the 3 site locations. This will provide baseline data going forward. However our results are limited as each survey was only performed once due to time restrictions. Another limitation of our data is that our team members performing the surveys had a limited knowledge of local bird identification by sight and sound. It is recommended that in future surveys, those conducting the survey are experts or have a high level of knowledge in local bird fauna. Our surveying process was largely to test our protocols and ensure they were feasible, nonetheless we believe they offer some valuable insight and would like to present our results below. See Appendix C.5 for all bird count data.

All Properties Results
Bird Abundance and Diversity

Among all three survey sites we counted a total of 117 individual birds and 17 different bird species. The Alder Flycatcher was the most common bird species heard or seen among all of the properties with 22 counts. This was followed by the Varied Thrush with 16 counts and the Golden-Crowned Sparrow with 14 counts. Eight of the 17 species were detected at all three site locations, while 5 species were detected only at one or both of the IRP sites, and 3 were only detected at the Wynn. As we only were able to conduct one survey, this is not to say that these species were not found at other sites, repeated data collections over many years would be needed to more accurately make conclusions regarding species distributions.

Southeast Alaska is a breeding ground for many bird species that have a range throughout North America. The mosaic of habitats, healthy streams, and relatively low human disturbance on the landscape makes CACS properties a prime ecosystem for migratory birds to breed. Headwaters and habitats on these properties support an abundance of insects for a food source and various nesting habitats to raise young. Taken from the Cornell Lab of Ornithology's All About Birds site, a complete list of all species found with year-round or migratory status and conservation status was made (See Appendix C.4). Most species found in our bird survey were of low-conservation concern, asides from two species. The Varied Thrush found during our bird survey, and observed by sight and sound often by CACS staff, are in steep decline. Another species detected in our bird survey, the Olive-Sided Flycatcher is of watch concern, since their populations are currently declining.

Table 5 showcases the descriptive statistics for bird counts and species diversity on each property, this includes the minimum, median, mean, maximum and quartiles. We see the minimum number of birds counted among all of the properties at a given bird count station was 3 and the max was 9, for species diversity these values were 3 and 6. The mean value for all sites hovered around 5 for bird abundance and 4 for species diversity.

Table 5: Bird species counts of abundance and diversity per point count station between the three survey site locations within CACS, Homer Alaska.

Bird Abundance

	Min	1st Quartile	Median	Mean	3rd Quartile	Max
Wynn	4	4.5	5	5.714	6.5	9
IRP Pond	3	5	5.5	5.333	6	7
IRP Ridge	3	5	5	5.429	6	9

Species Diversity

	Min	1st Quartile	Median	Mean	3rd Quartile	Max
Wynn	3	3	5	4.429	5.5	6
IRP Pond	3	4.250	5	4.667	5	6
IRP Ridge	3	4	5	4.476	5	6

Graphs depicting bird count and diversity by location and biodiversity index can be seen in Figures 5 and 5.1. From this we can see that the total bird count and diversity was similar among properties. However, it is important to note the number of bird count stations varied across properties. The biodiversity index was calculated by dividing the number of species at each site by the total number of individuals in the area, aiding in standardizing the unequal sampling efforts. Here we see that the IRP Pond side site has the highest biodiversity index, with a value of 0.38.

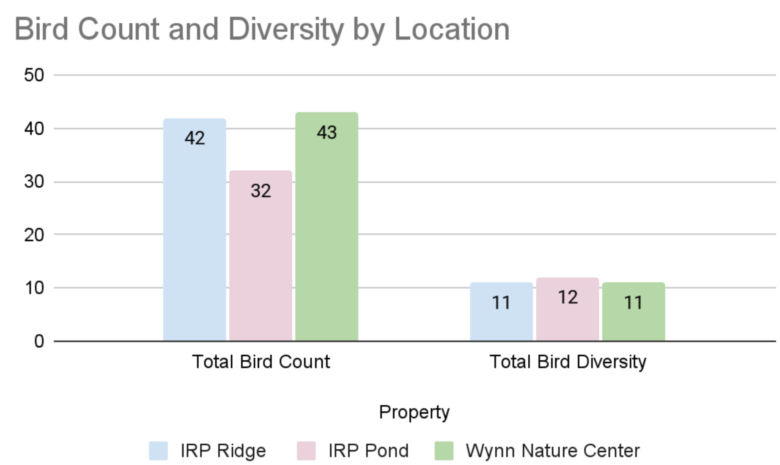


Figure 5. Bird count and diversity from surveys conducted summer 2021 on the IRP and Wynn properties, CACS, Homer Alaska.

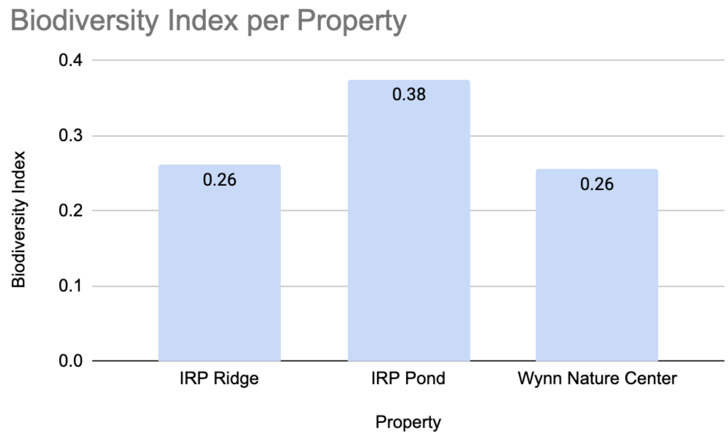


Figure 5.1. Bird biodiversity calculated by dividing the number of species at each site by the total number of individuals in the area, from surveys conducted summer 2021 on the IRP and Wynn properties, CACS, Homer Alaska

Habitat Structure

While the number of habitat-types visited per site varied, for example Bog/fen was only present in the study two times but Shrub-dominated Meadow was present seven times, results were still analyzed to determine average species diversity by habitat type. Bog/fen had the highest average observed species diversity with 5.5 species, followed by Shrub-dominated Meadow with 4.57, Riparian and Open Meadow habitats with 4.5, Mixed Forest 4, and lastly Spruce Dominated habitat having an observed average of 3 bird species (Fig. 5.2).

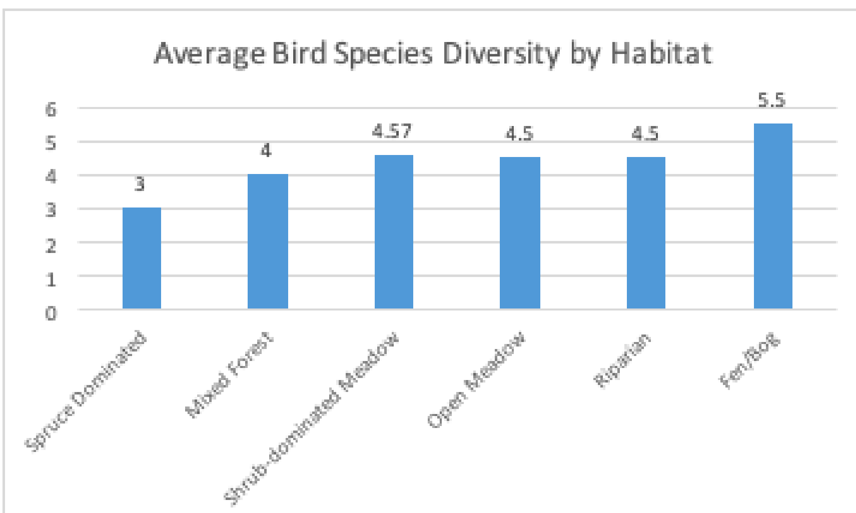


Figure 5.2 Average bird species counted by habitat structure type among all three survey site locations (Wynn, IRP Pond side, IRP Ridge side, CACS, Homer Alaska)

Individual Survey Sites Results

IRP: Pond Side
Bird Diversity and Abundance

There were a total of 32 individual birds counted and 12 different species of birds at the IRP Pond Side site. The species observed most frequently was the Golden-Crowned Sparrow with 7 observations, the American Robin was next with 5. The full list and counts of species observed at the IRP Pond side can be seen in Fig. 5.3.

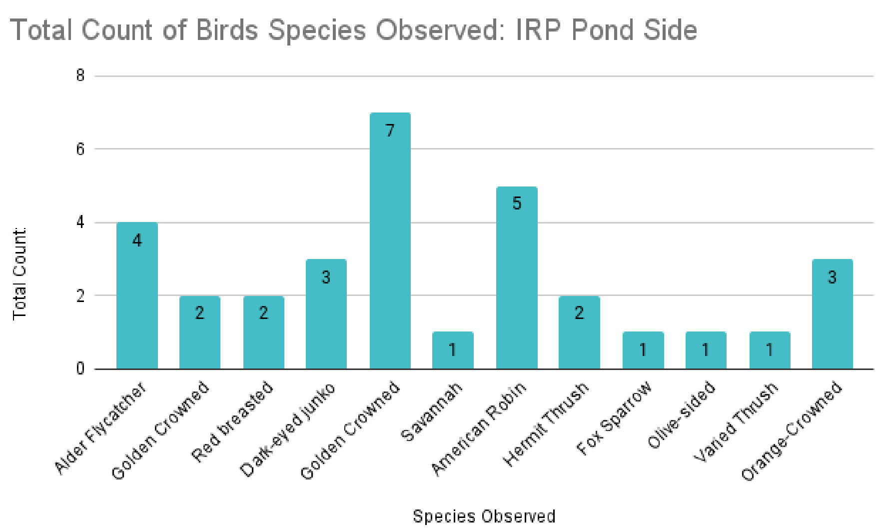


Figure 5.3: Birds observed during the survey conducted on the IRP Pond Side June 22, 2021 in Homer, Alaska.

Table 5.1: Bird diversity and abundance values between the point count stations at the IRP Pond side, CACS, Homer Alaska

Location	Point Count Station	Bird Abundance	Bird Diversity	Habitat Structure
IRP Pond Side	1	3	3	Riparian
IRP Pond Side	2	5	4	Open Meadow
IRP Pond Side	3	6	5	Riparian
IRP Pond Side	4	7	6	Riparian
IRP Pond Side	5	6	5	Bog/Fen
IRP Pond Side	6	5	5	Spruce Dominated

IRP: Ridge Side
Bird Diversity and Abundance

There were a total of 42 individual birds counted and 11 different species of birds at the IRP Ridge site. The species observed most frequently was the Alder Flycatcher with 9 observations, followed by the Varied Thrush with 6 observations. The full list and counts of species observed at the IRP Ridge side can be seen in Fig. 5.4.

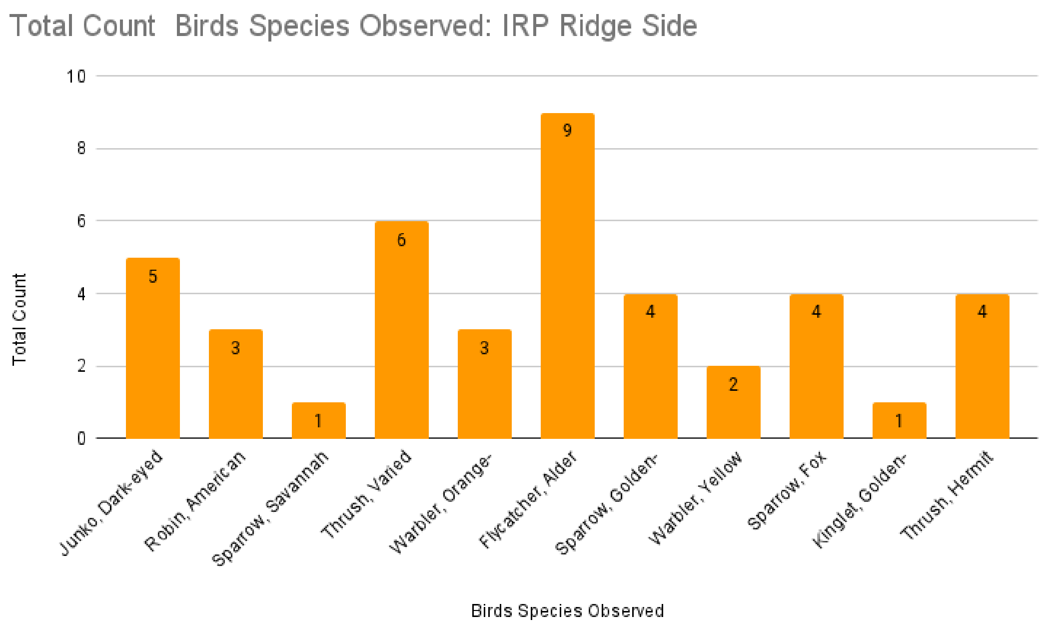


Figure. 5.4 Bird counts for species observed during the survey conducted on the IRP Ridge Side June 23, 2021 in Homer, Alaska.

Table 5.2. Bird diversity and abundance values between the point count stations at the IRP Ridge side, CACS, Homer Alaska.

Location	Point Count Station	Bird Abundance	Bird Diversity	Habitat Structure
IRP Ridge Side	1	5	4	Shrub Dominated Meadow
IRP Ridge Side	2	5	4	Shrub Dominated Meadow
IRP Ridge Side	3	6	5	Shrub Dominated Meadow
IRP Ridge Side	4	6	5	Shrub Dominated Meadow
IRP Ridge Side	5	3	3	Mixed Forest
IRP Ridge Side	6	5	5	Mixed Forest
IRP Ridge Side	7	6	4	Riparian
IRP Ridge Side	8	6	5	Open Meadow

Wynn Nature Center
Bird Diversity and Abundance

There were a total of 43 individual birds counted and 11 different species of birds at the Wynn Nature Center site. The species observed most frequently were the Alder Flycatcher and the Varied Thrush, both with 9 observations each. The full list and counts of species observed at the Wynn can be seen in Fig. 5.5.

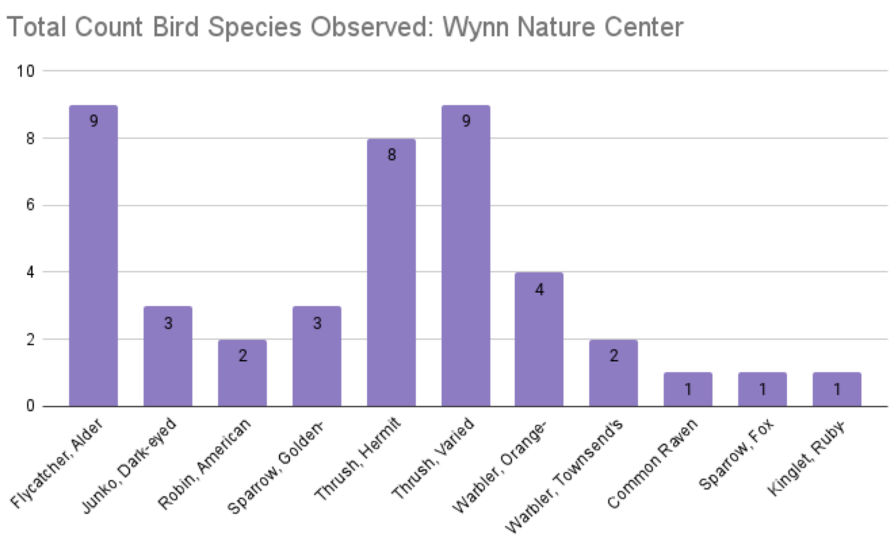


Figure. 5.5 Birds observed during the survey conducted on the Wynn Nature Center June 27, 2021 in Homer, AK.

Table 5.3. Bird diversity and abundance values between the point count stations at the Wynn Nature Center, CACS, Homer, Alaska

Location	Point Count Station	Bird Abundance	Bird Diversity	Habitat Structure
Wynn	1	9	6	Bog/Fen
Wynn	2	5	3	Spruce Dominated
Wynn	3	6	6	Shrub Dominated Meadow
Wynn	4	5	5	Spruce Dominated
Wynn	5	4	3	Shrub Dominated Meadow
Wynn	6	7	6	Spruce Dominated
Wynn	7	7	5	Shrub Dominated Meadow

Although this bird survey serves as an introductory baseline, two distinct findings stood out from these results. The first is that the Bog/Fen habitat, or the peatlands, supported the highest species diversity of any habitat type. Peatlands are known to contain diverse and distinct vegetation that supports high levels of biodiversity (IPS, 2020). We recommend that CACS continues to monitor and preserve this type of habitat on both the IRP and Wynn as they are important ecosystems that support the overall biodiversity on these properties. The second was the overlap that existed in bird species utilizing habitat types across the properties. This supports the notion that species may rely on a mosaic of diverse habitats, and that maintaining these habitat types and their connectivity is important for bird conservation efforts. The IRP and Wynn properties aid in maintaining habitat connectivity which facilitates movement for these birds. CACS should then continue to ensure that land management practices have a goal of preserving this diverse mosaic of habitats as climate change and surrounding land use changes may impact these ecosystems.

E. Recommendations

We recommend CACS conduct bird surveys annually during each breeding season. The ALMS recommends surveying in southern Alaska be done no earlier than May 25th and no later than the end of June, therefore surveying should be conducted within this date range. This will help to ensure that migratory birds have arrived in the region (Handel et al., 2021). Surveys should be completed by 11 am, as bird activity decreases after this time. We also recommend that CACS staff or volunteers complete the bird survey prior to any programming that may be taking place to limit noise and human disturbance.

Surveyors should fill out the data sheet as completely as possible. Data sheets will be provided to CACS in a supplemental document. After each survey is completed, input the data into a computer and keep the paper copy so it may be cross referenced in the future if needed. At the end of each survey season calculate the bird count and bird diversity at each site. These values should be noted both for each survey site and each survey point station, for example at IRP Pond Side survey point #1 and at the entire IRP Pond Side site location. This will allow for comparisons to be made among and between the sites. As this data continues to build, long term trends in bird abundance and diversity can be monitored. Allowing for possible insights into impacts of birds, including migratory species, that may be caused by a number of factors, including climate change and development. Additionally, the bird survey data can be updated to eBird, an online database of bird observations. Locations have been created for each of the three bird surveying sites and sharing this information can increase awareness and allow for scientific information to reach a wider audience.

Monitoring of populations over time will be particularly important for bird species who have a long migration distance who breed on CACS properties such as the Yellow-warbler and the Olive-sided flycatcher. whose population is in steep decline. Birds who complete long distance migrations have to face many challenges. However, climate change presents many new challenges such as the changes in weather patterns, changes in the abundance and diversity of food sources, and hazards such as wildfire smoke. When trying to avoid hazards such as air pollution, both from wildfires and industry, birds may try to go around or over it. However, adding distance to avoid pollution is energetically costly and in an effort to avoid smoke in one location these birds can end up in direct contact with another wildfire source (Leffer, 2021). Through CACS continuing to monitor birds who migrate to Southeast Alaska, particularly long-distance migrators, data can help to display how climate change hazards may be impacting bird populations migrations both in timing and numbers.

VI. Swallow Nest Monitoring

A. Introduction

Nesting boxes have been used in North America to support breeding bird populations by decreasing weather related damage to nests, providing security from predation, and decreasing competition for habitat between species. Nesting boxes have become increasingly important for bird populations as there continues to be loss of habitat for development, increase of non-native species, and ecological changes from climate change impacts. Bird boxes, when constructed correctly, can mimic natural tree cavities that provide shelter for specific bird species.

Nesting boxes also give opportunity to develop long term data on breeding bird populations through monitoring programs. With careful following of protocols to limit disturbance to nests in the boxes, one can record observations such as dates of nesting period, how many eggs were laid, survival rates of hatchlings, and many other details. This data can then be used to understand how breeding populations may be impacted over time by climate change, loss of habitat, non-native species, and environmental contaminants. This long-run data analysis can assist researchers, land managers, federal boroughs, community organizations, and many others in informing proper land management strategies, further research, and policies to protect breeding bird populations. Not only is this data helpful at a local scale, but since many breeding populations are migratory birds, observers can contribute to sharing of information to create a more holistic understanding of what may be impacting populations across boundaries.

Often another component of bird box monitoring is citizen science. Many noted programs, such as NestWatch, allow citizens to be trained in properly monitoring boxes, recording observations, and contributing to large databases. By allowing citizens to engage in monitoring nest boxes, researchers, biologists, and ecologists are able to analyze a greater breath of data. This contributes to findings through analyzing this data being more representative of current breeding population trends that scientists themselves would never have the time or resources to collect. Bird box monitoring programs also allow citizens to engage with the natural world, developing a deeper understanding and connection to these bird populations and the ecosystems they depend on.

B. Rationale

Upon our arrival to Homer in June 2021, the IRP had many bird boxes currently on the property that were once monitored. However, many boxes were dated, damaged, or simply missing from where they once were. Property manager Nina Faust was working with a local community member who wanted to sponsor building new bird boxes. As part of our project Nina asked our group to determine where new nest boxes should be located and which of the currently existing nest box locations should remain and be replaced with new boxes. The goal was to aid in revamping the swallow nest monitoring program by establishing a network of locations for boxes that would be easily accessible for staff and in locations that were inline with swallow habitat preferences. The locations for nest boxes would be determined by our team and Nina in the Summer of 2021 and CACS would plan on installing the nest boxes and begin monitoring at the next breeding season, Spring 2022.

While many species use bird boxes, the focus for the bird boxes on the IRP is swallow nest boxes. At the IRP there are two different species of swallows, Tree Swallows (*Tachycineta bicolor*) and Violet-Green Swallows (*Tachycineta thalassina*). Both species are currently declining in Alaska (The Cornell Lab of Ornithology, n.d.), making providing habitat a possible conservation strategy and way to study and monitor populations to gain more insight. Working alongside Nina, our team members used literary review, existing successful bird box locations, and an understanding of the property landscape to pinpoint where new swallow nest boxes should go, and which of the already existing nest boxes should be kept up or removed. When deciding which species to target for sampling efforts we reached out to Tricia Blake with the Alaska Songbird Institute for more information. We learned that if the aim of monitoring was to contribute to a larger network of data, Tree Swallows may be the best target species. The protocols for monitoring Tree Swallows were standardized in 2016 by numerous Alaska researchers, allowing for easier data sharing and comparisons across the state. Additionally, Tree Swallows are more robust and potentially more resilient to disturbance, making them ideal for citizen science monitoring. However, as the location and box dimension preferences are largely the same for both, which species is monitored may be simply determined by whichever species of swallow ultimately utilize the boxes.

C. Results

Protocols for dimensions of nest boxes, when and where they should be placed, and height/distance requirements provided were taken from Project NestWatch and Alaska Department of Fish and Game (ADFG). When the guidelines differ for Tree Swallows and Violet Green Swallows, information for both species is provided. However, we recommend ultimately favoring Tree Swallows preferences due to the information above. The information in Appendix D was taken from ADFG and Project NestWatch helped to inform our site location selections and to provide guidance on nest box building for CACS. Following these guidelines, using past successful site locations, and picking locations that would be accessible for staff, we recommended a total of 34 nest box sites. This included a mixture of new, current, and past (location where a nest box was once located but has since fallen or been taken down) locations. Nest box locations included a mixture of pond, meadow, and edge of forest habitats, as was recommended by Nestwatch and ADFG. The locations of these nest boxes can be seen in Fig 6. Additional location data for the swallow nest box recommendations can be found in Appendix C.6.

Swallow Nest Box Locations on Inspiration Ridge Preserve

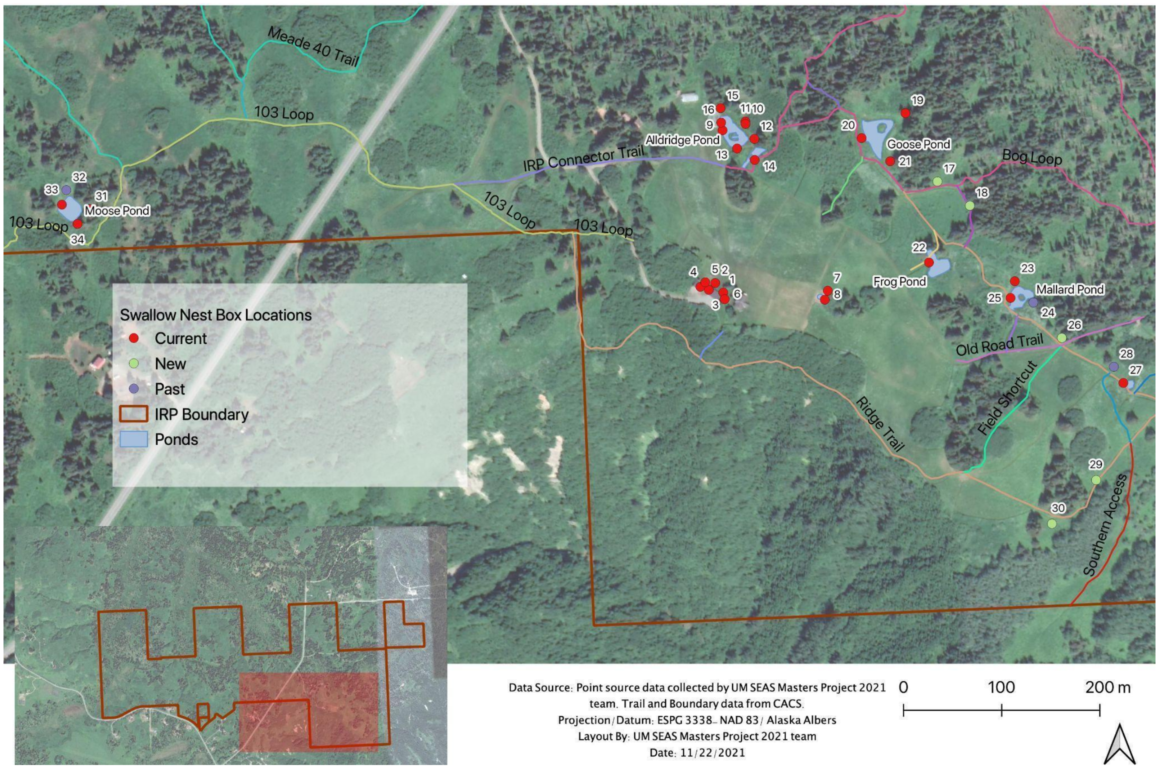


Figure 6. Map depicting the locations that our Master’s project 2021 team recommend for Swallow Nest Box locations on the Inspiration Ridge Preserve, Homer, Alaska.

D. Recommendations

In addition to the recommended placements for the swallow nest boxes, we recommend installing predator guards and the use of fledgling ladders. Predators in the area include other bird species, bears, and squirrels. More information regarding predator guard options may be found in Appendix D. CACS plans to work with and use the monitoring protocol developed by the Alaska Songbird Institute (ASI). As noted above, this protocol was standardized by a group of Alaska researchers and will allow for data sharing and comparisons with other locations in Alaska. Additionally, citizen scientists of various age groups can conduct this protocol. This will aid in increasing awareness, teaching research techniques, and hopefully leading to increased stewardship.

V. Peatland Assessments

Depth Probing and Vegetation Assessment with Homer Drawdown

A. Introduction

Peatlands, which includes bogs and fens, are a type of wetland ecosystem that covers approximately 2.84% of the Earth's surface and are found on every continent (IPS, 2020). In peatlands, plant material is prevented from fully decomposing due to the water-logged conditions. This causes the production of organic material to be greater than the rate of decomposition, resulting in a build-up of plant material called peat. (IPS, 2020). The lack of decomposition results in increased carbon storage. In fact, peatlands are the largest source of carbon storage of terrestrial habitats in the world, storing more than all other types of vegetation combined. Peatlands provide additional ecosystem services such as regulating water flows and flood mitigation, and are important habitats that support high biodiversity and provide habitat for a variety of indicator species, such as the Large Heath butterfly (*Coenonympha tullia*) (IPS, 2020). However, degradation to peatlands, including draining for agriculture, burning, and mining can result in the release of greenhouse gas emissions into the atmosphere, further leading to increased global temperatures. Therefore, peatland preservation is extremely important for climate change mitigation (IUCN, 2021).

In addition to direct human caused degradation, climate change itself is also resulting in alterations to peatlands. A study conducted on the Kenai Peninsula looked at the extent of wetland drying between 1950-1996. The authors found that there has been a substantial decrease in wetlands area, due in part to higher air temperatures and decreased precipitation (Klein et al., 2005). Increased global temperature is thought to be causing peatlands to dry, which may result in increased release of carbon into the atmosphere (Swindles et al., 2019). In the northern latitudes, there are many permafrost peatlands, meaning the ground is frozen, and increased temperatures are resulting in the thawing of this permafrost. This is expedited as the Arctic is warming roughly 2x faster than the rest of the globe (NSIDC, 2020). Permafrost thaw may result in peatlands going from long term carbon sinks to a carbon source.

Carbon may be released in the form of carbon dioxide (CO_2), but it appears that the release of methane (CH_4) is even more prevalent (Hugelius et al., 2020). Another study conducted in 2020 found that peatlands become more methanogenic with warming, this is highly concerning as methane is a much more potent greenhouse gas compared to CO_2, with 45 times the global warming potential of CO_2 over a 100-year timeframe (Hopple et al, 2020). However, there is still much that is unknown about how peatlands will react to a changing climate (Hopple et al, 2020) and peatland ecosystems remain poorly mapped (Hugelius et al., 2020). Therefore, as the Arctic continues to warm, mapping peatlands and studying how they respond to future climate conditions will give important insights in how to best manage and protect these ecosystems.

B. Rationale

Homer Drawdown is a community wide collaborative peatland project aimed at monitoring and protecting peatlands on the Kenai Peninsula. This project aims to bring the community together to share knowledge of the important role that peatlands play in climate stability and inspire stewardship for local climate action. With development increasing in the Homer area in recent decades, creating awareness and shared community value on preserving these ecosystems is an essential component for protection. This project involved samping the depth and vegetation composition of peatlands. Carbon data collected will contribute to ongoing projects through KBNERR, including calculating carbon storage capacity on the Kenai peninsula. Vegetation data will be used to monitor changes in plant communities. As peatlands dry this can lead to changes in their vegetation composition, notably, as drying occurs there is increased encroachment of woody plants including willows and spruce trees. Fig. 7 shows a drone image taken at the IRP fen, here we see the edges of the fen are composed of larger spruce trees, with smaller saplings growing closer to the center. As drying occurs it is expected that saplings will continue to encroach toward the center of the fen.

Figure. 7 Drone image taken by our Masters Project team at the IRP fen at 30 m height. The approximate center of the fen is marked with a red box, GPS location: 59.7018, -151.40462. This showcases the lack of spruce saplings near the center of the fen, which grow taller and more dense towards the edge of the fen.

The IRP, Wynn Nature Center, and PBFS properties owned by CACS each have fens. The fen at the IRP makes up approximately 0.2% of the IRP's total land cover (Blongewicz et al. 2019) and the Wynn fen makes up approximately 5.6% of the Wynn's total land cover. The terms Fen and Bog are often used interchangeably to describe these peatland ecosystems, however fens differ from bogs in that they are connected to water that has had contact with mineral soil and/or bedrock (Cohen et al., 2020). Local scientists have confirmed in recent years that groundwater feeds the peatlands at the IRP and Wynn sites, making them fens. As mentioned above in the ecological context section, since there is water exchange through groundwater, these fens play an important role in providing nitrogen and carbon inputs that support higher order streams with higher densities of macroinvertebrates and juvenile salmon. It is important to note the landscape surrounding fens can contain other wetland systems and peatlands in the Cook Inlet region are typically a mixture of bogs and fens (Gracz, 2017). Therefore, it's possible these properties contain a mosaic of wetland types.

In partnership with the Homer Drawdown project our Masters Project team utilized Homer Drawdowns protocols to perform the depth and vegetation assessments on the IRP, Wynn and PBFS fens.

C. Study Design

As noted above, we followed the protocol that was created by the Homer Drawdown project. Two of our team members attended a training session at the Wynn Nature Center put on by Homer Drawdown to learn and practice following the protocols. At the IRP and Wynn Nature Center we were joined by Kim Mcnett, a naturalist artist and organizer for the Homer Drawdown project. At each site, 6-10 locations were chosen to sample the peat depth and the dominant vegetation community present in that area. Sampling was done by beginning at the edge of the fen and transecting it to capture points along the edges and center of the peatland. However, if we came across vegetation communities that were not included in the original transect, these locations were individually incorporated into the sampling.

To begin, the fen was visually inspected to take note of its size, shape, and vegetation communities that were prevalent in the area. Next, we sampled our sites by using fiberglass rods to determine the depth of the peat and a quadrat to note the dominant vegetation types in the area. At each sample site the depth, dominant vegetation, and any other notes were marked on the data sheet. Dominant vegetation types that should be chosen from were supplied by Homer Drawdown, these included Forest, Shrubs >2', Low Shrubs <2', Herbaceas Forbes, Open Moss Mat, and Emergent.

For the step-by-step protocol instructions see Appendix B.5.1.

D. Results

Our SEAS team of 4 members sampled at the PBFS, and two of our team members sampled with Kim Mcnett at the IRP and Wynn properties. It should be noted that we did not sample the same number of quadrats at each location, this is due to attempting to capture various plant composition communities, and adjustments to our protocol after sampling at PBFS. We took 11 measurements at the PBFS, 6 at the IRP, and 9 at the Wynn. As shown in Fig. 7.1, the PBFS had the deepest average peat depth (9.12 ft) of our survey sites, followed by the IRP (5.08 ft) and Wynn (4.27 ft). Fig. 7.2 shows a breakdown of the dominant vegetation types for each property, with Gramindois being the most prevalent for the Wynn and PBFS, and Forest being the most prevalent at the IRP.

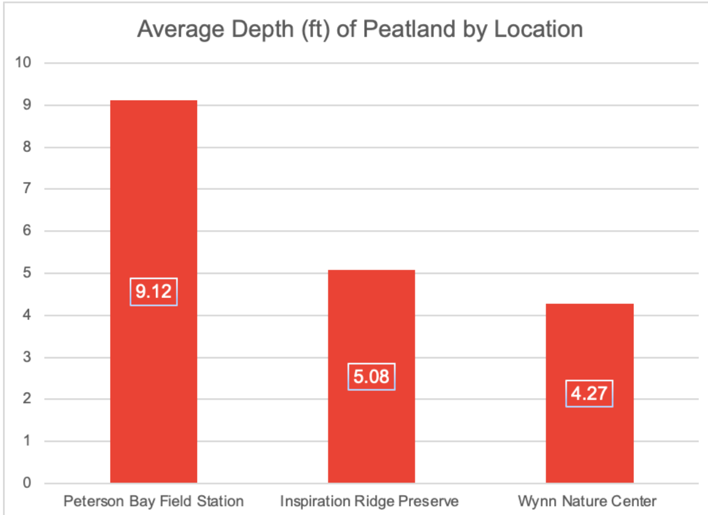


Figure 7.1 Average peat depth for CACS properties, PBFS, IRP, and Wynn, Homer, AK.

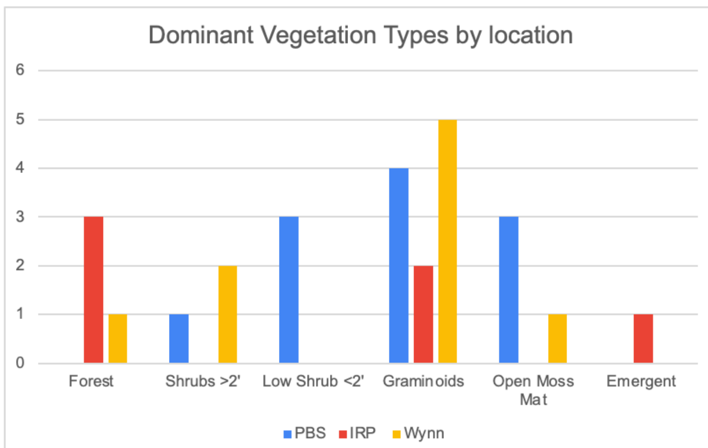


Figure 7.2 Dominant vegetation types for CACS properties, PBFS, IRP, and Wynn, Homer, AK.

Peterson Bay Field Station

PBFS had peat depths ranging from 5.3 ft - 11.6 ft and an average depth of 9.12 ft. This was the deepest among all three fen properties sampled. Graminoids was the most commonly noted dominant vegetation type, comprising 4 of the 11 sampling points. The next most common was Low Shrub and Open Moss Mat, with each making up the dominant vegetation in 3 of our sampling sites (Table 7). Vegetation species found at PBFS included Dune grass, Sphagnum moss, Crowberry, Bog blueberry and many more.

Table 7 Peat depth and dominant vegetation communities for each sampling site at PBFS, Homer, Alaska

Point	Location	Depth (ft)	Vegetation Community
1	PBFS	9.4	Shrubs
2	PBFS	10.4	Graminoids
3	PBFS	10.8	Graminoids
4	PBFS	8.3	Low Shrub
5	PBFS	5.3	Low Shrub
6	PBFS	5.4	Open Moss Mat
7	PBFS	11.6	Open Moss Mat
8	PBFS	10.7	Graminoids
9	PBFS	10.9	Open Moss Mat
10	PBFS	10.9	Graminoids
11	PBFS	6.6	Low Shrub

Inspiration Ridge Preserve

The IRP had peat depths ranging from 2.4 ft to 6.6 ft and an average depth of 5.08 ft. The most dominant vegetation type, comprising 3 of our 6 sampling sites, was Forest. Graminoids was the next most common dominant vegetation, making up 2 of our 6 sampling sites (Table 7.1)

Table 7.1. Peat depth and dominant vegetation communities for each sampling site at IRP, Homer, Alaska.

Point	*Location*	*Depth (ft)*	*Vegetation Community*
1	IRP	6.6	Graminoids
2	IRP	5.7	Graminoids
3	IRP	2.7	Forest
4	IRP	2.4	Forest
5	*IRP*	*6.5*	Emergent
6	*IRP*	*6.6*	Forest

Wynn Nature Center

The Wynn had peat depths ranging from 1.5 ft to 6.9 ft, with an average depth of 4.26 ft. This was our lowest average depth among each of the three properties (Table 7.2). Our most common dominant vegetation type here was Graminoids, comprising 5 of our 9 sampling sites. The next most common was Shrubs >2’.

Table 7.2. Peat depth and dominant vegetation communities for each sampling site at Wynn Nature Center, Homer, Alaska.

Point	***Location***	***Depth (ft)***	***Vegetation Community***
1	Wynn	2.2	Graminoids
2	Wynn	4.7	Forest
3	Wynn	3.5	Shrub
4	Wynn	6.9	Shrub
5	Wynn	5.6	Graminoids
6	Wynn	3.7	Graminoids
7	Wynn	3.6	Graminoids
8	Wynn	6.7	Open Moss Mat
9	Wynn	1.5	Graminoids

This depth data can be further utilized by the KBNERR as they calculate carbon storage capacity on the Kenai Peninsula. See additional data results in Appendix C.7.2.

E. Recommendations

We recommend that CACS continue to monitor the peatlands on the property to assess how climate change and land use changes are impacting these ecosystems. As the Homer Drawdown project is continuing to work with KBNERR to utilize this data to determine carbon storage in peatlands on the Kenai, CACS should continue to work with Homer Drawdown for their data collection timelines and analysis. However, CACS may also continue to sample and collect depth data of their own if they wish. In this case we recommend depth probing and sampling vegetation following these protocols approximately every 5 years. We also recommend taking drone images of the fens every 5 years to continue to visually monitor the encroachment of woody vegetation towards the center of the fen.

Partnering with Homer Drawdown's on this peatland project not only allows for increased data sharing and collaboration, it has the added benefit of facilitating CACS goals of promoting environmental education and stewardship. Homer Drawdown primarily collects its peatland data by having project team leads go out and sample with members of the community. Additionally, they hosted many Bioblitz events, in which peatland probing events were advertised to the entire community. At these events, community members of all ages could come to assist team leads with depth probing and plant identification. Therefore, encouraging the sampling of the fens on their properties to future events will allow the public to continue to be educated on the critical role peatlands play and to build a sense of stewardship and ownership of these lands.

I. Additional Fen Vegetation Sampling

A. Introduction

In addition to the vegetation sampling conducted as a part of the Homer Drawdown peatlands assessments, two of our team members conducted a more in-depth vegetation assessment of the IRP, Wynn, and PBFS peatlands. This involved creating sampling protocols that may be used by staff to track long term changes. As plants are immobile, they provide an indication of long-term impacts of changes to the landscape and allows for one to study and better understand local environmental abiotic and biotic changes occurring above and below ground in a specific location. Conducting a more robust vegetation survey was done in order to gain additional information regarding the plant composition of the fens and to be able to track and monitor long term changes in percent frequency, local frequency, percent coverage, and plant community composition.

B. Rationale

Surveying vegetation provides information that can be utilized when working on conservation projects and making land management decisions (Knollová et al., 2005). As noted above, peatlands may require particular conservation attention due to their key role in climate change mitigation. Under climate change projections, increasing temperatures and atmospheric CO2 will increase growth of vascular plants leading to decreasing sphagnum moss in peatlands (Fenner et al., 2007 as cited by Dieleman et al., 2014). This change in vegetation will lead to increasing release of CO_2 and methane, changes in dissolved organic carbon functions, and a decreased water table in the northern hemisphere (Rouse et al., 1997 as cited by Dieleman et al. 2014). As peatland vegetation changes this leads to changes in ecosystem functioning (Dieleman et al., 2014). Monitoring key vegetation species such as sphagnum moss and changes in the overall plant community is essential for understanding if a peatland may be changing type, i.e. from fen to poor fen, or poor fen to bog. This transition indicates that there is a drying out of the peatlands, which leads to release of CO_2 and methane.

As noted above, fens can be categorized into fen types. Currently the type of fen on these properties has not been identified. Although components such as hydrology and soil characteristics can help to classify a fen, another essential component of determining classification is vegetation composition (Cohen et al., 2020). One goal of this vegetation monitoring is to give detailed information that may help CACS determine the fen types on their properties, which may in turn aid in land management decisions.

This assessment was done to collect baseline data which was then used to calculate the local frequency, percent frequency, and plant community composition. Frequency is most often used to compare plant communities and monitor long term changes in vegetation composition (University of Idaho, 2009). These data can be compared to data gathered in future years to assess changes to the vegetation communities and to classify fen type. As previously discussed, rapid changes in peatlands due in part to increasing global temperatures makes understanding and collecting baseline information for these ecosystems vital to managing them properly.

C. Study Design

Sampling took place at the fens located on the IRP, Wynn, and PBFS properties. The protocol followed was based on information from the 2017 University of Michigan SEAS Master's project group (Turner et al., 2017), the Field Studies Council (FCS) online resource (FCS, 2021), and input from CACS staff.

On the IRP and Wynn properties, we identified a central point on the fen. To aid in randomizing our sample we chose this point by facing away from where we deemed to be roughly the center of the bog and threw a stick over our shoulder, where this landed was our center point. Next, we created three transects fanning out from the center in the NW, NE, and SE directions at the IRP, and in the W, NE, and SE directions at the Wynn. To help randomize the sample further we stepped approximately ten feet between each sampling spot and tossed the quadrat forward, sampling where the quadrat landed. We sampled at 5 locations along each transect, therefore at 15 quadrats per location. However, we added one additional quadrat sampling spot at Wynn to help ensure that we captured the fen edge adequately. At each sample point we used a ½ m by ½ m quadrat with a 25 square gridded pattern to sample the vegetation. For each species of vegetation present, the number of squares with greater than or equal to 50% coverage of that species were counted. Species that were present but did not take up at least 50% cover of any squares within the quadrat, were marked with an "x" to indicate species presence.

We followed a slightly modified protocol for the PBFS fen, this was due in part to the shape and size of the fen. It had a very narrow and oval shape, this made fanning out from a central point while still being able to collect 15 points difficult. We also performed the PBFS sampling prior to the sampling done at the IRP and Wynn sampling, where we received additional sampling insights from staff. At the PBFS, rather than fanning out from a central point, we ran two parallel 50 meter transects 5 meters away from each other and sampled at every 10 meters along that transect. We sampled at 6 points on the first transect, and at 5 points on the second transect, as the 6th point was inaccessible due to standing water and dense vegetation. However, we recommend following the protocol that was conducted at the IRP and Wynn properties when possible. For step-by-step protocols see Appendix B.5.2.

Data Entry and Analysis

Upon completion of sampling, the data was entered into excel and analyzed. This data was used to calculate the local frequency, percent frequency, and community composition of the fens. We recommend also calculating the percent cover in future sampling.

Local frequency

Local frequency tells you the frequency of a particular species in each quadrat. This is calculated by counting the number of squares within the gridded quadrat that are at least 50% occupied by a species. Then, as our square had 25 squares total, we used the following equation to make it a percentage:

Local frequency= (# of squares with at least 50% coverage)/(total number of squares in grid system)*100

For example: In our data, transect 1 quadrat 1 had 11 squares with at least 50% coverage of sphagnum moss. Additionally our quadrat had a 5x5 grid and therefore had 25 squares total. Therefore the local frequency is 11/25*100= 44%

Percentage frequency

Percentage frequency tells you the probability that a species will be found in a quadrat within your sample site. To calculate this you first need to note every species that was observed in your sample site, then use the following equation:

% frequency= (# of quadrats that species is found) / (the total # of quadrats sampled) x 100

For example: At the IRP, Bluejoint grass was found in 10 out of our 15 total quadrats sampled. Therefore the % frequency = 10/ 15 *100= 66.7%. This tells us that when sampling, there is a 66.7% chance of Bluejoint grass being found in our quadrat.

Local Composition

Local composition gives you insights into the plant communities that are most common in the fen. First, we classified each species into a community. The communities options we designated were Mosses, Low Shrub/ Ericaceous, Forbes/Herbaceous, Graminoids, Woody shrub, and Coniferous. These were established by literature review and then approved by CACS. Next using the local frequency values for each species, the % frequency of each community and % frequency of all communities was calculated for each quadrat.

Local composition= (% frequency of a community)/ (% frequency of all communities) x 100

For example: At PBFS, our first quadrat had one species of mosses, with 1 square that had at least 50% coverage. The total frequency for all communities was 136. Therefore the % frequency of mosses was 4/136*100= 2.94%.

Percentage Cover

We did not calculate percentage coverage, but we recommend doing this in future sampling. To do this, rather than marking species found in individual squares within the quadrat, simply estimate the percentage that each vegetation species is taking up for the entire ½ m by ½ quadrat space.

D. Results

Common vegetation species seen among the three fens included sphagnum moss, bluejoint grass (*Calamagrostis canadensis)*, crowberry (*Empetrum nigrum)*, bog blueberry (*vaccinium uliginosum*), and many more. Approximately 30 different species of vegetation were observed among all the properties. See Table 8 for a breakdown of each unique species observed across all properties and which properties they were found in. It is important to note that even if it says a species was not found on a particular property, it does not indicate that that species is not present on that property. That species may have simply not been in any of our quadrats as our sampling was not exhaustive. We would also like to note that a limitation of this data is the chance of plant misidentification. Our samplers were not experts with plant types in this region, however we utilized an Alaska plant guidebook and sought feedback from CACS staff with unknown plant types. Additionally of note, grasses in particular are difficult to identify. We noted an abundance of bluejoint grass (*Calamagrostis canadensis),* on the properties, especially at the PBFS. However, this may have been misidentified and represent another species of grass.

Table 8. List of all plant species observed and which properties each species was present on for the IRP, Wynn, and PBFS, Homer, Alaska.

	Unique Species Observed	Properties Found On		Unique Species Observed	Properties Found On
1	Alaska Violet (*Viola langsdorfil)*	PBFS	16	Dwarf dogwood (*Cornus canadensis* L.)	IRP, WYNN
2	Bluejoint grass (*Calamagrostis canadensis*)	PBFS, IRP, WYNN	17	Fireweed (*Epilobium angustifolium*)	IRP
3	Bog Buckbean (*Menyanthestrifoliata)*	PBFS	18	Horsetail (*Equisetum arvense)*	IRP, WYNN
4	Bog blueberry (*Vaccinium uliginosum)*	PBFS, IRP, WYNN	19	Labrador tea (*Ledum palustre)*	PBFS, IRP, WYNN
5	Bog cranberry (*Oxycoccus microcarpus*)	PBFS, IRP	20	Lingonberry (*Vaccinium vitis-idaea)*	IRP
6	Bog rosemary (*Andromeda polifolia*)	PBFS, IRP, WYNN	21	Lutz spruce (*Picea sitchensis x P. glauca)*	PBFS, IRP
7	Bog swertia	PBFS, IRP	22	Nagoonberry (*Rubus arctius*)	IRP, WYNN
8	Bog willow (*Salix fuscescens)*	PBFS, IRP, WYNN	23	Round leaved sundew (*Drosera rotundifolia)*	PBFS, IRP
9	Cloudberry (*Rubus chamaemorus)*	IRP	24	Sitka burnet (*Sanguisorba spp.*)	PBFS, IRP, WYNN
10	Club moss (*Lycopodium spp.)*	PBFS	25	Sphagnum moss	PBFS, IRP, WYNN
11	Cotton Grass (*Eriphorum angustifolium)*	PBFS, IRP, WYNN	26	Sweet gale (*Myrica gale)*	PBFS
12	Crowberry (*Empetrum nigrum)*	PBFS, IRP, WYNN	27	Trailing raspberry (*Rubus pedatus*)	PBFS, IRP
13	Dune grass (*Elymus mollis*)	PBFS, IRP, WYNN	28	Tundra rose (*Potentilla gracilis)*	PBFS
14	Dwarf birch (*Betula nana)*	PBFS, IRP, WYNN	29	Violet (*Viola spp.)*	IRP
15	Dwarf blueberry (*Vaccinium cepitosum)*	WYNN	30	Watermelon Berry (*Streptopus amplexifolius)*	PBFS

Local Frequency

Local frequencies of species can give insights into differences and similarities among the three fen properties. At PBFS, bluejoint reedgrass (*Calamagrostis canadensis*) had the highest local frequency value in 9 of the 11 quadrats sampled and was present in 10 of the 11 quadrats sampled. Its local frequency value ranged from 16-88% with an average local frequency of 53%. Crowberry (*Empetrum nigrum*) had the next highest local frequency values on PBFS. Alternatively, on the IRP and Wynn properties, sphagnum moss was most commonly the species with the highest local frequency per quadrat. On the IRP, 10 of the 15 quadrats had sphagnum moss as the species with the highest local frequency, and 9 out of 16 for the Wynn. On the IRP this was followed by Crowberry (*Empetrum nigrum*) and on the Wynn was followed by bog blueberry (*Vaccinium uliginosum)*. See Appendix C.7.2. for the completed data table for local frequency.

Percent Frequency

Percent frequency differs slightly from local frequency in that its value is calculated for the entire property rather than per quadrat. It tells you the probability of finding a specific species in a quadrat on the site. Sphagnum moss was the species with the highest percent frequency for the IRP and Wynn, while Bluejoint grass was highest for the PBFS. Sphagnum moss had the second highest percent frequency on PBFS with 63.64%. This makes sense as we saw that these species also had the highest local frequency in each quadrat above. See Appendix C.7.2. for the completed data table for percent frequency.

Table 8.1 Species with the highest percent frequency for each property, the IRP, Wynn, and PBFS, Homer, AK.

Location	Species w/ Highest % Frequency	% Frequency
PBFS	Bluejoint Grass	90.91%
IRP	Sphagnum Moss	93.33%
Wynn	Sphagnum Moss	100%

Community Composition

The community compositions varied among the properties. The PBFS plant communities consisted of more Graminoids, while the IRP and Wynn had more Mosses and Low Shrub/Ericaceous plant communities. Coniferous and Woody Shrub communities were consistently the lowest for each of the three properties. This may indicate that there is not a high level of encroachment occurring in the fens as of yet. The variation among these properties may be due to numerous factors that would have to be further investigated, such as differences in elevation, microclimates, soil competitions, and peat depth, to name a few. As noted in the peatland depth section, PBFS also had the deepest peatland depth, this may correlate with the difference in vegetation composition, although it is unclear if this is correlation or causation and further research would have to be conducted to draw conclusions regarding this. See Appendix C.7.2. for the completed data table for community composition

E. Recommendations

We recommend that this vegetation sampling be repeated approximately every 5 years, and that the local frequency, percent frequency, community composition, and percent coverage for each property is determined each time. These values can be compared among previous years to watch for trends in changes to the vegetation composition on the fens. As mentioned in the rationale, change in plant composition in combination with hydraulic measures can give an indication of if a fen may be changing state, i.e from rich to poor fen. This samling may also be paired with the drone images taken every 5 years that was recommended in the previous section. These protocols can also be used by citizen scientists to practice plant identification and calculate straightforward metrics of plant communities.

Bringing It All Together

Ecosystem Connections

The Center for Alaskan Coastal Studies properties of the Inspiration Ridge Preserve and Wynn Nature Center support headwater streams, wetlands, and critical habitat for fish and wildlife that are essential to the overall watershed health of the Anchor River Watersheds. During encounters in our field work and recorded in our monitoring results, we observed a diversity and abundance of species that the CACS property habitats support. This included various species of macroinvertebrates, including stone and mayflies, and dolly vardens in the streams. The macroinvertebrates that were present in the streams support that the stream and wetland ecosystems are high quality. While bird surveying, we identified several species including the Olive-sided Flycatcher, a near threatened species. Additionally, we observed species across a variety of habitats; such as the Alder Flycatcher in riparian, open meadow, and shrub dominated meadow habitats. The variety of habitats attracts a wide-range of bird species, including migratory species, many of which travel to Homer in early spring. Migratory species are suffering from a wide-range of anthropogenic and climate-change stressors, these pristine and diverse habitat ecosystems provide migratory species an essential seasonal refuge for foraging and breeding. This showcases the need and importance of conserving the diverse mosaic of habitats that exist on the IRP, Wynn, and PBFS properties for aquatic and terrestrial wildlife.

Through this project, we also gained greater insight into the connections within ecological communities. We noted in the introduction the connection between peatlands and stream productivity. Nutrient flow from peatlands and alders ultimately impacts stream health and aquatic communities. Water and habitat quality also impact benthic macroinvertebrate diversity and abundance, which in turn impacts fish populations that rely on the macroinvertebrates for food. Water quality indirectly affects bird populations, as they rely on streams and connected ponds for water, habitat and food. In fact, although less than 4-5% of the Earth’s land is covered by freshwater, 11-23% of bird species use land surface water at some point during their yearly life cycle (Ormerod & Tyler, 1993). The fen ecosystems also affect bird populations. For example, the encroachment of woody plants and tree species on fens can impact the diversity and composition of bird communities occupying the fen habitats (Lachance et al., 2005). Poor water quality and pollution can lead to mortality and reproductive impairment of bird species (Blus, 1977). Just as benthic macroinvertebrates are an indicator of water and habitat quality, birds are indicators of both terrestrial and water quality (Ormerod & Tyler, 1993).

Overall, the ecosystems we studied are all intricately connected and deleterious impacts to one portion of the ecosystem can have negative downstream effects on other parts of the ecological communities. Our study highlights the complexity of these pristine ecosystems and the many connections across habitats and species. Nevertheless, our findings show only a subset of the many direct and indirect connections that likely exist. The continued monitoring of each of these habitats and species individually can provide insight into other aspects of the overall ecosystem. Additionally, conservation work targeting these habitats and species at the individual level can ultimately have positive impacts on the ecosystem collectively.

The headwater streams, peatlands, species diversity, and vegetation communities that aid in making the IRP and Wynn high quality ecosystems also contribute to the overall quality of the Anchor River Watershed. For example, birds are essential for seed dispersal and pollination alongside being an important component of the food web. The Kachemak Bay Estuarine Research Reserve has documented the connection between watershed quality and headwater streams for salmonid populations (Walker et al., 2021). While the streams on CACS properties have not documented anadromous salmonid populations, maintaining ecosystem quality of headwater streams and riparian landscapes supports fish populations and ecosystems in the downstream watersheds. Additionally, headwater streams on the Wynn property ultimately provides Homer’s drinking water, through Bridge Creek.

Through the protection and ecological management by Nina Faust, Ed Bailey, and the Center for Alaskan Coastal Studies, past SEAS master’s projects and our 2021 ecological assessment aid in showcasing the high quality and connectivity of habitats that continues to support essential stream functioning and ecological services throughout the watersheds.

Community Members and Policy Makers

In addition to regulating and supporting ecological services provided through watershed components on the IRP and Wynn Properties, there are also many cultural and provisioning services for humans. As mentioned throughout this report, these species and habitats provide numerous services to the community, including ecological, economic, recreational, social, and cultural benefits. For example, the tourism industry in the Kenai is largely supported by healthy ecosystems that support high biodiversity. Fish are of great ecological and economic importance to Alaska as a whole and Homer specifically. Fish not only provide nutrients and a food source for wildlife, but attracts visitors from around the world for recreation purposes. This produces jobs and revenue that help stimulate Homer's economy. In addition, bird watchers, wildflower enthusiasts, hunters, and photographers, and nature lovers in general provide revenue to the community and to CACS specifically when participating in tours and education programs. These funds can lead to increased conservation efforts.

Other economic services offered by healthy watersheds include flood protection for the community, which can be provided when floodplains and natural landscapes are left intact. This can save lives and money due to flood damages. In 2002, the city of Homer experienced floods not seen in the last 50-100 years (Cook Inlet Keeper, 2007). A concern of the southern Kenai is the drainage of surrounding wetlands for development. CACS properties provide protection of a variety of wetland types that have and will continue to provide flood mitigation protection. As discussed, Homer’s drinking water is supplied by water that runs through CACS properties. This makes monitoring water quality and protecting the land from development essential to the supply of quality drinking water to the entire community. As water quality and resources decrease due to erosion runoff and climate change, the cost for water treatment will increase for the city of Homer. This supports the need to maintain watershed quality and functioning through ecological monitoring, protection, and conservation to benefit nature, human health and the economic stability of the Homer community.

Additionally, there is an immeasurable impact that the Center for Alaskan Coastal Studies and their properties have on conservation and land stewardship efforts through their outreach and education programs, which connect the community and visitors to natural ecosystems including boreal forests, fens, oceans, and estuaries. Field trips including those to tidepool, bird watch, and identify plants, all help to raise awareness, inspire action and create life-long connections between people and their surrounding landscapes. It also provides the entire community with a refuge to come and enjoy nature, which studies have found can have positive effects on stress levels and overall mental health (Lackey et al. 2014). Additionally, ecological monitoring and data sharing can help reduce uncertainty and disagreements amongst stakeholders and policy makers. Providing policy makers with information regarding the ecological, societal, and economic benefits of watershed properties may aid in new policies that further lead to enhanced land conservation and protection.

While it is always challenging to quantify the many ecological services of ecosystems; the previous discussion highlights many critical values they provide to local communities. Conserving the IRP, Wynn Nature Center and PBFS aid in conserving the integrity of the watershed as a whole. Additionally, working to conserve and protect this array of ecosystems and manage watersheds requires the joint efforts of non-profit organizations like CACS, community organizations like Homer Drawdown, community members, government agencies, tribal governments, research facilities like KBNERR, and local businesses. The hydrological connectivity of waters that flow through CACS properties as streams and groundwater through peatlands to distant land parcels makes collaboration particularly important. One thing that is readily apparent is how connected and collaborative the scientific community is in the Homer area. CACS is already partnering with many organizations in their conservation efforts. These highlighted projects, such as the peatland monitoring with Homer Drawdown and Tree Swallow monitoring utilizing the Alaska Songbird Institute, will enable CACS to further strengthen their community partnerships and aid in providing data and science communication to a wide network of researchers and users.

Through our monitoring we were able to gather data to aid in understanding the value and health of the watershed properties managed by CACS. Thinking back to the EPA definition of a healthy watershed in the introduction, some key aspects of a healthy watershed included; sufficient habitat and connectivity to support native aquatic and riparian species, physical and chemical water quality conditions that can support biological communities, natural vegetation cover which helps maintain stream flows, and intact and functioning headwater streams and biotic refugia (EPA, 2021)." Through our sampling we observed an array of natural vegetation in the peatland habitats, high water quality, headwater streams that were supporting native species of fish and a diversity of macroinvertebrates, and connected habitats supporting diverse migratory and resident bird species. Along with the ecosystem services provided by these habitats, this showcases the components of a healthy and valuable watershed.

Future Management Recommendations

Highlighted in each of the ecological monitoring sections above include our recommendations for future monitoring with respect to those ecosystems. Table 9 below is a consolidated version of the monitoring recommendations for each of our sampling sections.

Table 9. Consolidated recommendations for CACS resampling efforts on CACS properties, Homer, Alaska.

Ecological Monitoring Type	**Re-sampling Recommendation**	**Last/Next Sampling**
Fish Trapping	Resample every 3 years	Last: July 2021 Next: 2024
Macroinvertebrate Sampling	At least every 3 years, could be conducted yearly if time allows.	Last: July 2021 Next: 2024
Water Quality Testing	Seasonally, time allowing, but at least annually	Last: July 2021 Next: Summer 2022
Breeding Bird Surveying	Annually during the breeding season. Specifically between May 25th and the end of June.	Last: June 2021 Next: May/June 2021
Peat Depth Probing	In accordance with Homer Drawdown project recommendations, if CACS would like to do additional sampling on their own, we recommend every 5 years.	Last: July 2021 Next: Per Homer Drawdown or 2026.
Fen Vegetation Sampling (Including taking Drone Images)	Every 5 years	Last: July 2021 Next: July/August 2026
Swallow Nest Monitoring	Annually during Tree Swallow breeding season (May-June)	Last: Has not been conducted yet Next: Spring 2022

Although in CACS future plans already, broadly we recommend that CACS continues to monitor and allow monitoring results to impact management actions and objectives. Additionally, monitoring will be essential as CACS continues to protect headwaters and wetlands that provide benefits to the overall Anchor River Watershed. As many areas in these watersheds continue to be developed and utilized for recreation, such as ATV use, the IRP and Wynn waters can serve as a reference site. Being pristine with low disturbance, the streams on these properties can serve as a comparison against streams without protection in the Anchor River. This data comparison can serve either as a possible reference for stream restoration in other areas of the watershed and/or to display how these high quality streams and peatlands continue to support a healthy watershed and drinking water for the city of Homer.

The IRP also could serve as an ideal site for climate change research. Mentioned previously, the IRP is a mosaic of pristine and intact habitats. There are a lack of stressors on this property such as few visitors, lack of pollution, including light and noise pollution, minimal development other than a few wooden houses for property keepers, and intact vegetation. Due to the high ecological integrity, the IRP then can serve as a site to observe climate change impacts in the southern Kenai without a high level of interaction with other stressors. This furthers the importance of maintaining the IRP as a preserve with minimal disturbance and the continuing of funding to support land preservation on the property.

We also recommend that CACS continues to implement an adaptive management style in the face of conservation uncertainty. The following is the definition of adaptive management created by the National Research Council (Williams et al., 2009).

"Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders."

Adaptive management prioritizes "learning while doing" in a structured way to reduce uncertainty that is typically associated with making natural resource management decisions (Williams et al., 2009). The essential characteristic is that decisions are followed up by monitoring and that monitoring then allows land managers to evaluate the success and alter management plans. This moves aways from traditional settler land management practices such as restoring a site and then not following up to monitor success or change. It is important to note that like the idea of sustainability, conservation management approaches such as adaptive management are not new ideas. Indigenous peoples have and continue to apply practices that prioritize learning through observation and employ experiential learning in ways that contribute to understanding of best practices for land management.

Adaptive management also focuses on improving decision making amongst stakeholders. By setting clear objectives and goals, monitoring results, and reengaging in consensus there is a sustained collaboration (Williams et al., 2009). Adaptive management will also be increasingly critical as climate change continues to impact ecosystems in unknown ways. The Homer Climate Action plan that was produced in 2007 notes some of the key impacts that Homer may face due to climate change, including increased evaporation and transpiration of freshwater supplies, changes in storm intensity and frequency, and increased wildfires (Fiefel & Braddock 2010). Changes in temperature may also lead to ecological mismatch. An example of this may be warmer temperatures leading to plants blooming or insects hatching earlier in the season and not aligning with migratory birds typical arrivals. As the birds may rely on these plants or insects for food sources, this could decrease their fitness and reproduction rates. Although difficult to plan for, as many effects of climate change are yet to be seen, incorporating future climate scenario considerations when implementing land management decisions or observing long term data trends may lead to increased success.

Adaptive management could also be useful as CACS and property manager Nina Faust continue to decide where trail systems will be placed. Trying to decide where and how visitation will be allowed on a property that is pristine and relatively undisturbed comes with uncertainty. Particularly as CACS and property management decide how citizen scientists and research scientists will be interacting with wildlife and vegetation on the property. However, with an adaptive management approach CACS and IRP property land management can decide goals such as what would be the least impact on flora and fauna, what times to allow visitors would disturb wildlife the least, and what routes will allow for the most effective and accessible access to view the property. However, as expressed by CACS there will be a central goal of ensuring that the IRP maintains its ecological integrity and serves primarily to provide wildlife corridors and wildlife habitat for species. This may also apply to monitoring done if other changes to the property are to be made, for example, as development of the new Wynn Visitor Center continues, monitoring of the nearby streams water quality can be conducted to see how the streams are potentially impacted by the development.

Like past masters projects teams, such as the 2017 project, we recommend that wildfire mitigation practices such as removing downed spruced trees be implemented to reduce the fuel load on the landscape. The boreal forest of the Kenai have been significantly impacted by deforestation through spruce bark beetle outbreaks and afforestation through wetland drying into shrubs and trees (Baughman et al., 2020). Much of the drying out of wetlands has been contributed to climate change impacts from warmer temperatures and extended periods of drought. With warmer temperatures, spruce beetles are expected to increase in numbers. Additionally, warmer temperatures and prolonged drought are expected to continue to dry out some of the Kenai's wetland systems and increase abundance of *Calamagrostis* grass (Baughman et al., 2020). Overall, this will contribute to an increase in drier conditions and more fuel load on the landscape that may increase the intensity and frequency of wildfires. Mitigation through removing fuel load on the landscape, such as the downed spruce on the IRP property, is an important step in fire preventative measures to protect the unique habitats and water ecosystems on the IRP.

In conclusion, the bulk of this project was centered around creating ecological sampling protocols and collecting baseline data on CACS properties. This was in order to accomplish three overarching goals of helping CACS to monitor long term changes and trends in species composition in the face of a changing climate and development in the Homer area, to provide information for dissemination to the public and policymakers, and to continue to make space for citizen science and community engagement. The work outlined in this report ultimately contributes to CACS ongoing work and efforts to create awareness of and understanding regarding the importance of these watersheds for the ecosystem and community, as well as to continue to seek out increased protections for these watershed properties.

Appendices

Appendix A. Maps

A.1 Fish Survey Maps

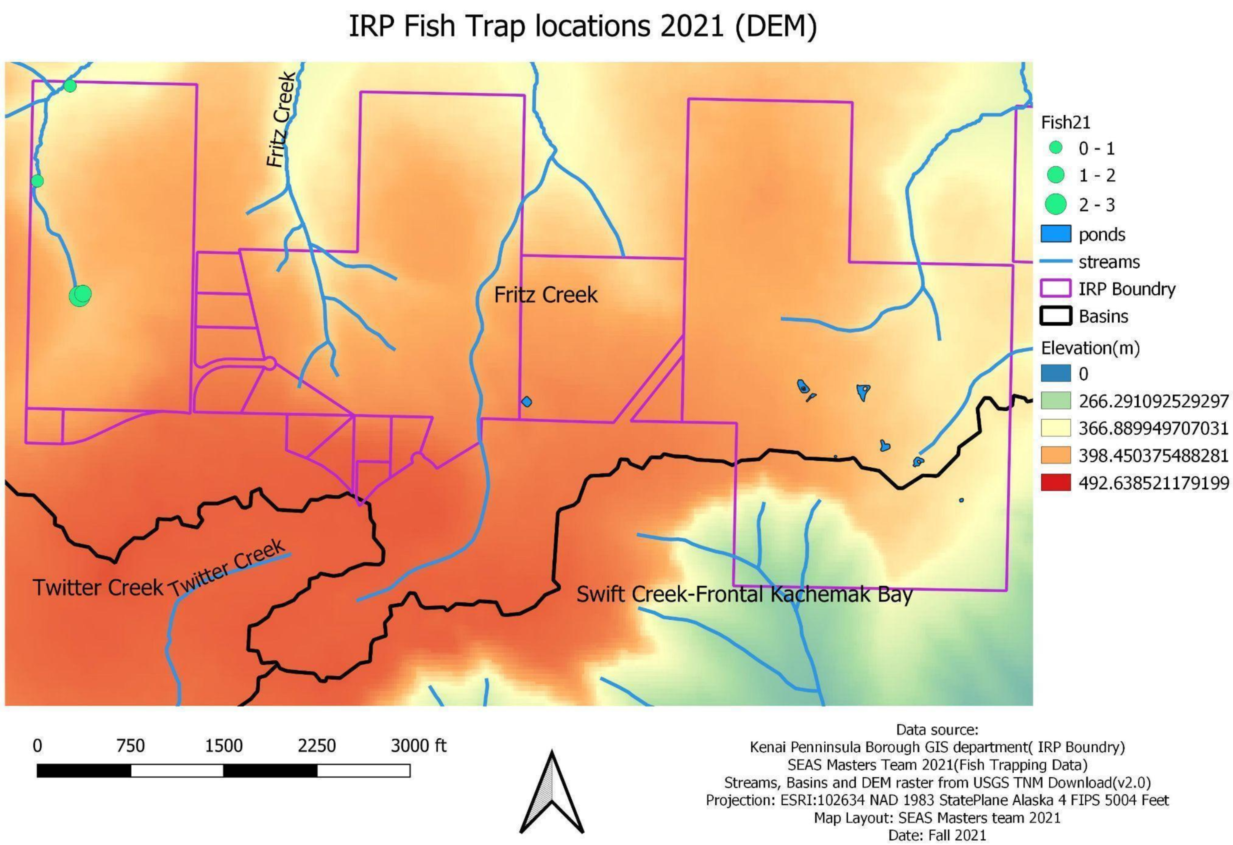
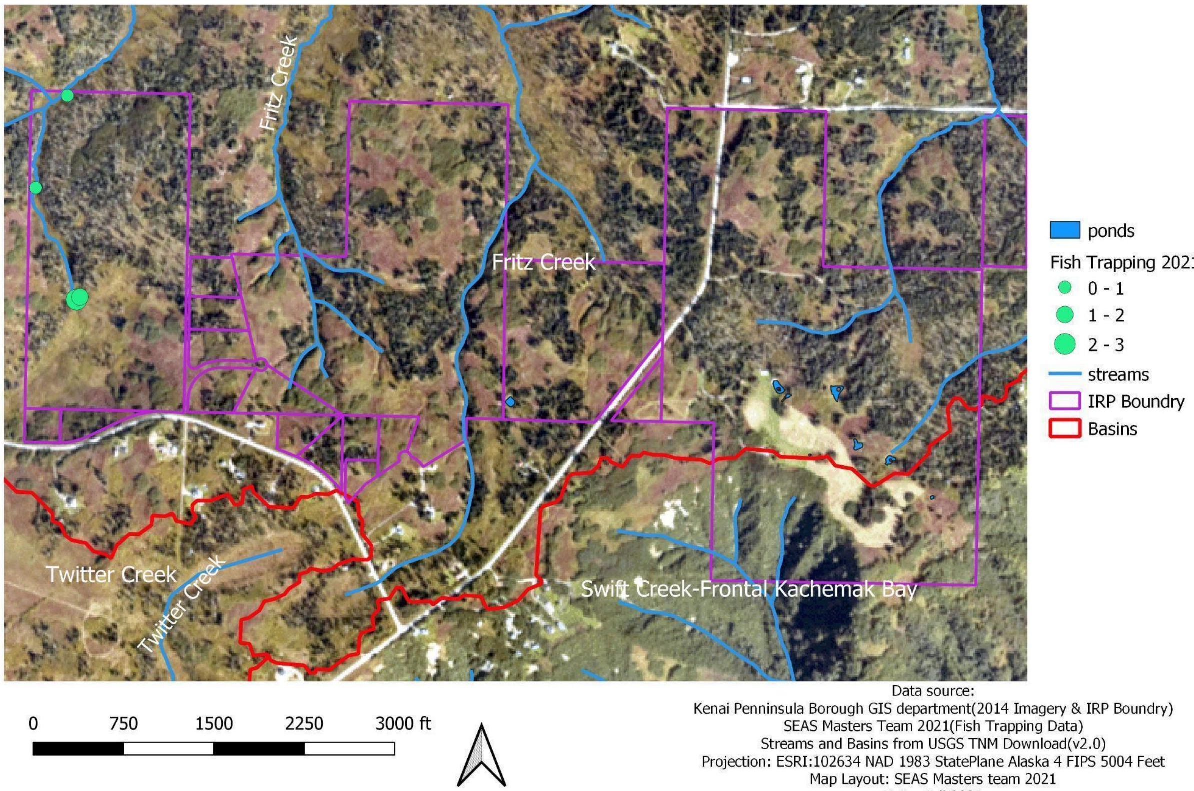


Figure A.1.1 DEM map of Inspiration Ridge preserve (IRP) showing the successful fish trapping sampling sites with size of circle corresponding to number of fish caught, Homer, AK.

IRP Fish Trap Locations 2021



Data source:
Kenai Penninsula Borough GIS department(2014 Imagery & IRP Boundry)
SEAS Masters Team 2021(Fish Trapping Data)
Streams and Basins from USGS TNM Download(v2.0)
Projection: ESRI:102634 NAD 1983 StatePlane Alaska 4 FIPS 5004 Feet
Map Layout: SEAS Masters team 2021
Date: Fall 2021

Figure. A.1.2 Map depicting successful fish trapping sites and results in 2021 on the Inspiration Ridge Preserve, Homer, AK.

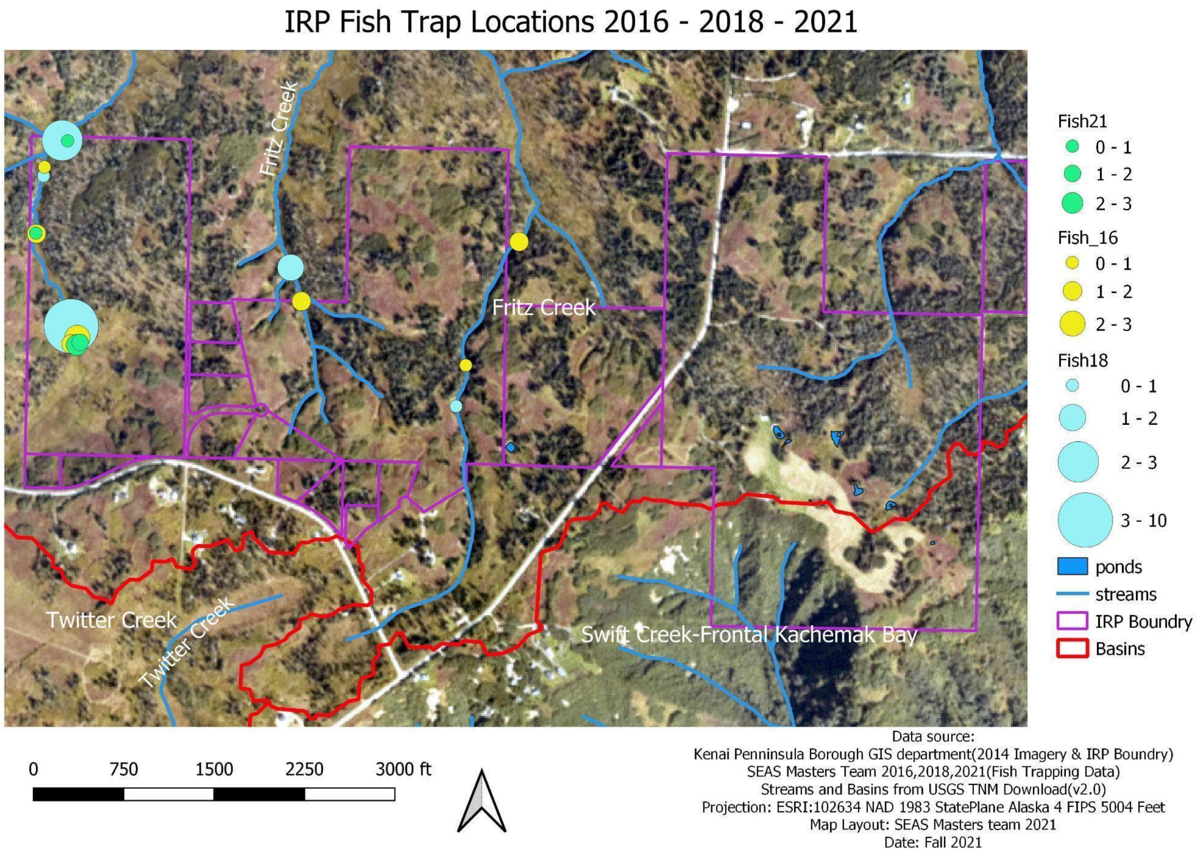


Figure. A.1.3 Map depicting the fish trapping results from the 2016, 2018, and 2021 masters project groups on the Inspiration Ridge Preserve, Homer, AK.

A.2. Macroinvertebrate Maps

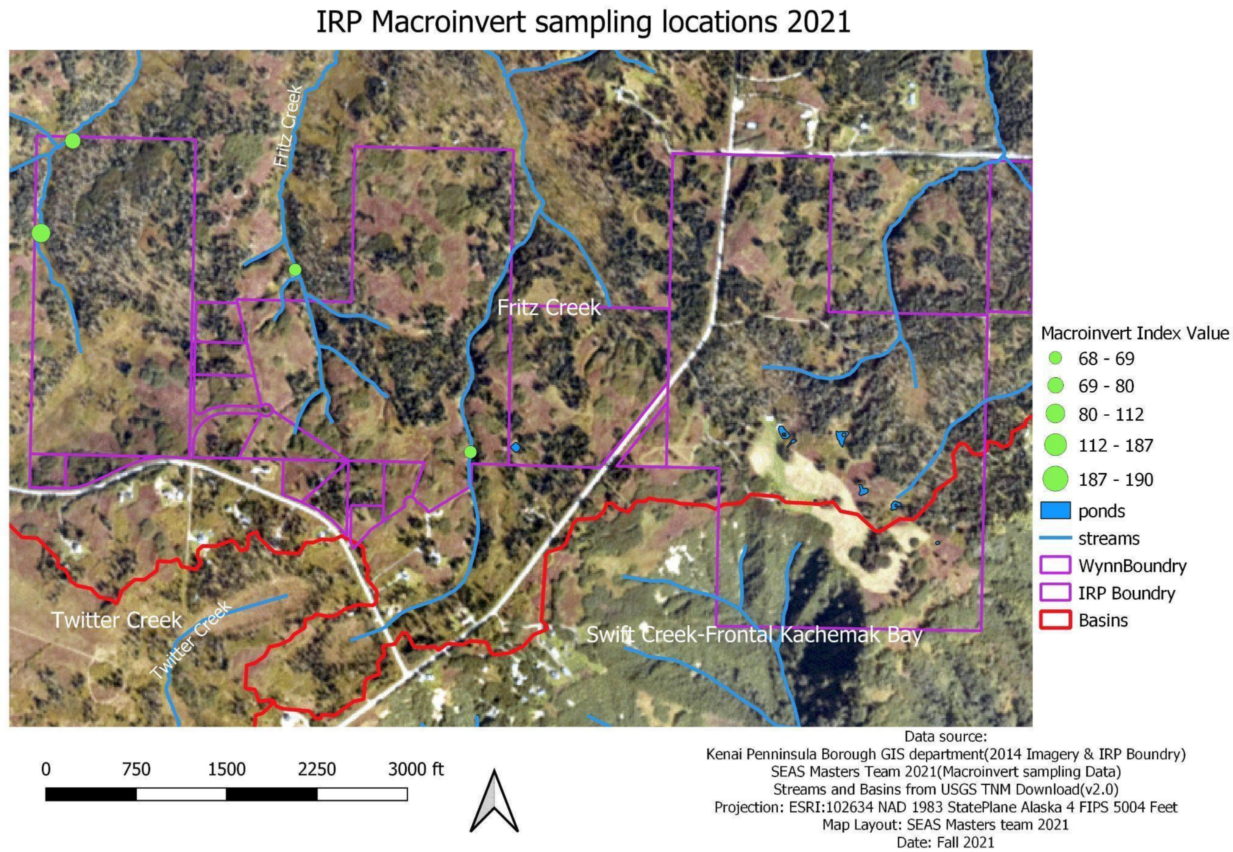


Figure.A.2.1 Map depicting the macroinvertebrate sampling results from 2021 on the Inspiration Ridge Preserve, Homer, AK.

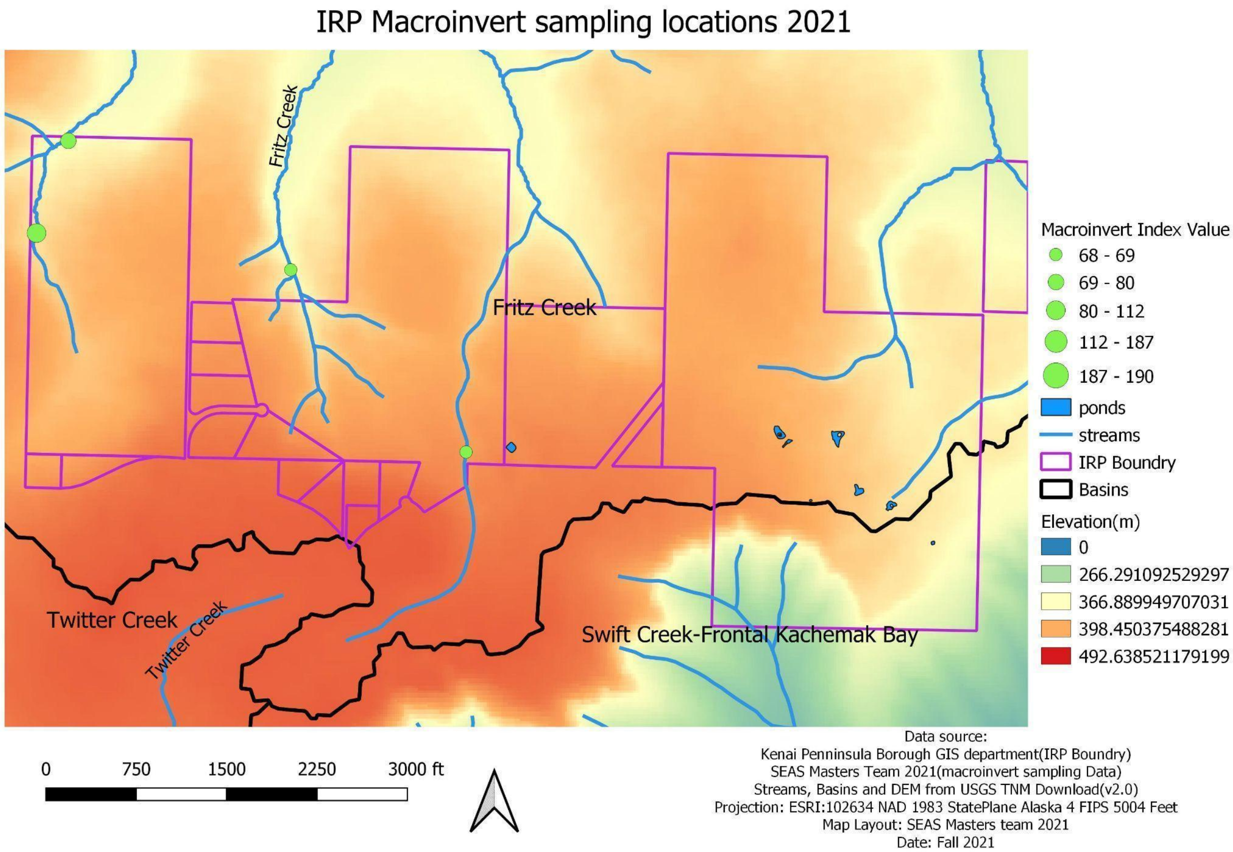


Figure A.2.2 DEM map of Inspiration Ridge preserve (IRP) showing the macroinvert sampling sites with size of circle corresponding to the magnitude of the index value, Homer, AK.

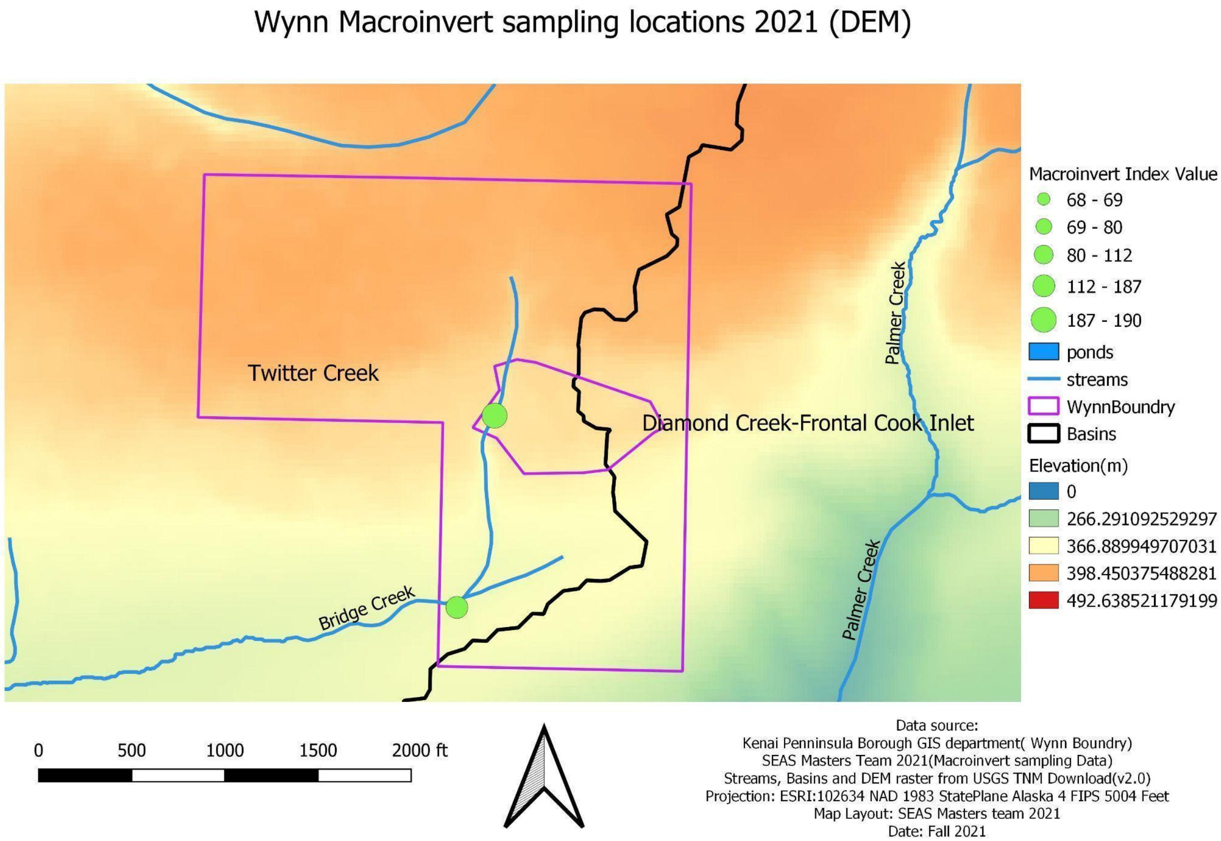


Figure A.2.3 DEM map of the Wynn Nature Center showing the macroinvert sampling sites with size of circle corresponding to the magnitude of the index value, Homer, AK.

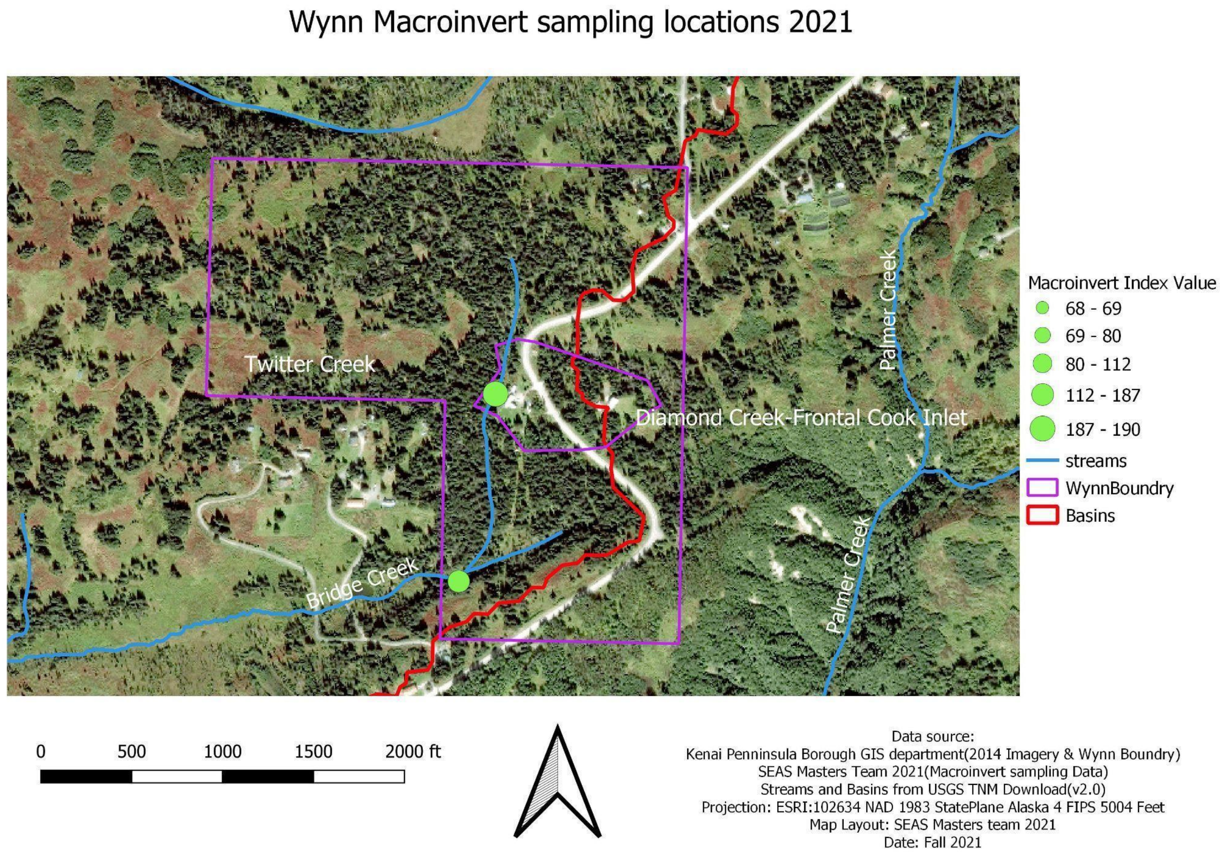


Figure. A.2.4 Map depicting the macroinvertebrate sampling results in 2021 on the Wynn Nature Center, Homer, AK.

A.3 Bird Survey Maps

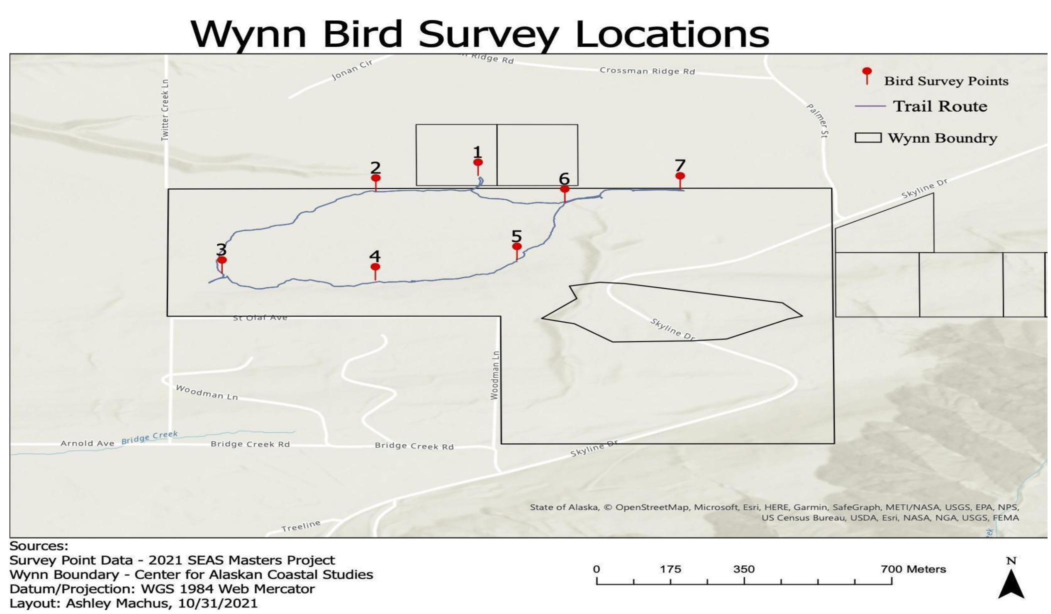


Figure. A.3.1 Map showcasing the survey point locations at the Wynn Nature Center Survey site in Homer, Alaska.

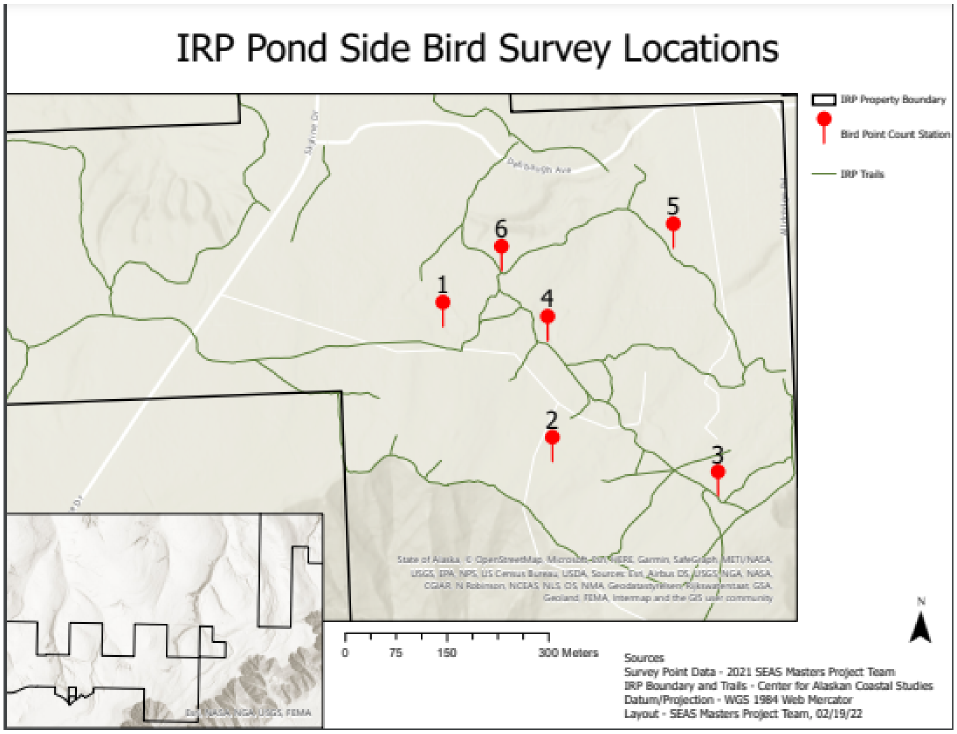


Figure A.3.2 Map showcasing the survey point locations at the IRP Pond Side survey site in Homer, Alaska.

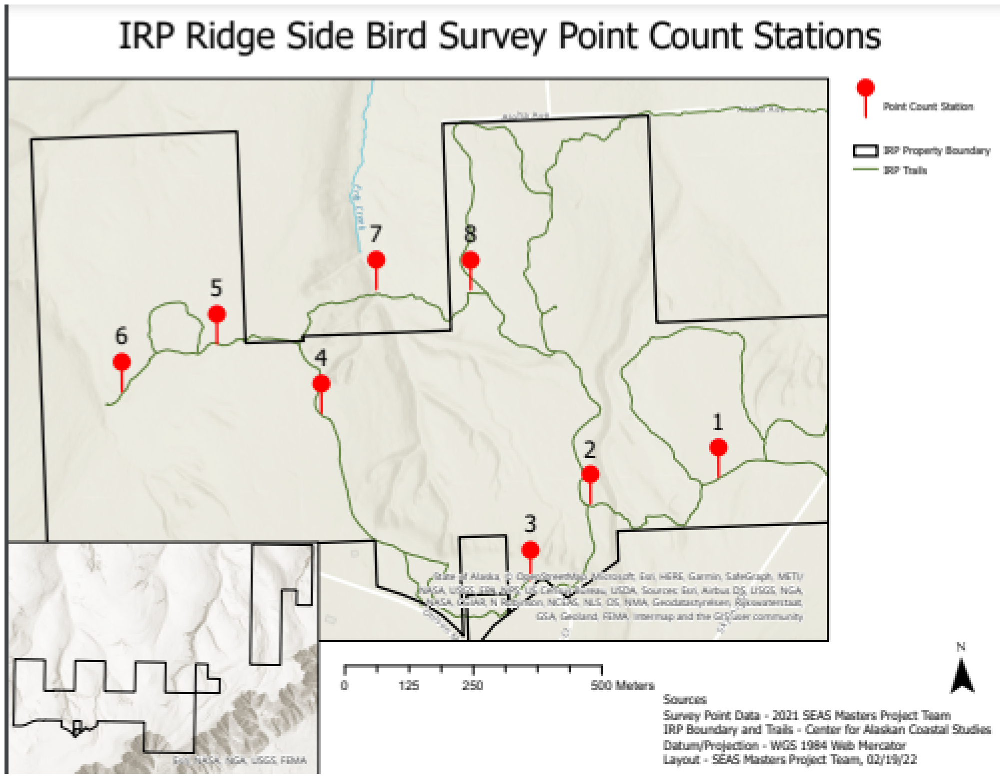


Figure A.3.3 Map showcasing the survey point locations at the IRP Ridge Side survey site in Homer, Alaska.

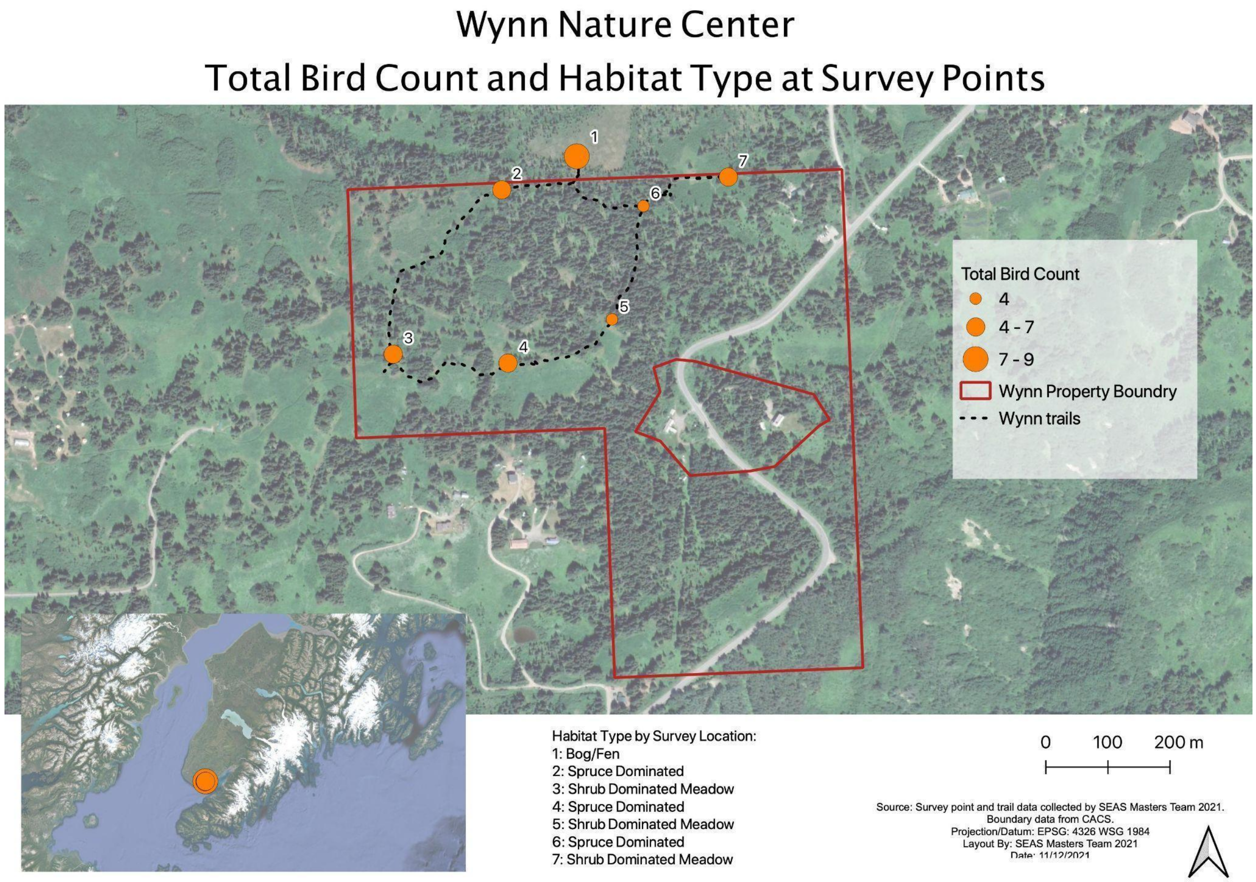


Figure. A.3.4 Map showcasing the total bird count at each survey point count station on the Wynn Nature Center, Homer, AK

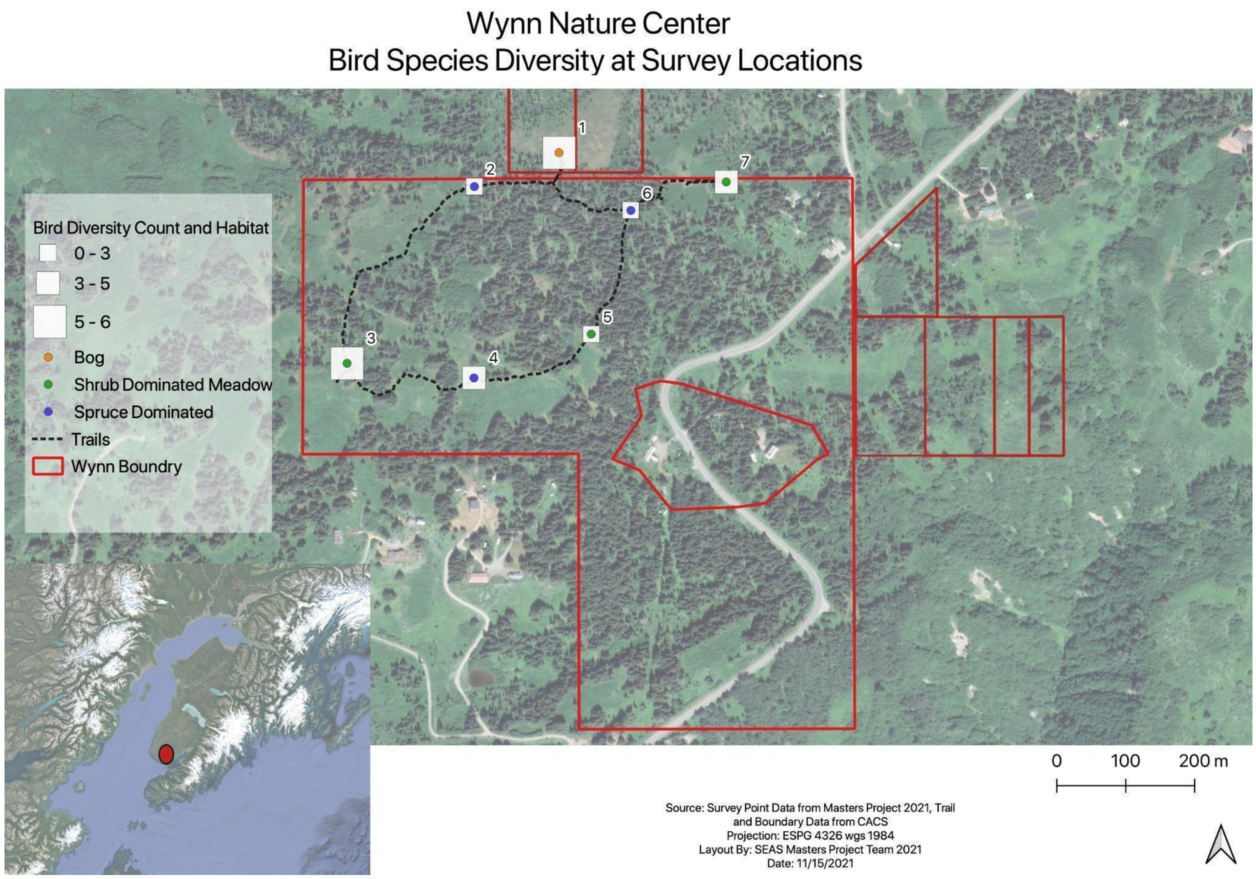


Figure A.3.5 Map showcasing the total bird diversity denoted by the size of the white box, and the habitat structure at each point count station denoted by the circle color. Wynn Nature Center, Homer, AK.

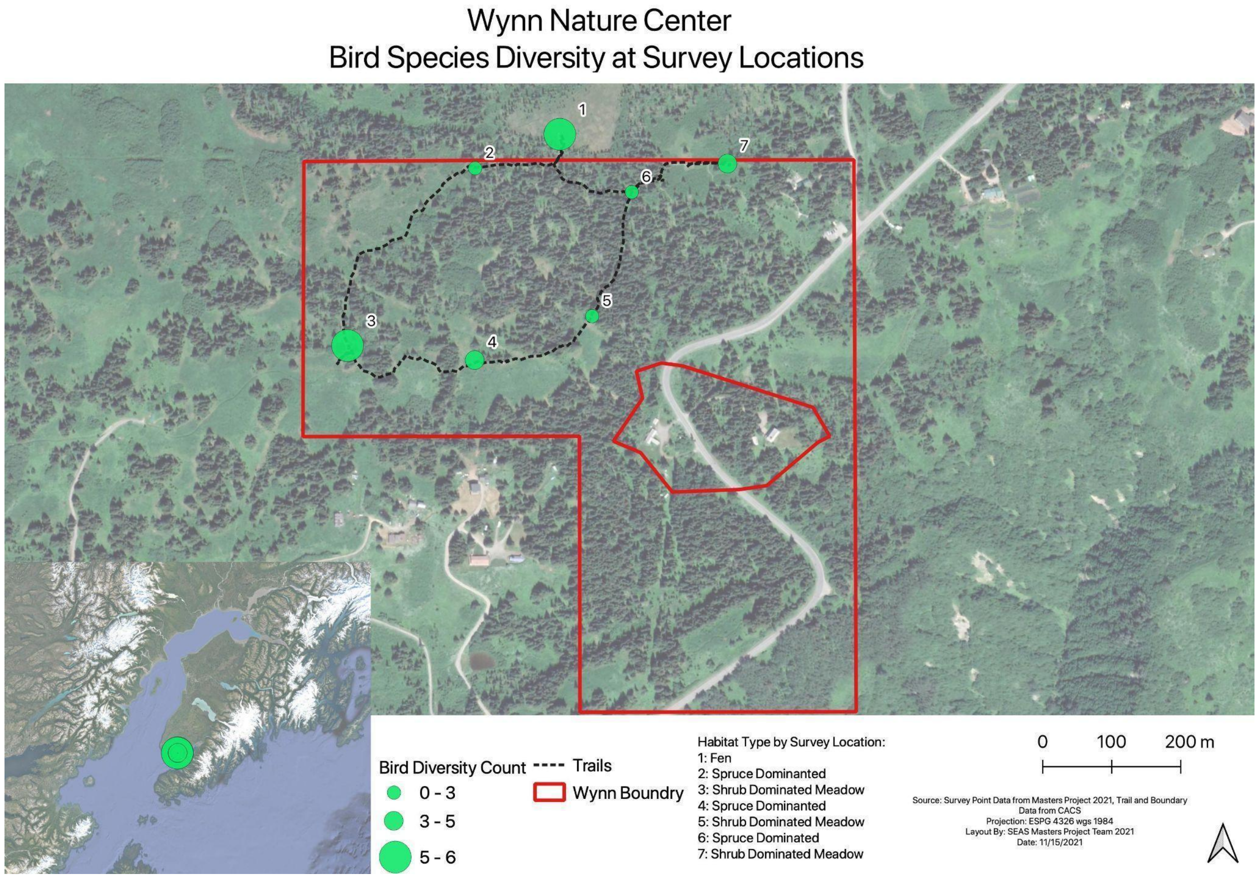


Figure A.3.6 Map depicting the bird diversity values at each point count station at the Wynn Nature Center, Homer, AK.

A.4 Peatland Survey Maps

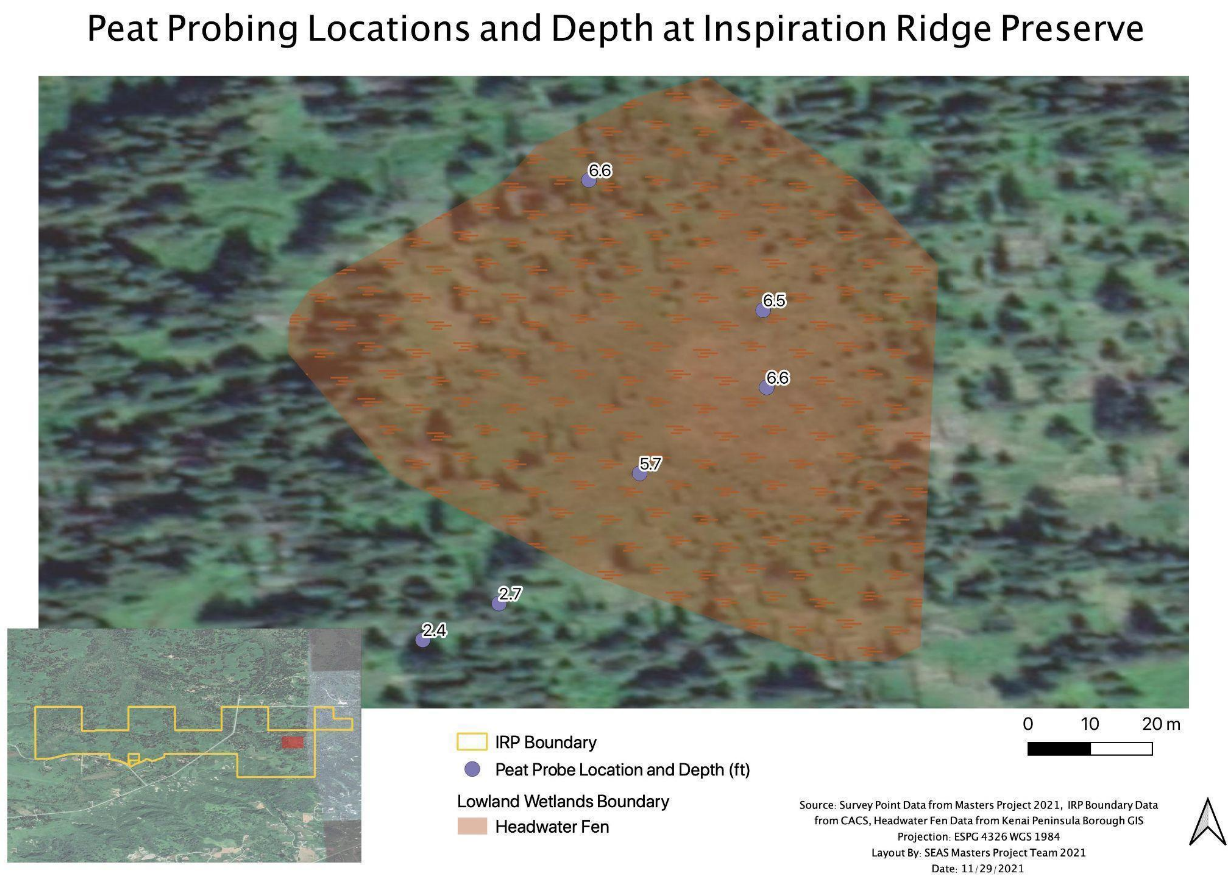


Figure A.4.1 Map depicting the peatland at the Inspiration Ridge Preserve denoting points where depth probing was completed, depth in feet labeled.

Peat Probing Locations and Depth at Wynn Nature Center

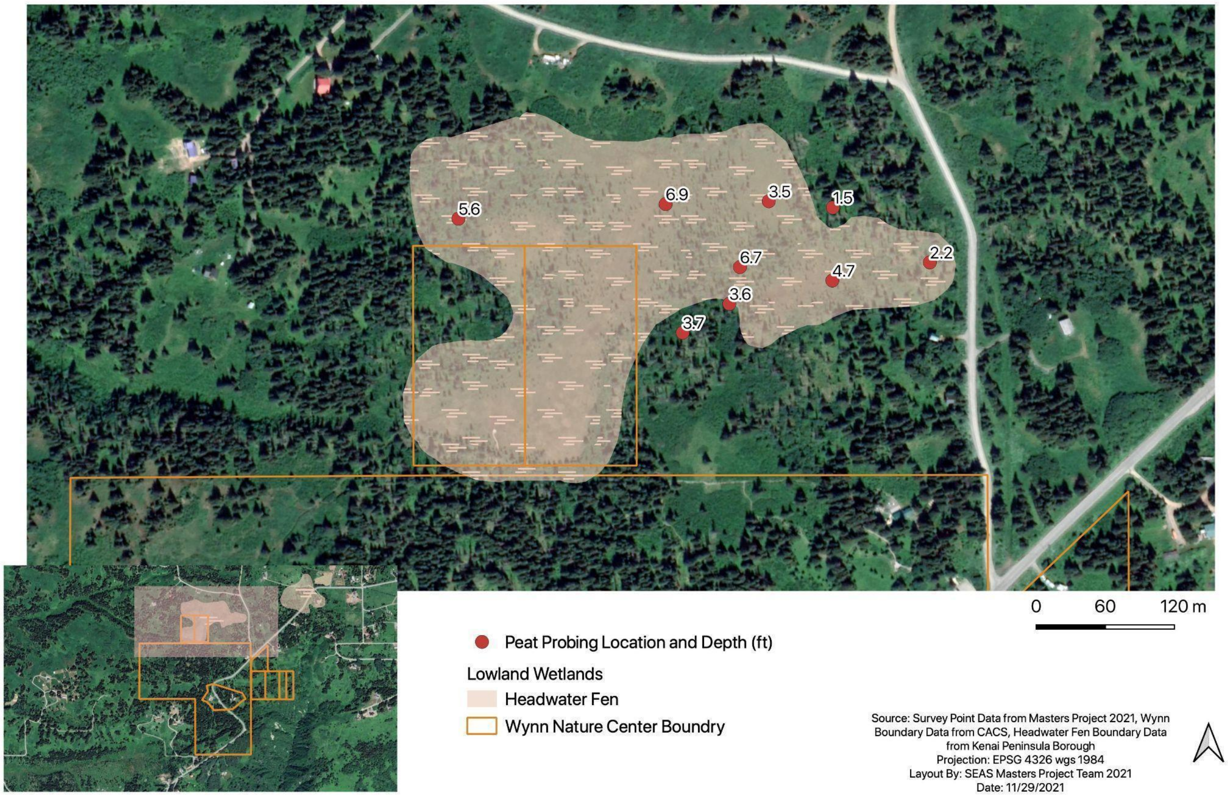


Figure A.4.2 Map depicting the peatland at the Wynn Nature Center denoting points where depth probing was completed, depth in feet labeled.

A.5 Context Maps

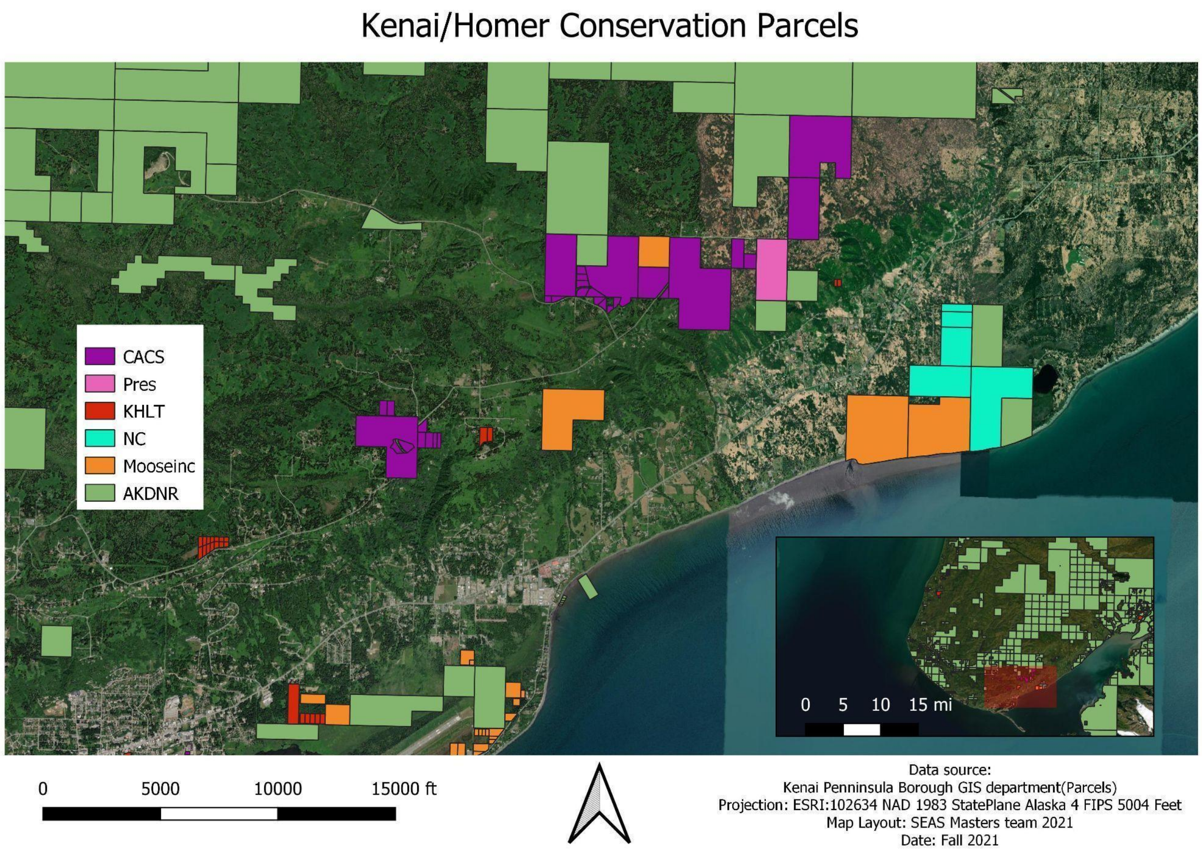


Figure A.5.1 Map showcases land parcels highlighting those owned by conservation organizations in the Homer, Alaska region. CACS(Center for Alaskan Coastal Studies), Pres(Preserved parcels),KHLT(Kachemak Heritage land trust), NC(Nature conservancy), Moose inc(Moose inc non-profit), AKDNR(Alaska Department of Natural resources).

CAC's Properties and Basins

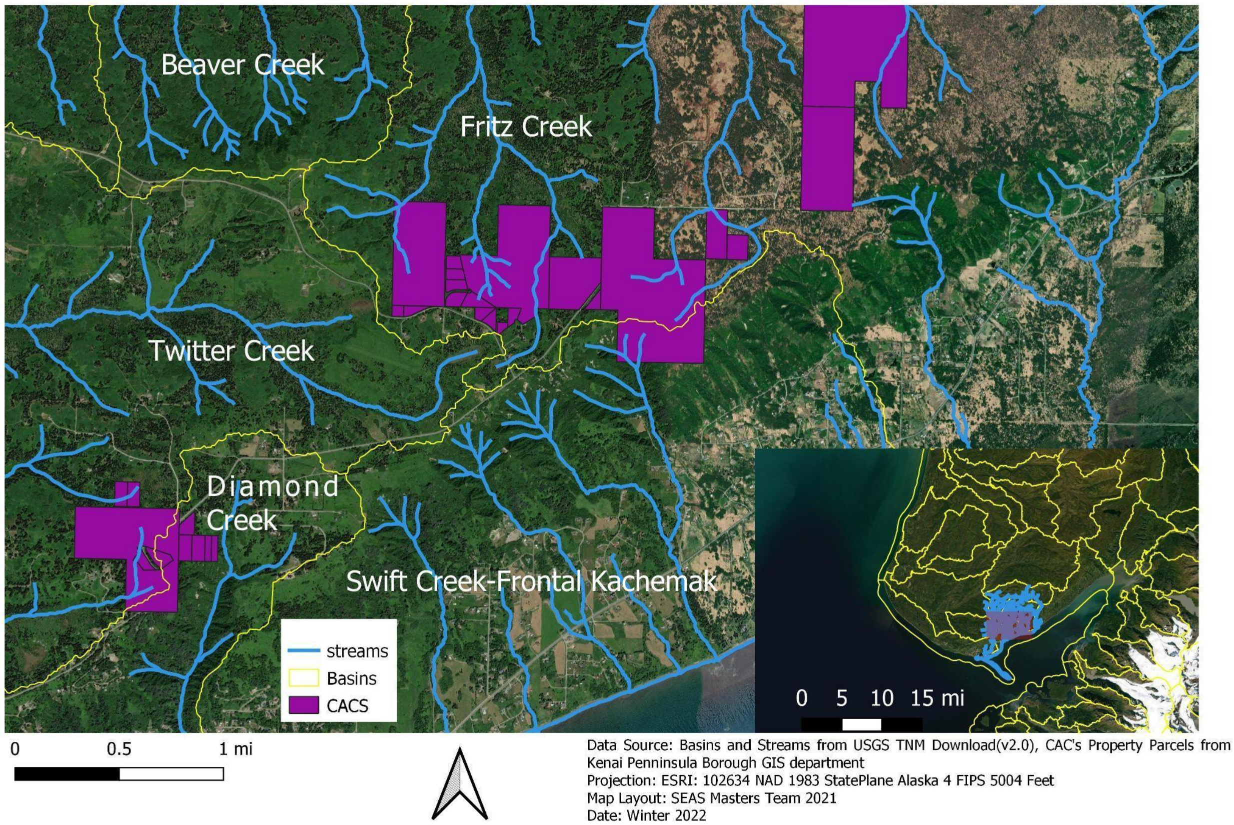


Figure A.5.2 Map showcasing CACS property Parcels (purple) with watershed extents/boundaries (yellow) and streams.

Appendix B. Data Collection Protocols/Methods

B.1 Fish Trapping Protocol

Trapping Method Protocol

Trap locations

Ideally streams have thalweg depth which allows for trap to be fully submerged, however streams depths that only submerge the holes in the minnow trap will suffice if necessary.

a. Record the latitude and longitude GPS coordinates.
b. Anchor the trap to the bank either tying them off to branches or tied off to a stake in the ground.
c. Mark trapping locations with surveying tape for easier collection.

Baiting and Trap Placement

Galvanized steel traps (gee's cylindrical minnow traps) and plastic minnow traps were used. Some supplied through CACS and others through ADFG.

Fish trapping and baiting

1. Obtain pre-cured Salmon Skein or free eggs from local sources (Ulmer's), keep frozen until roughly 1 hour before use.
2. Place a quarter sized chunk of skein or a dozen eggs and a few pebbles into a sandwich bag. Use a small stick to perforate said sandwich bag
3. Place bait in the minnow trap secure the trap shut
4. Submerge the trap fully if able, if not be SURE to submerge at least the trap's entrance holes.
5. Secure the traps with cordage or chain to either vegetation on the bank or to a user placed stake well above the water level.
6. Label the traps (using a piece of tape on cordage or chain) with the Permit holder's name, phone number, and permit number.
7. Leave traps for approximately 24 hours before retrieval.

Trap Retrieval and Analysis

1. Check the traps approximately 24 hours after they were placed.
2. Remove fish and place them in a bucket of stream water.
3. Take a quick digital picture of the fish on a "*Write in the Rai*n" notebook for later identification if needed
4. Release back into the stream.

Figure. B.1 Example of Dolly Varden Fish picture on "write in the rain" notebook

B.2 Macroinvertebrate Sampling Protocol

Equipment needed:

- 2 Plastic trays
- Tweezers(Plastic or metal)
- Stream Macroinvert Dichotomous key or Picture Key
- Ideally a triangular or rectangular Dip net(we Used a aquarium net 6”x8” with very fine mesh)
- Stopwatch to record time (Phone works)
- Write in the rain & pencil to record species and counts
- Thermacell (optional but recommended)

Figure B.2 Benthic macroinvertebrate collection and field identification.

Macroinvertebrate sampling protocol

1. Locate Sand/Gravel/Rocky Substrate
2. Mark Coordinates and Name Site on data sheet
3. 3 scoops (kick net style) kicking substrate downstream into the net
4. Pour out contents in plastic tray
5. Identify and mark species at Genus level using the Izaak Walton league of America Biological Monitoring Data Form for Stream Monitors while transferring them to water filled tray
6. 1 person for ½ hour(or until all macroinvertebrates are counted) or 2 people for 15 minutes(or until all macroinvertebrates are counted)

7. Classify the stream's water quality rating using the aforementioned metrics.
8. Repeat as necessary

Figure B.2.1. Sampling site BEVMD, a prime example of benthic macroinvertebrate riffle habitat.

B.3 Water Quality Protocol

1. Water Quality Protocol

Equipment needed:

- Smart Device with BluTooth capabilities
- Vernier Go Direct Optical Dissolved Oxygen Probe
- Go Direct pH Sensor
- pH storage solution
- GPS/GNSS Enabled Device

Data Recording

The app provided by Vernier that allows for an interface with the equipment also allows for the saving of data collected from devices. This feature allows us to set unique file names as identifiers of our data collection and the file metadata records the creation date automatically. A companion notebook or survey equipment to record qualitative data, geospatial data, and other observations in the field. This allows for efficient data collection, organization, and storage.

Data Sheet Set-up

There should be columns for recording the date, time, latitude and longitude, and site IDs. There should also be columns for all variables being recorded (e.g., DO, pH, temperature, *etc.*). Also, a column with qualitative notes should be present. In this column, records of weather conditions like rain or shine can be conducted as well as any other relevant notes that give context to the situation at sampling stations.

2. Procedure

Prior to beginning field work, it should be noted that long-term monitoring is reliant on revisiting the same sites repeatedly. When conducting monitoring activities, the same sites should be revisited to maintain a consistent record of all measurements for every site. When adding new sites, it is important to consider sample times (time of day and time of year) as well as spatial distribution of sites. Sites should be spatially separated to prevent spatial auto-correlation and to ensure there is no resampling of what is essentially the same waters.

Step by Step Instructions

1. Identify important sites– often coincides with fish trapping and larger bodies of water or previously sampled sites
    a. Sites should be spatially distinct or exhibit different stream characteristics in the form of riparian area, riffles, pools, runs, or benthic substrate
    b. Environmental data should be taken along with all fish trapping, macroinvertebrate sampling, or other aquatic sampling activities
2. Upon identifying an appropriate site, there should be enough water to fully submerge the end of the probe or sensor and should not be in direct sunlight if possible or touching any physical structure or substrate
3. The sensor should then be ran for at least 150 seconds to ensure that a plateau is reached
4. Save the file with a descriptive and unique file name associated with the site
    a. Optionally, you can also include some qualitative notes in the title like “rainy” or “sunny”
5. Write down the coordinates and any other notes or data being collected at the site
6. Take photographs of all sights
    a. There should be at least three photos:
        i. Upstream of the site
        ii. Downstream of the site
        iii. Top-down of the site
7. In post processing, all of these data files can be converted to CSVs or viewed within the native Vernier desktop or mobile apps for quick visualization and summary statistics
8. Compile all data into a centralized master data sheet for water quality monitoring
9. Perform QA/QC for entered data
    a. Highlight any n/a’s
    b. Double check for accuracy of entered data

c. Ensure all variables are entered
d. Digitize and written notes or other written data into the master data sheet

B.4 Breeding Bird Survey Protocol

1. Protocol

<u>Equipment needed:</u>

- A timing device
- GPS
- Pen/Pencil
- Clipboard
- Data sheets
- Binoculars
- Camera
- Water and snacks

Data Sheet Set-Up
First sheet

- Captures details including name of observer, point count coordinates and number, noise, weather details, habitat type,and start and end time at each point count station at the site.
- This sheet also contains room for field notes the observer thinks may be important
  - Ex: The habitat category is “Mixed Forest” but the observer may want to note there’s lots of detritus or “The air is hazy due to nearby/far wildfires”
- List of species, in alphabetical order, are listed that are known to visit these properties. However, there are blank spaces at the end of each list to record species observed not on the list
- Space to mark whether bird was observed in the first 0-3 minutes or within the 3-5 minute time frame
- Space to mark distance the bird was detected
  - 0 to 50 m: birds up to top of vegetation/ canopy, ≤50 m from the station center point.
  - > 50 m: birds up to top of vegetation or canopy, >50 m from station center point.
  - Fly-over associated: Bird above top of vegetation or canopy

- If multiple of the same species are observed, keep track of which time frame is associated with what distance during observation

2. Procedure

Prior to beginning the bird survey we recommend the surveyors visit each site location. This will allow you to gain familiarity with the trail and ensure that you are able to locate each survey point using a GPS device. You may also verify there are no barriers along the trail, such as a downed tree, that may impact your sampling efforts. On the day you plan to conduct the survey, start as close to sunrise as possible and complete the bird survey by 11 am, as bird activity drops quickly late morning (Handel et al., 2021).

Step by Step Instructions

1. Using a GPS device, or application such as GAIA, locate the first survey count station at the site you are monitoring provided by the coordinates in appendix 3.E. For example: IRP Pond Side Survey Point #1.
2. Upon arriving at the survey point wait two minutes before beginning to survey to allow for the location to settle from any disturbance caused by your arrival.
3. During this time, fill out the information on the front side of the data sheet regarding the climatic conditions at the count station on the data sheet. Codes are provided as options for the Wind, Weather, Noise, and Habitat.
4. When you are ready to begin surveying, mark the time on the data sheet under “start time”, set a timer device for 5 minutes and press start.
5. During the 5 minutes you will note any species of bird you hear or see. Trying not to recount the sample bird individual. If you are unsure of a bird species, do not mark it.
6. While surveying fill in the information on the point count sheet of the data sheet.
    a. The species seen or heard
    b. The time interval it was heard or seen, the first 0-3 min or the 3-5 min.
    c. The estimated distance from your location to the individual, within 0-50 m or beyond 50 m.
    d. Behavior (only applies if the bird is seen and not only heard)
7. Stop your survey at each point when the timer goes off.
8. Take a picture in the N, S, E, W directions so that changes in vegetation may be monitored over time. Note the time the first picture was taken so you can keep track of which photograph corresponds to which location
9. Move on to the next survey point count station and repeat steps 2-6.

Notes/ Best Practices

- If weather is inclement, including high winds, rain, snow, etc wait to conduct the bird survey on another day as this may impact bird counts.
- Surveys should be conducted 7-10 days apart
- Blank data sheets will be provided to CACS as a supplemental document.
- See breakdown of codes for surveying below:

Table. B.4.1 Table depicting the codes for conducting the breeding bird surveys including those for wind, weather, noise, behavior, and habitat

Wind	Code	Meaning
	WINL	Wind speed 0-8 km/h- low, calm
	WINM	wind speed >8 to 20 km/h - moderate
		*Surveying should not be conducted in winds higher than moderate.
Weather	Code	Meaning
	DRIZ	Drizzle, very light rain
	OVC	Overcast, >90 percent cloud cover
	BRK	Broken, 50-90 percent cloud cover
	SCT	Scattered, 10-50 percent cloud cover
	CLR	Clear, <10 percent cloud cover
Noise	0	No / very little background noise
	1	Soft noises (such as gentle bubbling creek) no bird sound likely to be masked
	2	Light noises, louder creeks, etc., might miss high pitched sounding/ distant birds
	3	Rushing creek level noise likely detecting only birds within 50 m
	4	Roaring creek, heavy vehicle noise, plane overhead, etc, likely only detecting the loudest calls and songs within 50 m
Behavior if observed	P	Perched on tree/branch
	FR	On the ground foraging
	FL	Flying
Habitat	RIPARIAN	Riparian zones
	BOG/FEN	peatlands/ fen
	OPMEAD	Open meadow
	MIXEDFOR	Mixed Forest
	SPRUCEDOM	Spruce dominated
	SHDOMMEAD	Shrub dominated meadow

B.5 Peatland Depth and Vegetation Assessment Protocol

B.5.1 Depth Probing and Vegetation Assessment with Homer Drawdown Protocols

<u>Equipment Needed:</u>

Clipboard
Pen/Pencil
GPS device
Camera
Blank data sheets
Measuring tape
Quadrat
Fiberglass rods for samping (Available through homer draw down)
½ by ½ meter quadrat

Procedure

(This procedure is taken from Homer Drawdown Community Peatlands Survey, with very slight modifications to indicate how it was completed by our team)

1. Prior to beginning any sampling visit the fen that you plan to sample and visually inspect the site. Observe and identify peatland vegetation communities.
2. Plan to collect depth measurements in each vegetation community type beginning at the edges and transecting the fen. If vegetation communities are present but outside of your planned transect incorporate them individually.
3. Fill out the data sheet adding the names of those sampling, date, and road/access/ general location of fen.
4. At your initial sampling spot collect the latitude and longitude to 5 significant figures.
5. Circle the dominant vegetation community at that site, if able to identify the species, note this below the category. *
6. Take a picture of the vegetation at each site facing straight down with the point you will take the depth measurement roughly in the center of the photo. (Fig B.5.1)

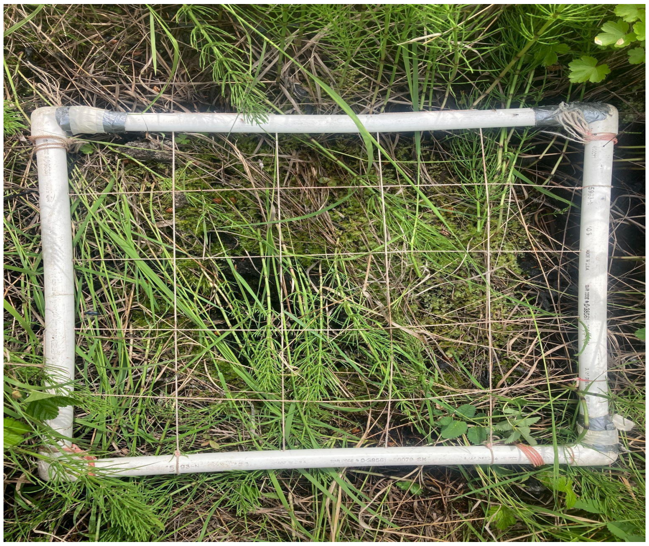


Figure B.5.1 Example of image taken of vegetation straight down at the Inspiration Ridge Preserve peatland, Homer, AK.

1. Take a photograph facing N, E, S, W with camera at chest height from the center of your probing location.
2. Note time that first photo was taken on data sheet.
3. Insert peat probe one segment at a time into the ground, beginning with the probe segment with the pointed end. While the probe is in the ground, only turn the probe clockwise, this will help ensure that the segments of the probe do not become separated. Add segments as needed.
4. Once you are unable to push the probe in further, note the depth of the probe.
5. Remove the probe from the ground without unscrewing the segments.
    a. Attach T handle if needed to aid in removing the probe.
6. Once the probe is retrieved, use the measuring tape to measure the depth of the peat in feet to the nearest inch.
7. Enter the depth in feet on the data sheet
8. Enter additional information in the notes section, such as standing water, peat bottom substrate (gravel, sand, etc), wildlife, human impacts.
9. Repeat this process until you have sampled at a minimum of 6 sites on each fen property.
10. All boxes on the data sheet should be filled out for each probing site.

* Addition information regarding collecting vegetation information:

- At each probing site, walk around and inspect the area around of about 30 feet, based on observation, circle the vegetation community that best represents the dominant vegetation community.
- We used a quadrat to determine the dominant vegetation at our probing location.
- The six plant communities that are most likely to be found in the peatlands are: Forest, Shrub >2’, Low Shrub <2’, Herbaceous Forbes, Graminoid, Open Moss Mat.
    - If you are able to identify specific plant species, document this under the circled dominant vegetation community.
    - If when inspecting the area you notice a distinct, large-scale change in vegetation, make a point to sample at that site.
    - If you are unable to push the probe any further, you may try to pull the probe slightly out and push again to see if it will go any further. It may feel like you have reached the bottom but you may be facing some resistance while still in the peat.
    - Often you will be able to tell if you have reached the bottom of the peat if it feels like you are hitting gravel/ rock.

B.5.2 Additional Fen Vegetation Sampling Protocols

<u>Equipment Needed:</u>

- ½ meter by ½ meter quadrat with a 5x5 square grid pattern (see Fig. B.5.2).
    - A quadrat fitting this description is available at the CACS headquarters office.
- Transect Tape

- Field guide with southeastern Alaska plant species.
- GPS device
- Compass
- Pen/Pencil
- Data sheets

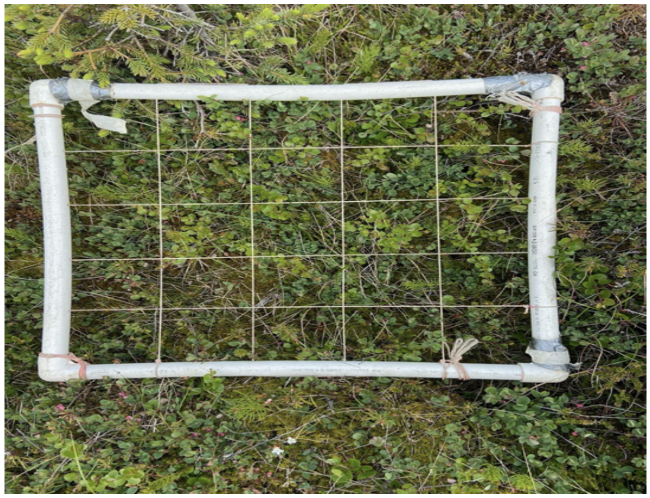


Figure B.5.2 Example of quadrat used for vegetation sampling at the Inspiration Ridge Preserve peatland, Homer, AK.

Procedure

Prior to sampling we recommend familiarizing yourself with common fen vegetation you might encounter on the Kenai Peninsula. When ready to begin surveying follow the steps below*:

1. Designate a central point within the fen, to aid in randomizing our sampling we threw a pencil over our shoulders towards what we deemed the center of the fen. Where the pencil landed we marked as the center.
2. Write the coordinates of your central point on the data sheet.
3. Assign a number to each cardinal direction, for example 1:N, 2:NE, 3:E, 4:SE, 5:S, 6:SW, 7:W, 8:NW. Using a random number generator, such as the one provided by google, generate a number 1-8. The number chosen will determine the direction you follow for the first transect.
4. Using a compass (we used the GAIA phone app) to determine the direction. Take ~10 steps in the cardinal direction chosen and toss the quadrat slightly forward to aid in randomizing the sample.
5. Where the quadrat lands, mark the latitude and longitude of that point on the data sheet.
6. Take a picture of the quadrat facing straight down, mark the time the picture was taken on the data sheet.
7. Take time to examine the plant species located in the quadrat. Fill in the data sheet to include the transect, direction from center, and quadrat number.

8. Write down each species observed in the quadrat. Mark each square of the 25 where that species takes up at least 50% of the square. For example, if sphagnum moss takes up at least 50% of 10 out of the 25 squares in the quadrat grid system, mark 10.
9. If the plant species is present but does not exceed greater than 50% coverage of any squared, mark it as 0.
10. Take pictures of any unidentified plant species to aid in identification later.
11. Repeat this process along one transect until you have sampled 5 times.
12. Return to the central point and repeat this process two more times staring with step three. When finished, you should have 15 quadrat sample points along 3 different directions.

Notes/ Best Practices: Plan for approximately 3 hours to complete the sampling at each location. Sampling during July and August is recommended.

The procedure followed at PBFS was as follows:

1. Standing on the boardwalk of the fen, we threw a pen over our shoulder to determine the location of the first transect.
2. Along that transect we started at the outermost edge of the fen as our first quadrat location starting point.
3. We ran a transect along this point and measured out 50 meters, which covered roughly from one edge of the fen to the other
4. Record the coordinates of the quadrat and take a picture facing directly down at the quadrat.
5. Fill out the data sheet for each quadrat sampling location.
6. Sample every ten meters along the transect following the same protocols.
7. A second transect was measured out 5 meters to the east of the first transect.
8. Follow the same sampling procedure for the second transect.

This should result in 12 quadrat sampling points, however, we were unable to sample our 12th point due to emergent water and dense vegetation. Therefore our data contained 11 quadrats

- Data sheets will be provided to CACS as a supplemental document.

Appendix C. Data Tables/Results

C.1 Fish Trapping

Table C.1.1: This table shows the summary statistics for the fish survey done by our Master's Project group in 2021.

	Overall (N=4)
Fish Caught	
Mean (SD)	1.75 (0.957)
Median [Min, Max]	1.50 [1.00, 3.00]

Table C.1.2: This table shows the summary statistics for the fish survey done in 2018 by a previous Master's Project group.

	Overall (N=6)
Fish Caught	
Mean (SD)	3.00 (3.52)
Median [Min, Max]	1.50 [1.00, 10.0]

Table C.1.3: This table shows the summary statistics for the fish survey done in 2016 by a previous Master's Project group.

	Overall (N=7)
Fish Caught	
Mean (SD)	1.86 (0.690)
Median [Min, Max]	2.00 [1.00, 3.00]

Table C.1.4 Shows total fish summary statistics of fish caught for the 2021 fish trap sites locations.

Row Labels	Sum of Fish
BEVMA	2
BEVMB	3
BEVMC	1
BEVMD	1
Grand Total	**7**

C.2 Macroinvertebrates

Table C.2.1 This table shows summary statistics for macroinvertebrate surveys done in 2021

	Overall (N=6)
Index Value	
Mean (SD)	118 (57.1)
Median [Min, Max]	96.0 [68.0, 190]
Watershed	
Bridge Creek	2 (33.3%)
Fritz Creek	3 (50.0%)
Twitter Creek	1 (16.7%)
Diversity(#taxa)	
Mean (SD)	6.50 (1.97)
Median [Min, Max]	7.00 [3.00, 8.00]
Quality Index	
Excellent	6 (100%)

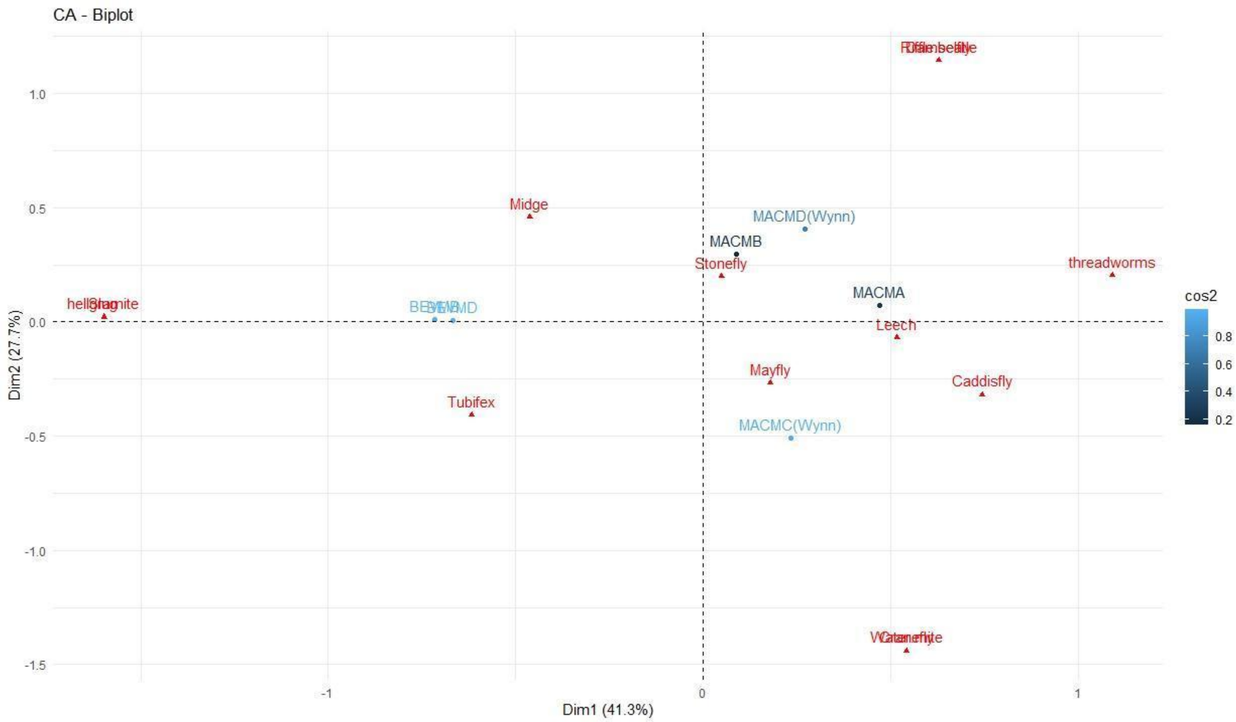


Figure C.2.2 Biplot of Correspondence Analysis of Taxa vs Sites created using macroinvertebrate data

Table C.2.2 Table of Chi-X^2 residuals from Figure 3.B.1 Correspondence Analysis

	Mayfly	Stonefly	Caddisfly	Midge	Leech	Tubifex	hellgramite	Slug	threadworms	Cranefly	Water.mite	Damselfly	Riffle.beatle
BEVMB	-0.99	-0.27	-1.1	1.55	-1.76	2.15	1.98	1.4	-0.37	-0.37	-0.37	-0.9	-0.37
MACMA	-0.26	1.53	2.46	-0.98	-0.73	-1.71	-0.6	-0.42	3.05	-0.3	-0.3	-0.73	-0.3
MACMB	-0.16	2.72	-0.88	-0.3	-1.4	-1.68	-0.58	-0.41	-0.29	-0.29	-0.29	-0.72	-0.29
MACMC(Wynn)	2.38	-1.73	0.92	-2.51	1.39	0.89	-1.06	-0.75	-0.53	1.36	1.36	-1.3	-0.53
MACMD(Wynn)	-0.73	-0.19	-0.28	1.13	1.92	-1.98	-1.04	-0.74	-0.52	-0.52	-0.52	3.44	1.4
BEVMD	-1.06	-0.36	-1.12	1.48	-1.23	2.07	1.94	1.37	-0.37	-0.37	-0.37	-0.91	-0.37

Table C.2.3 Table of total Genus Level Taxa count for macroinvertebrate sampling in 2021

Values	Count
Sum of Riffle beetle	1
Sum of Damselfly	6
Sum of Water mite	1
Sum of Cranefly	1
Sum of threadworms	1
Sum of Slug	2
Sum of Tubifex	33
Sum of hellgramite	4
Sum of Leech	23
Sum of Midge	29
Sum of Caddisfly	9
Sum of Stonefly	96
Sum of Mayfly	75

C.3 Water Quality

Table C.3.1: A table of the water quality data correlation results. The figure is a composition of all combinations of variables and correlations calculated. The axes can be construed by the denotation on the top and right sides of the graph and tracing across.

	Dissolved Oxygen (mg/L)	pH
pH	$\rho = 0.57$ p-value = 0.004	not assessed
Temperature (ºC)	$\rho = -0.75$ p-value = 0.000	$\rho = -0.63$ p-value = 0.001

Table C.3.2: This table shows the average water quality measurements taken across all sites as well as the standard deviation for each parameter. The standards used are pursuant to those defined for growth and propagation of fish, shellfish, other aquatic life, and wildlife which exceed those for consumption or other uses for the selected parameters.

Parameter	State Standard	Average Water Quality	Standard Deviation	Standard Met?
Dissolved Oxygen (mg/L)	7 mg/L	10.913	1.81	Yes
pH	between 6.5 and 8.5	6.846	0.237	Yes
Temperature (°C)	>25°C	9.358	3.548	Yes

Table C.3.3: This table shows the data that was used to calculate the Spearman Correlation Coefficient.

Site_code	Date	do_mgL	pH	temp_C	salinity_mgL	Property
BEVMA-2	7/6/21	11.552	6.865	6.75	0	IRP
BEVMB-1	7/4/21	12.131	7.009	5	9.603	IRP
BEVMB-2	7/6/21	12.055	7.157	6.75	0	IRP
BEVMB-3	7/8/21	11.885	6.823	8.1	9.424	IRP
BEVMB-4	7/10/21	12.12	6.991	5	9.886	IRP
BEVMC-1	7/16/21	12.322	6.738	10.3	9.774	IRP
BEVMC-2	7/19/21	11.788	6.905	7.243	9.373	IRP
BEVMD-1	7/16/21	12.15	6.747	9.8	9.654	IRP
BEVMD-2	7/19/21	11.983	6.969	7.569	9.536	IRP
IRPMA-1	7/6/21	10.812	7.293	11.6	0	IRP
IRPMB-1	7/6/21	10.349	6.491	12	0	IRP
IRPMC-1	7/6/21	10.032	6.956	14	8.07	IRP
IRPMC-2	7/8/21	10.382	6.583	13.8	7.843	IRP
IRPMD-1	7/6/21	5.998	6.538	10.8	4.8	IRP
IRPMD-2	7/8/21	6.499	6.564	11	5.206	IRP
IRPME-1	7/8/21	10.028	6.558	14	8.079	IRP
MACMA-1	7/10/21	12.424	6.861	4.7	9.831	Misc
MOSMA-1	7/15/21	9.9	6.715	15.3	7.992	Misc
PETMB-1	7/14/21	8.377	6.477	15.932	6.773	Misc
WYNMA-1	7/8/21	12.232	6.981	6.6	9.715	Wynn
WYNMB-1	7/8/21	12.273	7.168	6.5	9.746	Wynn
WYNMB-2	7/13/21	12.114	7.168	6.5	9.619	Wynn
WYNMC-1	7/8/21	11.595	6.911	6	9.198	Wynn

C.4 Bird Species Migratory/Year-round and Conservation Status

Table C.4.1 This table details the migration patterns and conservation status for each bird species that were observed in our bird surveying in Homer, AK.

Species	Year-round or Migratory	Conservation Status
Flycatcher, Alder	May migrate south during winter into the Appalachians and tip of South America.	Low-concern
Thrush, Varied	Most coastal breeders stay year-round, some inland breeders migrate short distances to places such as western northern California.	Steep Decline
Sparrow, Golden-crowned	Migrates from northern breeding grounds, such as the Kenai, down to the West Coast during winter.	Low-concern
Thrush, Hermit	Migrates from northern breeding grounds to southern North America.	Low-concern
Junko, Dark-eyed	Ones that breed in Canada and Alaska migrate south in winter.	Low-concern
Robin, American	Ones that breed in Canada and Alaska migrate south in winter.	Low-concern
Warbler, Orange-Crowned	Medium to long-distant nocturnal migrant.	Low-concern
Sparrow, Fox	Ones that breed in Alaska migrate at night to south-eastern U.S.	Low-concern
Kinglet, Golden-crowned	Year-round in southeast Alaska.	Low-concern
Sparrow, Savannah	Year-round in southeast Alaska.	Low-concern
Warbler, Yellow	Long-distance migrant. Will fly across the Gulf of Mexico without stopping during the journey.	Low-concern
Warbler, Townsends	Medium to long-distance migrant.	Low-concern
Nuthatch, Red-breasted	Year-round in southeast Alaska.	Low-concern
Common Raven	Year-round in southeast Alaska.	Low-concern
Kinglet, Ruby-crowned	Most migrate short distances.	Low-concern
Flycatcher, Olive-Sided	Most are long-distance migrants.	Near-Threatened/Watch: In decline
Sandhill Crane	Ones that breed in southeast Alaska are migratory.	Low-concern

C.5 Bird Survey Data Results

Table C.5.1 This table depicts information regarding each point count station for the IRP Ridge Side Survey Site, Homer, AK.

Observers: Kristin & Ashley Location: IRP Ridge Side Date: 06/23/2021 Wind: WINM Weather: BRKN									
Point Count Station	**Start Time (am)**	**End Time (am)**	**Latitude**	**Longitude**	**Elev (m)**	**Temp (F)**	**Habitat structure at point**	**Noise**	**Field Notes / Dominant vegetation noted**
1	7:16	7:21	59.70091	-151.42107	1365	48	SHDOMMEAD	0	Grassland/meadow w/ patch ader & spruce
2	7:35	7:40	59.70053	-151.42555	1353	48	SHDOMMEAD	0	Grassland enclosed in Alder, spruce, and elderberry
3	7:57	8:02	59.69925	-151.42773	1440	48	SHDOMMEAD	1	Upper Ridge meadow overlook
4	8:21	8:26	59.70229	-151.43476	1340	50	SHDOMMEAD	1	Edge of spruce meadow overlook
5	8:34	8:39	59.70357	-151.43829	1331	50	MIXEDFOR	1	Mixed forest cottonwood/spruce w/ lots of detritus
6	8:50	8:55	59.7028	-151.44165	1295	50	MIXEDFOR	0	Mixed forest cottonwood/spruce
7	9:13	9:18	59.70441	-151.43269	1207	50	RIPARIAN	0	Down b/w ridges by stream
8	9:32	9:37	59.70434	-151.42942	1310	51	OPMEAD	0	Opening meadow b/w spruce and alder

Table C.5.2 This table depicting species observation results by point count station IRP Ridge Side, Homer, AK

Point Count Station	Species Observed	0-3 min	3-5 min	Behavior (if obs)	Distance 0-50 m	Distance >50 m	Flyover
1	Junko, Dark-eyed		1		x		
1	Robin, American	1				x	
1	Sparrow, Savannah	1			x		
1	Thrush, Varied	1	1		x	x	
2	Flycatcher, Alder	2				xx	
2	Junko, Dark-eyed		1			x	
2	Thrush, Varied	1				x	
2	Warbler, Orange-Crowned		1		x		
3	Flycatcher, Alder	1	1			xx	
3	Sparrow, Golden-crowned		1		x		
3	Thrush, Varied	1				x	
3	Warbler, Orange-Crowned	1		Perched on alder	x		
3	Warbler, Yellow		1		x		
4	Flycatcher, Alder	1				x	
4	Junko, Dark-eyed	2				xx	
4	Sparrow, Fox	1				x	
4	Sparrow, Golden-crowned		1			x	
4	Warbler, Orange-Crowned	1				x	
5	Junko, Dark-eyed	1				x	
5	Kinglet, Golden-crowned	1			x		
5	Thrush, Varied	1				x	
6	Flycatcher, Alder	1			x		
6	Sparrow, Fox		1			x	
6	Sparrow, Golden-crowned	1			x		
6	Thrush, Hermit	1			x		
6	Warbler, Yellow	1			x		
7	Flycatcher, Alder	1				x	
7	Robin, American		1		x		

7	Sparrow, Fox		1	Perched on spruce	x		
7	Thrush, Hermit	2	1		x	xx	

Table C.5.3 This table depicting information regarding each point count station for the IRP Pond Side Survey Site, Homer, AK.

Observers: Kristin & Ashley Location: IRP Pond Side Date: 06/23/2021 Wind: WINM Weather: BRKN									
Point Count Station	**Start Time (am)**	**End Time (am)**	**Latitude**	**Longitude**	**Elev (ft)**	**Temp (F)**	**Habitat structure at point**	**Noise**	**Field Notes**
1	7:40	7:45	59.70086	-151.41073	1303	52	RIPARIAN	0	Pond
2	7:56	8:01	59.69902	-151.40799	1276	52	OPMEAD	0	Meadow
3	8:16	8:21	59.69848	-151.40367	1219	52	RIPARIAN	0	Pond, Meadow, Shrub
4	8:46	8:51	59.70062	-151.40799	1276	52	RIPARIAN	0	Pond and Shrub, Edge of Forest
5	9:11	9:16	59.70178	-151.40459	1224	52	BOG/FEN	0	Bog/peatland
6	9:27	9:32	59.70157	-151.40913	1298	52	SPRUCEDOM	0	Broken mixed-forest

Table C.5.4 This table depicting species observation results by point count station IRP Pond Side, Homer, AK

Point Count Station	Species Observed	0-3 min	3-5 min	Behavior (if obs)	Distance 0-50 m	Distance >50 m	Flyover
1	Flycatcher, Alder	1				x	
1	Kinglet, Golden-crowned	1			x		
1	Nuthatch, Red-breasted	1				x	
2	Flycatcher, Alder	2				xx	
2	Junko, Dark-eyed		1			x	
2	Sparrow, Golden-crowned	1			x		
2	Sparrow, Savannah		1		x		
3	Flycatcher, Alder	1			x		
3	Kinglet, Golden-crowned	1				x	
3	Robin, American	1			x		
3	Sparrow, Golden-crowned	2			xx		
3	Thrush, Hermit	1				x	
4	Junko, Dark-eyed	1			x		
4	Robin, American	2			xx		
4	Sparrow, Fox		1		x		
4	Sparrow, Golden-crowned	1				x	
4	Thrush, Varied	1			x		
4	Warbler, Orange-Crowned		1		x		
5	Flycatcher, Olive-sided	1				x	
5	Robin, American	1				x	
5	Sparrow, Golden-crowned	2			x	x	
5	Thrush, Hermit	1				x	
5	Warbler, Orange-Crowned	1			x		
6	Junko, Dark-eyed	1			x		
6	Nuthatch, Red-breasted	1				x	
6	Robin, American	1			x		
6	Sparrow, Golden-crowned	1				x	

6	Warbler, Orange-Crowned	1			x	

Table C.5.5 This table depicting information regarding each point count station for the Wynn Nature Center Survey Site, Homer, AK.

Observer: Ashley
Location: Wynn Nature Center
Date: 07/27/2021
Wind: WINL
Weather: CLR

Point Count Station	Start Time (am)	End Time (am)	Latitude	Longitude	Elev (ft)	Temp (F)	Weather code	Habitat structure at point	Noise	Field Notes
1	8:03	8:08	59.68598	-151.48057	1300	48	CLR	PEATLAND	0	Bog
2	8:13	8:08	59.68554	-151.48275	1288	48	CLR	SPRUCEDOM	0	
3	8:28	8:33	59.68324	-151.48603	1300	48	CLR	SHDOMMED	0	
4	8:40	8:45	59.68305	-151.48276	1299	48	CLR	SPRUCEDOM	1	
5	8:52	8:57	59.68362	-151.47974	1288	48	CLR	SHDOMMED	0	On edge of spruce forest
6	9:00	9:05	59.68523	-151.47872	1300	48	CLR	SPRUCEDOM	1	B/w two trails/ spruce
7	9:12	9:17	59.6856	-151.47626	1312	48	CLR	SHDOMMED	0	

Table C.5.6 This table depicting species observation results by point count station Wynn Nature Center, Homer, AK

Point Count Station	Species Observed	0-3 mins	3-5 min	Behavior (if obs)	Distance 0-50m	Distance >50m	Flyover
1	Flycatcher, Alder	2			x	x	
1	Junko, Dark-eyed	1			x		
1	Robin, American		1		x		
1	Sparrow, Golden-crowned		1		x		
1	Thrush, Hermit	2				xx	
1	Thrush, Varied	1	1		x	x	
2	Flycatcher, Alder	2			x	x	
2	Thrush, Varied	2				xx	
2	Warbler,	1			x		

	Orange-Crowned						
3	Flycatcher, Alder	1				x	
3	Robin, American	1			x		
3	Thrush, Hermit	1			x		
3	Thrush, Varied	1				x	
3	Warbler, Townsend's	1			x		
3	Common Raven	1				x	
4	Flycatcher, Alder	1				x	
4	Sparrow, Fox	1			x		
4	Thrush, Hermit	1				x	
4	Thrush, Varied	1				x	
4	Warbler, Orange-Crowned	1				x	
5	Thrush, Hermit	2			x	x	
5	Thrush, Varied	1				x	
5	Warbler, Townsend's	1			x		
6	Flycatcher, Alder	1				x	
6	Junko, Dark-eyed	2			x	x	
6	Kinglet, Ruby-crowned	1			x		
6	Thrush, Hermit	1			x		
6	Thrush, Varied	1				x	
6	Warbler, Orange-Crowned	1			x		
7	Flycatcher, Alder	1	1		x	x	
7	Sparrow, Golden-crowned	2			xx		
7	Thrush, Hermit	1			x		
7	Thrush, Varied	1				x	
7	Warbler, Orange-Crowned	1			x		

Table C.5.7 This table depicting species observed among survey sites (IRP Ridge Side, IRP Pond Side, and Wynn). Includes total bird counts, and which survey site species were detected at, Homer, AK.

Unique Species	Total Count Among All Properties	Survey Sites Observed At
Flycatcher, Alder	22	All
Thrush, Varied	16	All
Sparrow, Golden-crowned	14	All
Thrush, Hermit	14	All
Junko, Dark-eyed	11	All
Robin, American	10	All
Warbler, Orange-Crowned	10	All
Sparrow, Fox	6	All
Kinglet, Golden-crowned	3	IRP Pond, IRP Ridge
Sparrow, Savannah	2	IRP Pond, IRP Ridge
Warbler, Yellow	2	IRP Ridge Side
Warbler, Townsends	2	Wynn
Nuthatch, Red-breasted	2	IRP Pond
Common Raven	1	Wynn
Kinglet, Ruby-crowned	1	Wynn
Flycatcher, Olive-Sided	1	IRP Pond

C.6 Swallow Nest Box Data

Table C.6.1 Proposed Swallow nest box locations on the Inspiration Ridge Preserve property, Homer, AK.

Swallow Nest Box Locations				
New #	**e to determine)**	**Latitude**	**Longtidue**	Location Description
1	Unknwn	59.69946	-151.41086	Back of garage
2	Unknwn	59.69955	-151.411	Back of garage
3	Unknwn	59.69949	-151.41112	Back of garage
4	Unknwn	59.69952	-151.41127	Fenced area on barn
5	Unknwn	59.69956	-151.41118	Back of shed
6	Unknwn	59.6994	-151.41084	Side of garage above man door
7	Unknwn	59.69944	-151.40897	Crane pond near house
8	Unknwn	59.69936	-151.40903	Crane pond near house
9	10	59.70091	-151.41704	Alldridge Pond
10	8	59.701	-151.41034	Alldridge Pond
11	7	59.70098	-151.41034	Alldridge Pond
12	12	59.70084	-151.41019	Alldridge Pond
13	9	59.70076	-151.41051	Alldridge Pond
14	32	59.70065	-151.4102	Alldridge Pond- Near Spillway
15	34	59.70113	-151.41078	On side of aviary
16	37	59.701	-151.41078	On side of aviary
17		59.70039	-151.40691	Edge of forest/ open meadow area - just past alldrige pond
18		59.70016	-151.40634	Edge of forest/ open meadow area - just past alldridge pond
19	15	59.70102	-151.40744	Goose pond
20	13	59.70081	-151.40825	Goose pond
21	16	59.70059	-151.40775	Goose pond
22	17/18	59.69966	-151.40712	Frog pond
23	44	59.69946	-151.40558	Mallard pond
24	20	59.69926	-151.40526	Mallard pond
25	21	59.69931	-151.40567	Mallard pond
26		59.69893	-151.40477	Between mallard and snipe- forested/open
27	22	59.6985	-151.40369	Snipe ponds near bench
28	Unknwn	59.69865	-151.40385	Near snipe ponds towards large pine tree
29		59.69763	-151.40425	B/w cottonwood/ coniferous forest at bottom of property
30		59.69725	-151.40508	B/w cottonwood/ coniferous forest at bottom of property
31	1	59.70044	-151.42227	Moose pond
32	2	59.70062	-151.42267	Moose Pond
33	3	59.70049	-151.42276	Moose Pond
34	4	59.70031	-151.42249	Moose pond
Color coding:				
	New location			
`	Location where box previously existed - has since fallen or been taken down			
	Location where box is currently- may need replacement			
Total:	34 boxes			

C.7 Peatlands Assessment Data

C.7.1 Homer DrawDown Protocol Depth and Vegetation Data

Table C.7.1 Depicts the results from peatlands assessment utilizing Homer Drawdown protocols. Includes coordinates, depth, and dominant vegetation types for sampling locations on the PBFS, IRP, and Wynn properties.

Date	Time	Location	Latitude	Longitude	Depth (ft)	Dominant Vegetation Number	Dominant Vegetation
6/30/21	10:25 AM	PBFS	59.57334	-151.29546	9.4	2	Shrubs
6/30/21	10:48 AM	PBFS	59.57331	-151.29558	10.4	5	Graminoids
6/30/21	11:16 AM	PBFS	59.57322	-151.2956	10.8	5	Graminoids
6/30/21	11:24 AM	PBFS	59.57318	-151.29576	8.3	3	Low Shrub
6/30/21	11:34 AM	PBFS	59.57315	-151.29569	5.3	3	Low Shrub
6/30/21	11:57 AM	PBFS	59.57296	-151.29592	5.4	6	Open Moss Mat
6/30/21	12:13 PM	PBFS	59.57333	-151.29536	11.6	6	Open Moss Mat
6/30/21	12:28 PM	PBFS	59.5733	-151.29536	10.7	5	Graminoids
6/30/21	12:37 PM	PBFS	59.57318	-151.29556	10.9	6	Open Moss Mat
6/30/21	12:46 PM	PBFS	59.57313	-151.29566	10.9	5	Graminoids
6/30/21	12:55 PM	PBFS	59.57305	-151.29577	6.6	3	Low Shrub
7/1/21	10:19 AM	IRP	59.701825	-151.404494	6.6	5	Graminoids
7/1/21	10:47 AM	IRP	59.701579	-151.404857	5.7	5	Graminoids
7/1/21	10:59 AM	IRP	59.701207	-151.405259	2.7	1	Forest
7/1/21	11:04 AM	IRP	59.701103	-151.405477	2.4	1	Forest
7/1/21	11:16 AM	IRP	59.702046	-151.404504	6.5	7	Emergent
7/1/21	11:27 AM	IRP	59.702418	-151.405002	6.6	1	Forest
7/1/21	12:51 PM	Wynn	59.687305	-151.473898	2.2	5	Graminoids
7/1/21	1:01 PM	Wynn	59.687164	-151.475402	4.7	1	Forest
7/1/21	1:10 PM	Wynn	59.687782	-151.476382	3.5	2	Shrub
7/1/21	1:18 PM	Wynn	59.68776	-151.477972	6.9	2	Shrub
7/1/21	1:30 PM	Wynn	59.687646	-151.481168	5.6	5	Graminoids
7/1/21	1:47 PM	Wynn	59.686758	-151.47771	3.7	5	Graminoids
7/1/21	1:57 PM	Wynn	59.686983	-151.47699	3.6	5	Graminoids
7/1/21	2:02 PM	Wynn	59.687269	-151.476826	6.7	6	Open Moss Mat
7/1/21	2:17 PM	Wynn	59.687733	-151.475394	1.5	5	Graminoids

C.7.2 Additional Fen Sampling

Local Frequency

Table C.7.2.1 Depicts the local frequency values for vegetation species sampled at PBFS, Homer, AK.

Location	Quadrat	Species	# of squares with ≥ to 50% cover	Local Frequency (%)
PBFS	1	Bluejoint grass	13	52
PBFS	1	Crowberry	10	40
PBFS	1	Lutz spruce	5	20
PBFS	1	Dwarf birch	2	8
PBFS	1	Sweet gale	2	8
PBFS	1	Dune grass	1	4
PBFS	1	Sphagnum moss	1	4
PBFS	1	Bog rosemary	0	0
PBFS	2	Bluejoint grass	16	64
PBFS	2	Crowberry	5	20
PBFS	2	Round sundew	2	8
PBFS	2	Dwarf birch	1	4
PBFS	2	Bog rosemary	0	0
PBFS	2	Labrador tea	0	0
PBFS	2	Watermelon Berry	0	0
PBFS	3	Bluejoint grass	20	80
PBFS	3	Sphagnum moss	6	24
PBFS	3	Tundra rose	2	8
PBFS	3	Bog Bean	0	0
PBFS	3	Bog cranberry	0	0
PBFS	3	Round sundew	0	0
PBFS	4	Bluejoint grass	17	68
PBFS	4	Dwarf birch	4	16
PBFS	4	Bog rosemary	3	12
PBFS	4	Bog swertia	2	8
PBFS	4	Dune grass	0	0
PBFS	4	Crowberry	0	0
PBFS	5	Bluejoint grass	16	64
PBFS	5	Crowberry	7	28
PBFS	5	Sphagnum moss	5	20
PBFS	5	Bog blueberry	5	20
PBFS	5	Dwarf birch	3	12
PBFS	5	Sweet gale	1	4
PBFS	6	Bluejoint grass	4	16
PBFS	6	Trailing raspberry	1	4
PBFS	6	Sphagnum moss	1	4
PBFS	1	Alaska Violet	6	24
PBFS	1	Sphagnum moss	6	24
PBFS	1	Sitka burnet	2	8
PBFS	1	Club moss	1	4

PBFS	2	Bluejoint grass	22	88
PBFS	2	Bog swertia	4	16
PBFS	2	Alaska Violet	1	4
PBFS	3	Bluejoint grass	9	36
PBFS	3	Bog Bean	3	12
PBFS	3	Cottongrass	2	8
PBFS	3	Alaska violet	0	0
PBFS	3	Dwarf birch	0	0
PBFS	4	Sphagnum moss	14	56
PBFS	4	Bluejoint grass	11	44
PBFS	4	Dwarf birch	6	24
PBFS	4	Sweet gale	3	12
PBFS	4	Lutz spruce	2	8
PBFS	4	Crowberry	0	0
PBFS	5	Bluejoint grass	15	60
PBFS	5	Crowberry	14	56
PBFS	5	Sphagnum moss	2	8
PBFS	5	Bog willow	1	4

Table C.7.2.2. Depicts the local frequency values for vegetation species sampled at IRP, Homer, AK.

Location	Quadrat	Species	# of squares with ≥ to 50% cover	Local Frequency (%)
IRP	1	Sphagnum moss	11	44
IRP	1	Bluejoint grass	8	32
IRP	1	Bog blueberry	4	16
IRP	1	Crowberry	3	12
IRP	1	Bog cranberry	2	8
IRP	1	Dwarf birch	1	4
IRP	2	Crowberry	9	36
IRP	2	Sphagnum moss	9	36
IRP	2	Cloudberry	5	20
IRP	2	Dwarf birch	4	16
IRP	2	Bog blueberry	2	8
IRP	2	Bluejoint grass	1	4
IRP	2	Bog rosemary	0	0
IRP	3	Sphagnum moss	6	24
IRP	3	Lingonberry	5	20
IRP	3	Dwarf birch	4	16
IRP	3	Bog willow	3	12
IRP	3	Horsetail	1	4
IRP	3	Bog cranberry	1	4
IRP	3	Bog blueberry	1	4
IRP	3	Dwarf nagoonberry	0	0
IRP	4	Cloudberry	7	28
IRP	4	Sphagnum moss	6	24
IRP	4	Bog willow	4	16
IRP	4	Horsetail	2	8
IRP	4	Dwarf dogwood	2	8

IRP	4	Fireweed	1	4
IRP	4	Trailing raspberry	0	0
IRP	5	Sphagnum moss	13	52
IRP	5	Dune grass	12	48
IRP	5	Horsetail	3	12
IRP	5	Sitka burnet	2	8
IRP	5	Violet	1	4
IRP	5	Nagoonberry	0	0
IRP	5	Bog blueberry	0	0
IRP	1	Sphagnum moss	15	60
IRP	1	Bluejoint grass	14	56
IRP	1	Ribbed bog moss	6	24
IRP	1	Dwarf birch	4	16
IRP	1	Nagoonberry	0	0
IRP	2	Sphagnum moss	20	80
IRP	2	Dwarf birch	12	48
IRP	2	Bog blueberry	6	24
IRP	2	Bluejoint grass	6	24
IRP	2	Dune grass	1	4
IRP	2	Cottongrass	0	0
IRP	3	Sphagnum moss	15	60
IRP	3	Bluejoint grass	10	40
IRP	3	Bog blueberry	6	24
IRP	3	Dwarf birch	3	12
IRP	3	Lutz spruce	1	4
IRP	3	Bog cranberry	1	4
IRP	3	Cottongrass	0	0
IRP	4	Crowberry	16	64
IRP	4	Sphagnum moss	15	60
IRP	4	Labrador tea	11	44
IRP	4	Bluejoint grass	1	4
IRP	4	Bog blueberry	0	0
IRP	4	Nagoonberry	0	0
IRP	5	Sphagnum moss	15	60
IRP	5	Crowberry	5	20
IRP	5	Horsetail	3	12
IRP	5	Bog willow	3	12
IRP	5	Dwarf birch	0	0
IRP	5	Labrador tea	0	0
IRP	5	Bog cranberry	0	0
IRP	5	Bog blueberry	0	0
IRP	5	Lingonberry	0	0
IRP	1	Dwarf birch	21	84
IRP	1	Sphagnum moss	20	80
IRP	1	Bluejoint grass	5	20
IRP	1	Round sundew	0	0
IRP	1	Dune grass	0	0
IRP	2	Crowberry	15	60

IRP	2	Sphagnum moss	10	40
IRP	2	Dwarf birch	4	16
IRP	2	Nagoonberry	4	16
IRP	2	Labrador tea	1	4
IRP	2	Lingonberry	0	0
IRP	2	Bog cranberry	0	0
IRP	3	Sphagnum moss	13	52
IRP	3	Crowberry	6	24
IRP	3	Bog cranberry	5	20
IRP	3	Lutz spruce	3	12
IRP	3	Bluejoint grass	3	12
IRP	3	Bog blueberry	3	12
IRP	3	Dwarf birch	2	8
IRP	4	Sphagnum moss	5	20
IRP	4	Nagoonberry	3	12
IRP	4	Bog blueberry	2	8
IRP	4	Dwarf dogwood	2	8
IRP	4	Bluejoint grass	2	8
IRP	4	Crowberry	1	4
IRP	4	Dwarf birch	1	4
IRP	4	Lingonberry	0	0
IRP	4	Horsetail	0	0
IRP	4	Dune grass	0	0
IRP	5	Bluejoint grass	22	88
IRP	5	Horsetail	5	20
IRP	5	Dwarf dogwood	4	16
IRP	5	Nagoonberry	4	16
IRP	5	Trailing raspberry	2	8
IRP	5	Bog swertia	1	4
IRP	5	Sphagnum moss	0	0
IRP	5	Dune grass	0	0

Table C.7.2.3 Depicts the local frequency values for vegetation species sampled at Wynn Nature Center, Homer, AK.

Location	Quadrat	Species	# of squares with ≥ to 50% cover	Local Frequency(%)
WYNN	1	Sphagnum moss	13	52
WYNN	1	Bog blueberry	9	36
WYNN	1	Crowberry	8	32
WYNN	1	Dwarf birch	2	8
WYNN	1	Bluejoint grass	1	4
WYNN	2	Sphagnum moss	16	64
WYNN	2	Bog blueberry	5	20
WYNN	2	Crowberry	5	20

WYNN	2	Bluejoint grass	2	8
WYNN	2	Dwarf birch	1	4
WYNN	2	Bog rosemary	0	0
WYNN	3	Sphagnum moss	13	52
WYNN	3	Bog blueberry	9	36
WYNN	3	Crowberry	7	28
WYNN	3	Dwarf birch	4	16
WYNN	3	Bluejoint grass	3	12
WYNN	3	Dune grass	0	0
WYNN	3	Horsetail	0	0
WYNN	3	Bog willow	0	0
WYNN	4	Bog blueberry	11	44
WYNN	4	Crowberry	9	36
WYNN	4	Sphagnum moss	7	28
WYNN	4	Dwarf birch	6	24
WYNN	4	Bluejoint grass	1	4
WYNN	4	Horsetail	0	0
WYNN	5	Bog blueberry	17	68
WYNN	5	Dwarf birch	11	44
WYNN	5	Sphagnum moss	3	12
WYNN	5	Dune grass	2	8
WYNN	5	Crowberry	1	4
WYNN	1	Bog blueberry	13	52
WYNN	1	Labrador tea	6	24
WYNN	1	Sphagnum moss	5	20
WYNN	1	Dwarf birch	2	8
WYNN	1	Crowberry	2	8
WYNN	1	Horsetail	0	0
WYNN	1	Bluejoint grass	0	0
WYNN	2	Sphagnum moss	19	76
WYNN	2	Bog blueberry	15	60
WYNN	2	Dwarf birch	5	20
WYNN	2	Crowberry	0	0
WYNN	2	Horsetail	0	0
WYNN	2	Bluejoint grass	0	0

WYNN	3	Crowberry	15	60
WYNN	3	Bog blueberry	11	44
WYNN	3	Sphagnum moss	7	28
WYNN	3	Dwarf birch	2	8
WYNN	3	Labrador tea	1	4
WYNN	3	Ribbed bog moss	1	4
WYNN	3	Horsetail	0	0
WYNN	3	Nagoonberry	0	0
WYNN	4	Sphagnum moss	13	52
WYNN	4	Crowberry	5	20
WYNN	4	Bog blueberry	3	12
WYNN	4	Nagoonberry	2	8
WYNN	4	Dwarf birch	2	8
WYNN	4	Labrador tea	1	4
WYNN	4	Horsetail	0	0
WYNN	4	Bluejoint grass	0	0
WYNN	5	Sphagnum moss	19	76
WYNN	5	Dune grass	12	48
WYNN	5	Dwarf birch	6	24
WYNN	5	Bluejoint grass	0	0
WYNN	5	Cottongrass	0	0
WYNN	5	Horsetail	0	0
WYNN	1	Dwarf birch	9	36
WYNN	1	Dwarf blueberry	4	16
WYNN	1	Sphagnum moss	2	8
WYNN	1	Crowberry	1	4
WYNN	1	Bluejoint grass	0	0
WYNN	2	Bog blueberry	14	56
WYNN	2	Crowberry	11	44
WYNN	2	Sphagnum moss	11	44
WYNN	2	Dwarf birch	4	16
WYNN	2	Horsetail	0	0
WYNN	2	Labrador tea	0	0
WYNN	2	Bluejoint grass	0	0

WYNN	2	Dune grass	0	0
WYNN	3	Sphagnum moss	19	76
WYNN	3	Crowberry	9	36
WYNN	3	Bog blueberry	6	24
WYNN	3	Nagoonberry	1	4
WYNN	3	Dwarf birch	1	4
WYNN	3	Bluejoint grass	0	0
WYNN	3	Bog willow	0	0
WYNN	4	Sphagnum moss	15	60
WYNN	4	Bog blueberry	9	36
WYNN	4	Crowberry	5	20
WYNN	4	Dwarf birch	3	12
WYNN	4	Dwarf blueberry	1	4
WYNN	4	Dune grass	0	0
WYNN	5	Dune grass	21	84
WYNN	5	Sphagnum moss	7	28
WYNN	5	Sitka burnet	2	8
WYNN	5	Bog willow	1	4
WYNN	5	Dwarf dogwood	0	0
WYNN	5	Nagoonberry	0	0
WYNN	5	Horsetail	0	0
WYNN	5	Bluejoint grass	0	0
WYNN	1	Sphagnum moss	14	56
WYNN	1	Bog blueberry	6	24
WYNN	1	Crowberry	2	8
WYNN	1	Lutz spruce	1	4
WYNN	1	Dwarf birch	1	4
WYNN	1	Labrador tea	1	4
WYNN	1	Bluejoint grass	1	4
WYNN	1	Dwarf blueberry	0	0
WYNN	1	Dune grass	0	0
WYNN	1	Horsetail	0	0

*0 indicates that species was present but did not make up at least 50% of any squares within quadrat.

Percent Frequency

Table C.7.2.4 Depicts the percent frequency values for vegetation species sampled at PBFS, Homer, AK.

Location	Species Observed PBFS	% Frequency
PBFS	Bluejoint grass	90.91
PBFS	Sphagnum moss	63.64
PBFS	Crowberry	54.55
PBFS	Dwarf birch	54.55
PBFS	Sweet gale	27.27
PBFS	Bog rosemary	27.27
PBFS	Alaska Violet	27.27
PBFS	Lutz spruce	18.18
PBFS	Dune grass	18.18
PBFS	Round sundew	18.18
PBFS	Bog bean	18.18
PBFS	Bog swertia	18.18
PBFS	Clear moss	18.18
PBFS	Labrador tea	9.09
PBFS	Watermelon Berry	9.09
PBFS	Tundra rose	9.09
PBFS	Red Peat moss	9.09
PBFS	Bog cranberry	9.09
PBFS	Bog blueberry	9.09
PBFS	Trailing raspberry	9.09
PBFS	Club moss	9.09
PBFS	Sitka burnet	9.09
PBFS	Cottongrass	9.09
PBFS	Bog willow	9.09

Table C.7.2.5 Depicts the percent frequency values for vegetation species sampled at IRP, Homer, AK.

Location	Species Observed	% Frequency
IRP	Sphagnum moss	93.33
IRP	Bluejoint grass	66.67
IRP	Crowberry	46.67
IRP	Bog cranberry	40
IRP	Bog blueberry	66.67
IRP	Dwarf birch	73.33
IRP	Cloudberry	13.33
IRP	Ribbed bog moss	33.33

IRP	Bog rosemary	6.67
IRP	Horsetail	40
IRP	Bog willow	20
IRP	Lingonberry	26.67
IRP	Dwarf nagoonberry	6.67
IRP	Fireweed	6.67
IRP	Dwarf dogwood	20
IRP	Dune grass	33.33
IRP	Star sphagnum	6.67
IRP	Sitka burnet	6.67
IRP	Nagoonberry	40
IRP	Violet	6.67
IRP	Cottongrass	13.33
IRP	Lutz spruce	13.33
IRP	Labrador tea	20
IRP	Round sundew	6.67
IRP	Bog swertia	6.67
IRP	Trailing raspberry	6.67

Table C.7.2.6 Depicts the percent frequency values for vegetation species sampled at the Wynn Nature Center, Homer, AK.

Location	Species Observed	% Frequency
Wynn	Sphagnum moss	100
Wynn	Dwarf birch	93.75
Wynn	Crowberry	87.5
Wynn	Bluejoint grass	87.5
Wynn	Bog blueberry	81.25
Wynn	Dune grass	43.75
Wynn	Horsetail	37.5
Wynn	Labrador tea	31.25
Wynn	Nagoonberry	25
Wynn	Bog willow	18.75
Wynn	Dwarf blueberry	18.75
Wynn	Shaggy sphagnum moss	12.5
Wynn	Bog rosemary	6.25
Wynn	Ribbed bog moss	6.25
Wynn	Cottongrass	6.25
Wynn	Sitka burnet	6.25
Wynn	Dwarf dogwood	6.25

Community Composition

Table C.7.2.7 Depicts the community composition values for vegetation species sampled at PBFS, Homer, AK.

Location	Quadrat	Individual Communities	% Frequency of communities
PBFS	1	Low Shrub/Ericaceous	41.18
PBFS	1	Graminoids	41.18
PBFS	1	Coniferous	14.71
PBFS	1	Mosses	2.94
PBFS	2	Graminoids	66.67
PBFS	2	Low Shrub/Ericaceous	25
PBFS	2	Forbes/Herbaceous	8.33
PBFS	3	Graminoids	71.43
PBFS	3	Mosses	21.43
PBFS	3	Forbes/Herbaceous	7.14
PBFS	3	Low Shrub/Ericaceous	0
PBFS	4	Graminoids	65.38
PBFS	4	Low Shrub/Ericaceous	26.92
PBFS	4	Forbes/Herbaceous	7.69
PBFS	5	Low Shrub/Ericaceous	43.24
PBFS	5	Graminoids	43.24
PBFS	5	Mosses	13.51
PBFS	6	Graminoids	66.67
PBFS	6	Forbes/Herbaceous	16.67
PBFS	6	Mosses	16.67
PBFS	1	Forbes/Herbaceous	53.33
PBFS	1	Mosses	46.67
PBFS	2	Graminoids	81.48
PBFS	2	Forbes/Herbaceous	18.52
PBFS	3	Graminoids	78.57
PBFS	3	Forbes/Herbaceous	21.43
PBFS	3	Low Shrub/Ericaceous	0
PBFS	4	Mosses	38.89
PBFS	4	Graminoids	30.56

PBFS	4	Low Shrub/Ericaceous	25
PBFS	4	Coniferous	5.56
PBFS	5	Graminoids	46.88
PBFS	5	Low Shrub/Ericaceous	43.75
PBFS	5	Mosses	6.25
PBFS	5	Woody shrub	3.13

Table C.7.2.8 Depicts the community composition values for vegetation species sampled at IRP, Homer, AK.

Location	Quadrat	Individual Communities	% Frequency of communities
IRP	1	Mosses	37.93
IRP	1	Low shrub/Ericaceous	34.48
IRP	1	Graminoids	27.59
IRP	2	Low shrub/Ericaceous	50
IRP	2	Mosses	30
IRP	2	Forbes/ Herbaceous	16.67
IRP	2	Graminoids	3.33
IRP	3	Forbes/ Herbaceous	28.57
IRP	3	Mosses	28.57
IRP	3	Low shrub/Ericaceous	28.57
IRP	3	Woody shrub	14.29
IRP	4	Forbes/ Herbaceous	45.45
IRP	4	Mosses	27.27
IRP	4	Woody shrub	18.18
IRP	4	Low shrub/Ericaceous	9.09
IRP	5	Mosses	41.94
IRP	5	Graminoids	38.71
IRP	5	Forbes/ Herbaceous	19.35
IRP	5	Low shrub/Ericaceous	0
IRP	1	Mosses	45.45
IRP	1	Graminoids	42.42
IRP	1	Low shrub/Ericaceous	12.12
IRP	1	Forbes/ Herbaceous	0
IRP	2	Mosses	44.44

IRP	2	Low shrub/Ericaceous	40
IRP	2	Graminoids	15.56
IRP	3	Mosses	41.67
IRP	3	Graminoids	36.11
IRP	3	Low shrub/Ericaceous	27.78
IRP	3	Coniferous	2.78
IRP	4	Low shrub/Ericaceous	62.79
IRP	4	Mosses	34.88
IRP	4	Graminoids	2.33
IRP	4	Forbes/ Herbaceous	0
IRP	5	Mosses	57.69
IRP	5	Low shrub/Ericaceous	19.23
IRP	5	Forbes/ Herbaceous	11.54
IRP	5	Woody shrub	11.54
IRP	1	Low shrub/Ericaceous	45.65
IRP	1	Mosses	43.48
IRP	1	Graminoids	10.87
IRP	1	Forbes/ Herbaceous	0
IRP	2	Low shrub/Ericaceous	58.82
IRP	2	Mosses	29.41
IRP	2	Forbes/ Herbaceous	11.76
IRP	3	Low shrub/Ericaceous	45.71
IRP	3	Mosses	37.14
IRP	3	Coniferous	8.57
IRP	3	Graminoids	8.57
IRP	4	Low shrub/Ericaceous	37.5
IRP	4	Mosses	31.25
IRP	4	Forbes/ Herbaceous	18.75
IRP	4	Graminoids	12.5
IRP	5	Graminoids	57.89
IRP	5	Forbes/ Herbaceous	31.58
IRP	5	Low shrub/Ericaceous	10.53
IRP	5	Mosses	0

Table C.7.2.9 Depicts the community composition values for vegetation species sampled at the Wynn Nature Center Homer, AK.

Location	Quadrat	Individual Communities	% Frequency of communities
WYNN	1	Low shrub/ Ericaceous	57.58
WYNN	1	Mosses	39.39
WYNN	1	Graminoids	3.03
WYNN	2	Mosses	55.17
WYNN	2	Low shrub/ Ericaceous	37.93
WYNN	2	Graminoids	6.9
WYNN	3	Low shrub/ Ericaceous	55.56
WYNN	3	Mosses	36.11
WYNN	3	Graminoids	8.33
WYNN	3	Forbes/Herbaceous	0
WYNN	3	Woody shrub	0
WYNN	4	Low shrub/ Ericaceous	76.47
WYNN	4	Mosses	20.59
WYNN	4	Graminoids	2.94
WYNN	4	Forbes/Herbaceous	0
WYNN	5	Low shrub/ Ericaceous	85.29
WYNN	5	Mosses	8.82
WYNN	5	Graminoids	5.88
WYNN	1	Low shrub/ Ericaceous	82.14
WYNN	1	Mosses	17.86
WYNN	1	Forbes/Herbaceous	0
WYNN	1	Graminoids	0
WYNN	2	Low shrub/ Ericaceous	51.28
WYNN	2	Mosses	48.72
WYNN	2	Forbes/Herbaceous	0
WYNN	2	Graminoids	0
WYNN	3	Low shrub/ Ericaceous	80.56
WYNN	3	Mosses	19.44
WYNN	3	Graminoids	0
WYNN	3	Forbes/Herbaceous	0
WYNN	4	Mosses	50

WYNN	4	Low shrub/ Ericaceous	42.31
WYNN	4	Forbes/Herbaceous	7.69
WYNN	4	Graminoids	0
WYNN	5	Mosses	51.35
WYNN	5	Graminoids	32.43
WYNN	5	Low shrub/ Ericaceous	16.22
WYNN	5	Forbes/Herbaceous	0
WYNN	1	Low shrub/ Ericaceous	87.5
WYNN	1	Mosses	12.5
WYNN	1	Graminoids	0
WYNN	2	Low shrub/ Ericaceous	72.5
WYNN	2	Mosses	27.5
WYNN	2	Forbes/Herbaceous	0
WYNN	2	Graminoids	0
WYNN	3	Mosses	52.78
WYNN	3	Low shrub/ Ericaceous	44.44
WYNN	3	Forbes/Herbaceous	2.78
WYNN	3	Graminoids	0
WYNN	3	Woody shrub	0
WYNN	4	Low shrub/ Ericaceous	54.55
WYNN	4	Mosses	45.45
WYNN	4	Graminoids	0
WYNN	5	Graminoids	67.74
WYNN	5	Mosses	22.58
WYNN	5	Forbes/Herbaceous	6.45
WYNN	5	Woody shrub	3.23
WYNN	5	Low shrub/ Ericaceous	0
WYNN	1	Mosses	53.85
WYNN	1	Low shrub/ Ericaceous	38.46
WYNN	1	Coniferous	3.85
WYNN	1	Graminoids	3.85
WYNN	1	Forbes/Herbaceous	0

Appendix D. Additional Supplement Documents

D.1 Swallow Nest Box Guidelines Document

IRP Swallow Nest Boxes Project

Protocols for dimensions of nest boxes, when and where they should be placed, and height/distance requirements provided in this document are taken from Project NestWatch and Alaska Department of Fish and Game (ADFG). Some of this information is different for Tree Swallows and Violet Green Swallows, in these instances information for both species is provided. We will provide a separate document that includes our recommendations for next box locations. We believe that many of the previously placed nest boxes are good nesting sites and simply need to be replaced. Most of our new site location suggestions were tailored towards forest edges, between the ponds, and in areas with mixed deciduous and coniferous trees, this is based on recommendations from the above resources and for ease of access and monitoring.

<u>When next boxes should be placed:</u>

- Mid-late March before breeding season (Project NestWatch)

<u>Dimensions of nest box:</u>

- Both Violet-green and Tree Swallow species
    - Depth: 9 inches
    - Width and Length: 5.5 inches
    - Hole Size: 1 ⅜” round

<u>Direction nest box should be facing:</u>

Per ADFG:

- Face away from prevailing winds. (ADFG)

Per NestWatch:

- For both species of swallows: Place box south or east facing
    - Per an article from the Journal of Field Ornithology, tree swallows showed a preference for east and south facing boxes in the first half of the breeding season. Nest boxes with entrances that faced east or south were found to be warmer in the first half of the breeding season. This suggests that warmer nesting temperatures may be correlated with increased fitness (Ardia et al., 2006).

<u>Habitats where nest boxes should be placed:</u>

Per ADFG:

- Swallow nest boxes should be placed in open areas including cities, field edges, open forests, lawns or gardens. Near lakes, river or stream in forested area; Open areas (forest opening, recent burned over forests, clearcuts, agricultural areas.

Per Nestwatch:

- Tree Swallow: Open fields, near water, expansive open areas, marshes, meadows, wooded swamps; on a post in open areas near trees or fences.
- Violet-Green Swallow: Open or broken deciduous or mixed deciduous- coniferous forests, wooded canyons, edges of dense forest.

<u>Box Height above ground:</u>

- Tree Swallow: 5-6 ft
- Violet-Green Swallow: 9-15 ft
    - As Violet-Green swallows are the primary swallow in the area, we suggest tailoring the box heights to this species, however placing boxes on the low end of their range to accommodate tree swallows as well, at closer to 9 ft.

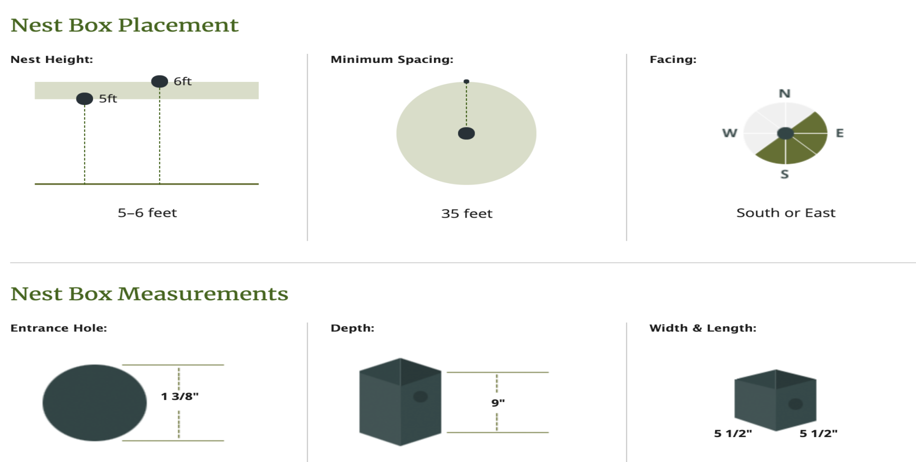
<u>Minimum Spacing Between Boxes:</u>

- Tree Swallow: 35 feet
- Violet-Green Swallow: 30 feet
    - As the feet between boxes is a minimum distance recommendation, to accommodate for Tree Swallows we recommend spacing the boxes 35 feet apart to help prevent competition.

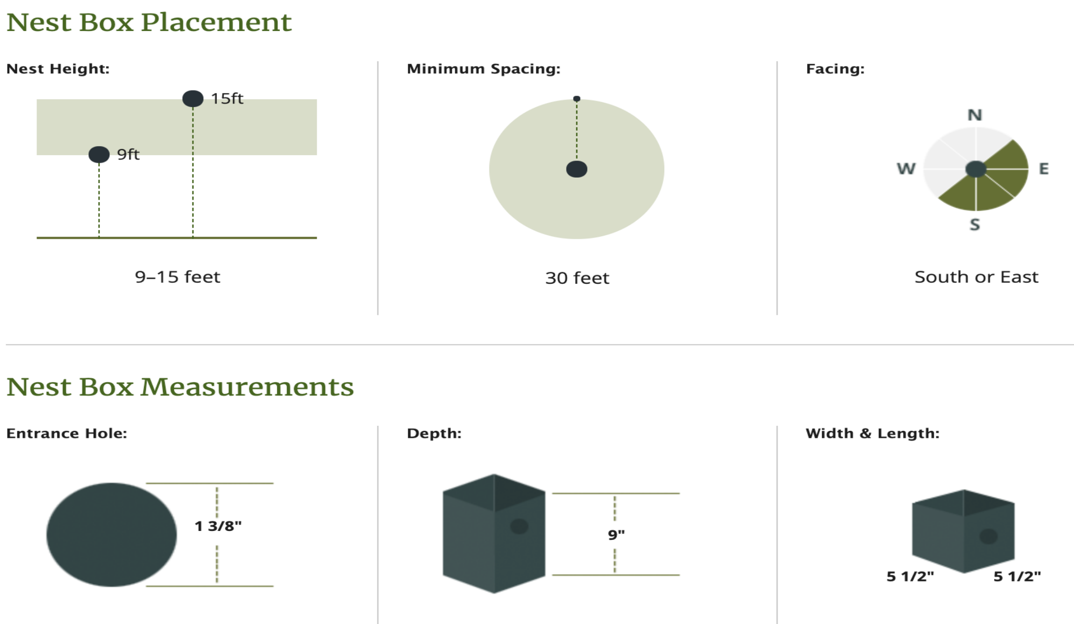
Table D.1 Summary of swallow species nesting preferences from Nest Watch.

Species	Nesting Habitat	Box Height	Hole Size	Minimum Spacing
Tree Swallow	Open fields near water, expansive open areas, marshes, meadows, wooded swamps; on a post in open areas near tree or fence, east facing	5-6 feet	1 3/8" round	35 feet
Violet-green Swallow	Open or broken deciduous or mixed deciduous-coniferous forests, wooded canyons, edges of dense forest	9-15 feet	1 3/8" round	30 feet

Tree Swallows



Violet Green Swallows



<u>Birdhouse construction:</u>

- Construction Plan for both Violet Green Swallows and Tree Swallows:
  - https://nestwatch.org/wp-content/themes/nestwatch/birdhouses/violet-green-swallow.pdf
- Use untreated, unpainted wood, preferably cedar, pine, cypress, or for larger owl boxes, non pressure-treated CDX exterior grade plywood.
- Galvanized screws
  - Better for sealing as nails can loosen over time and screws are easier to remove for repairs.
- Sloped roof that overhangs the front by 2-4” and the sides by 2”
  - Helps protect against rain and predators
  - Can add ¼” deep cuts under the roof on all three edges to act as rain gutters.
- Recessed floor
  - Helps keep box dry, recess floor ¼’ from bottom
- Drainage holes
  - Add at least 4 drainage holes ⅜” to ½”
- Walls should be at least ¾” thick
- Ventilation holes
  - Two ⅝” holes on each of the side walls near the top.
- Interior Grooves (Fledgling ladder)
  - Series of shallow horizontal cuts make it easier for birds to climb out of the box.
- Extended Back

    - A few inches on the top and bottom of the bird house can make it easier to attach to the pole
- Summary of the above information and more: https://nestwatch.org/learn/all-about-birdhouses/features-of-a-good-birdhouse/

Predator Guards:

Per Nest Watch the best options for fledgling success are cone-type baffles, stovepipe baffles, or entrance hole extenders.

Conical metal predator guard:

Figure. D.1 Image depicting the conical metal predator guard.

- Good for boxes on free standing poles, made using galvanized sheet metal placed around pole.
- Instructions for construction and materials needed: https://nestwatch.org/wp-content/uploads/2013/06/guardcon.pdf

Stovepipe Baffle:

Figure D.1.1. Image depicting the stovepipe baffle predator guard.

- Made from stovepipe or PVC that encircles the nest-box pole, held in place w/ hardware cloth and straps
- Most complex, but possibly the most effective.
- Instructions for construction and materials needed: https://nestwatch.org/wp-content/uploads/2013/06/guardsto.pdf

Noel Predator Guard:

Figure. D.1.2 Image depicting the Noel predator guard.

- Rectangular tube of hardware cloth stapled to the entrance of the nest box.
- Recommend to use in combination with another predator guard.
- Instructions for construction and material: https://nestwatch.org/wp-content/uploads/2013/06/guardnoe.pdf

We recommend either the first or second option for predator guard, the conical metal guard appears to be the simplest to implement, however the stovepipe may be more effective.

For protection against squirrels: Add a rectangular piece of sheet metal to the front of the next box with a hole the same size as the nest box entrance hole so squirrels are not able to chew into the next box.

Fledgling ladders:
To help fledglings get out of the nesting boxes a fledgling ladder can be made.

- This can be either a series of horizontal kerf cuts
    - There are multiple options for this, one suggesting is to use a router, table saw, or radial arm saw and make ⅛' deep grooves at intervals of ¼, ½, or ¾ " going from the entrance to just above the floor.
        - http://www.sialis.org/kerfs.htm
- Or place a piece of hardware cloth stapled inside of the box.

Sleeves and Poles:

- Most sources say to use a metal or wooden pole, Michiganbluebirds.org states a round metal pole works best.
- Video showcasing instructions on building a telescoping pole using conduit, this allows you to raise and lower the boxes:
    - https://www.youtube.com/watch?v=fU2c03w48nY

Other Useful Information:

- Tree and Violet- Green Swallows line their nest with feathers, and more feathers can enhance chick survival. You can provide chicken feathers in the area for Tree Swallows to add to their nests.
- Nest Watch recommends not using any perches as this can help predators access the nest box.
- Rough interior walls are helpful for fledglings to leave the nest, plain wood is rough enough, but smooth boards can be made rougher with sandpaper.

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