Soil and Vegetation Survey of the Willow National Petroleum Reserve-Alaska

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Contents

Chapter 1

Interactive Project Map

1.1 Introduction

The survey area within the National Petroleum Reserve-Alaska (NPR-A) is in the Arctic Coastal Plain of the North Slope of Alaska, approximately 90 miles (145 km) west of Prudhoe Bay. These lands were originally inhabited by various Alaska Native groups, including the Inupiat people for thousands of years. In 1923, President Warren G. Harding established the Naval Petroleum Reserve No.4 (NPR-4) through an executive order, which brought this area under federal ownership without consultation or compensation to the Alaska Native peoples. In 1976, the Naval Petroleum Reserves Production Act renamed the area to the National Petroleum Reserve-Alaska and transferred the management of the reserve from the United States Navy to the United States Department of Interior, Bureau of Land Management. In recent years, there has been increased interest in developing the oil resources in the NPR-A, exemplified by projects such as the Willow Project. The NPR-A is approximately 24 million acres stretching across the North Slope of Alaska. The soil and vegetation survey area is approximately 500,000 acres on the Eastern most side of the NPR-A.

1.2 Survey Purpose

The primary purpose of the survey was to describe and map the soils and vegetation of the Willow area in the NPR-A. Area soils and vegetation were mapped at a scale of 1:24,000 and detailed description of the map units, soil types, and vegetation cover types were developed. This data will be published on Web Soil Survey in 2025 and can be found here: https://websoilsurvey.nrcs.usda.gov/app/

Figure 1.1: Figure 1.1: Fish Creek taken from R44 helicopter. Notice the progression of ice-wedge polygon development from the floodplains to uplands.

1.3 Acknowledgements

This project would have never been possible without the expertise of the scientist, pilots, and the managers of this incredible area. Countless thanks to Tyler Annetts, Jessica Lene-Ashley, Phillip Barber, Luke Breneman, Krista Bryant, Brad Casar, Charolette Crowder, Sara Datson, Noah Hull, Ted Inman, Nic Jelinski, Jamin Johanson, Monica Kopp, Amy Li, Travis Nauman, Nathan Perry, Craig Prink, Nathan Roe, Stephanie Schmidt, Michael Sousa, Michael Singer, Mark Stott, Maddie Tucker.

1.4 Usage

This survey was a cooperative effort of the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) and the United States Department of Interior, Bureau of Land Management (BLM). NRCS was responsible for survey design and methodology, data collection and analysis, and this report. Fieldwork was completed in July and August of '21, '23, and '24. Soil names and descriptions were approved in 2024. Unless indicated otherwise, maps and supporting documentation in this report refer to conditions in the survey area in 2024.

Maps in this report may be copied without permission. However, enlargement of these maps could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils and vegetation that could gave been shown at a larger scale.

All programs and services of the Natural Resources Conservation Service and the Bureau of Land Management are offered on a nondiscriminatory basis, without regard to race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, marital or family status.

Chapter 2

Environmental Setting

2.1 Climate

The Arctic Coastal Plain of Alaska is characterized by a harsh tundra climate, classified as ET in the Köppen system. This region experiences extreme temperature variations, with brutally cold winters where average temperatures often plummet below -15°F, and brief, cool summers barely reaching 50°F in July. The average annual temperature ranges from 8 to 14°F. The average freeze-free period is fewer than 5 days to 20 days. Freezing temperatures can occur in any month.

This is NRCS Snotel data from https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=1177

Despite its frigid nature, the arctic coastal plain receives surprisingly little precipitation, typically ranging from 6-10 inches annually. Most of this falls as snow, blanketing the landscape for much of the year. The average annual snowfall is about 50 to 100 centimeters. The low precipitation, coupled with minimal evaporation rates due to the cold, creates a unique hydrologic balance that doesn't quite fit the traditional definition of a desert.

This is NRCS Snotel data from https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=1177

2.2 Growing Season

One of the most striking features of this climate is the dramatic swing in daylight hours throughout the year. Summers bring the phenomenon of the midnight sun, with 24 hours of continuous daylight, while winters plunge the region into weeks of polar night. This extreme light regime profoundly impacts biological rhythms and human activities alike. The coastal plain is also known for its windy conditions, with strong easterly winds being common. These winds, combined with the already frigid temperatures, can create dangerously low wind chill factors.

The growing season in the Arctic Coastal Plain is exceptionally brief, usually lasting only 50-60 days. This short window of relatively warmer temperatures and thawed ground surface supports a unique but fragile tundra ecosystem. Coastal areas are further influenced by sea ice, which is typically present for 8-9 months of the year, affecting local weather patterns and wildlife migrations.

This is NRCS SNOTEL data from https://wcc.sc.egov.usda.gov/nwcc/view

Underlying this harsh surface climate is a layer of continuous permafrost, a defining characteristic of the region. The active layer, which thaws seasonally, is typically shallow, extending only 30-50 cm (12-20 inches) deep. This frozen ground significantly influences the area's ecology and presents unique challenges for construction and resource extraction.

2.3 Geomorphology

Topography: general elevations and slope characteristics

Landscape/Landforms: Insert landscape diagram of area

Chapter 3

Field Work

For this project getting to the site with enough gear to be self-sustainable was a logistical challenge. Thankfully the BLM has a remote camp called Inigok Field Station.

1. Label the heading: `# Hello world {#nice-label}`.
    - Leave the label off if you like the automated heading generated based on your heading title: for example, `# Hello world` = `# Hello world {#hello-world}`.
    - To label an un-numbered heading, use: `# Hello world {-#nice-label}` or `{# Hello world .unnumbered}`.
2. Next, reference the labeled heading anywhere in the text using `\@ref(nice-label)`; for example, please see Chapter **??**.
    - If you prefer text as the link instead of a numbered reference use: any text you want can go here.

3.1 Captioned figures and tables

Figures and tables *with captions* can also be cross-referenced from elsewhere in your book using `\@ref(fig:chunk-label)` and `\@ref(tab:chunk-label)`, respectively.

See Figure 3.1.

```
par(mar = c(4, 4, .1, .1))
plot(pressure, type = 'b', pch = 19)
```

Don't miss Table 3.1.

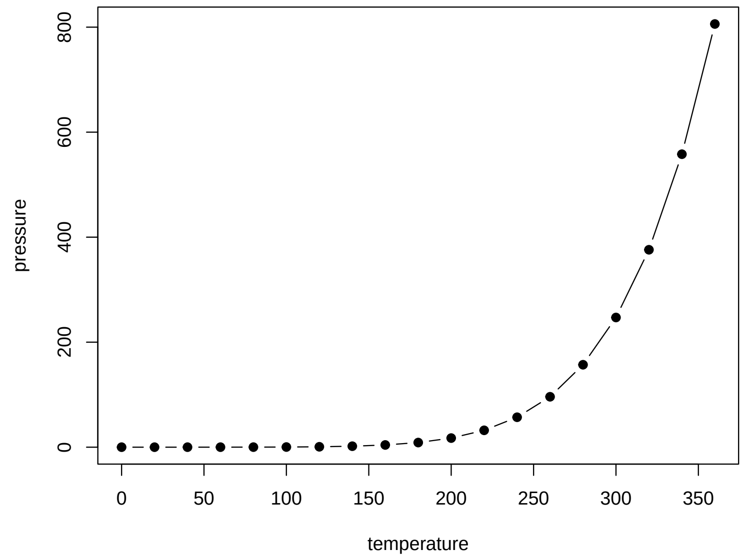

Figure 3.1: Here is a nice figure!

```
knitr::kable(
  head(pressure, 10), caption = 'Here is a nice table!',
  booktabs = TRUE
)
```

You can add parts to organize one or more book chapters together. Parts can be inserted at the top of an .Rmd file, before the first-level chapter heading in that same file.

Add a numbered part: `# (PART) Act one {-}` (followed by `# A chapter`)

Add an unnumbered part: `# (PART\*) Act one {-}` (followed by `# A chapter`)

Add an appendix as a special kind of un-numbered part: `# (APPENDIX) Other stuff {-}` (followed by `# A chapter`). Chapters in an appendix are prepended with letters instead of numbers.

Table 3.1: Here is a nice table!

temperature	pressure
0	0.0002
20	0.0012
40	0.0060
60	0.0300
80	0.0900
100	0.2700
120	0.7500
140	1.8500
160	4.2000
180	8.8000

Chapter 4

Footnotes and citations

4.1 Footnotes

Footnotes are put inside the square brackets after a caret `^[]`. Like this one [1].

4.2 Citations

Reference items in your bibliography file(s) using `@key`.

For example, we are using the **bookdown** package [Xie, 2024] (check out the last code chunk in index.Rmd to see how this citation key was added) in this sample book, which was built on top of R Markdown and **knitr** [Xie, 2015] (this citation was added manually in an external file book.bib). Note that the `.bib` files need to be listed in the index.Rmd with the YAML `bibliography` key.

The RStudio Visual Markdown Editor can also make it easier to insert citations: https://rstudio.github.io/visual-markdown-editing/#/citations

[1] This is a footnote.

Chapter 5

Map Unit

5.1 Equations

Here is an equation.

$$f\left(k\right) = \binom{n}{k} p^k \left(1 - p\right)^{n-k} \tag{5.1}$$

You may refer to using `\@ref(eq:binom)`, like see Equation (5.1).

5.2 Theorems and proofs

Labeled theorems can be referenced in text using `\@ref(thm:tri)`, for example, check out this smart theorem 5.1.

Theorem 5.1. *For a right triangle, if c denotes the* length *of the hypotenuse and a and b denote the lengths of the* ***other*** *two sides, we have*

$$a^2 + b^2 = c^2$$

Read more here https://bookdown.org/yihui/bookdown/markdown-extensions-by-bookdown.html.

5.3 Callout blocks

The R Markdown Cookbook provides more help on how to use custom blocks to design your own callouts: https://bookdown.org/yihui/rmarkdown-cookbook/custom-blocks.html

Chapter 6

Component

6.1 Publishing

HTML books can be published online, see: https://bookdown.org/yihui/bookdown/publishing.html

6.2 404 pages

By default, users will be directed to a 404 page if they try to access a webpage that cannot be found. If you'd like to customize your 404 page instead of using the default, you may add either a `_404.Rmd` or `_404.md` file to your project root and use code and/or Markdown syntax.

6.3 Metadata for sharing

Bookdown HTML books will provide HTML metadata for social sharing on platforms like Twitter, Facebook, and LinkedIn, using information you provide in the `index.Rmd` YAML. To setup, set the `url` for your book and the path to your `cover-image` file. Your book's `title` and `description` are also used.

This `gitbook` uses the same social sharing data across all chapters in your book-all links shared will look the same.

Specify your book's source repository on GitHub using the `edit` key under the configuration options in the `_output.yml` file, which allows users to suggest an edit by linking to a chapter's source file.

Read more about the features of this output format here:

https://pkgs.rstudio.com/bookdown/reference/gitbook.html

Or use:

```
?bookdown::gitbook
```

Chapter 7

useful code

this is how you commit and push stuff in terminal git add .

git commit -m “commit message”

git push

ctrl + Alt + i = insert r script echo = false means the scrubs dont see code

library(tidyr) library(ggplot2) library(readr) library(dplyr) library(tidyverse) library(lubridate)

df1 <- read_delim(“_book/dailyMinTemp.csv”, delim = “|”)

data <- df1

data_long <- data %>% pivot_longer(cols = -c(`Water Year`, Day), names_to = “Month”, values_to = “Temperature”)

month_order <- c(“Jan”, “Feb”, “Mar”, “Apr”, “May”, “Jun”, “Jul”, “Aug”, “Sep”, “Oct”, “Nov”, “Dec”) data_long <- data_long %>% mutate(Month = factor(Month, levels = month_order, ordered = TRUE), Date = as.Date(paste(“2000”, Month, Day, sep = “-”), format = “%Y-%b-%d”))

Chapter 8

Calculate the average temperature for each day across all years

avg_temp <- data_long %>% group_by(Date) %>% summarise(AvgTemperature = mean(Temperature, na.rm = TRUE))

Chapter 9

Create the combined line graph

ggplot() + # Individual year lines geom_line(data = data_long, aes(x = Date, y = Temperature), alpha = 0.5) + # Average temperature line geom_line(data = avg_temp, aes(x = Date, y = AvgTemperature), color = "black", size = 1.2) + scale_x_date(date_labels = "%b", date_breaks = "1 month") + scale_color_viridis_d(option = "plasma") + # Color-blind friendly palette labs(title = "Minimum Daily Temperature 2004-2024", x = "Month", y = "Temperature (Fahrenheit)") color = "Water Year"

```r
library(plotly)
library(tidyr)
library(ggplot2)
library(readr)
library(dplyr)
library(tidyverse)
library(lubridate)

df1 <- read_delim("_book/dailyAvgTemp.csv", delim = "|")
```

```
## Rows: 682 Columns: 14
## -- Column specification --------------------------------------------------------
## Delimiter: "|"
## dbl (14): Water Year, Day, Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun, Jul,...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
data <- df1

data_long <- data %>%
  pivot_longer(cols = -c(`Water Year`, Day),
               names_to = "Month",
               values_to = "Temperature")

month_order <- c("Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug", "Sep", "Oct",

data_long <- data_long %>%
  mutate(
    Month = factor(Month, levels = month_order, ordered = TRUE),
    Date = as.Date(paste("2000", Month, Day, sep = "-"), format = "%Y-%b-%d"),
    `Water Year` = as.factor(`Water Year`),
    hover_text = paste("Water Year:", `Water Year`, "<br>",
                       "Month:", Month, "<br>",
                       "Day:", Day, "<br>",
                       "Temperature:", round(Temperature, 1), "°F")
  ) %>%
  arrange(Month, Day)

# Calculate the average temperature for each day of the year
avg_temp <- data_long %>%
  group_by(Month, Day) %>%
  summarise(AvgTemperature = mean(Temperature, na.rm = TRUE), .groups = 'drop') %>%
  mutate(
    Date = as.Date(paste("2000", Month, Day, sep = "-"), format = "%Y-%b-%d"),
    hover_text = paste("Average Temperature", "<br>",
                       "Month:", Month, "<br>",
                       "Day:", Day, "<br>",
                       "Temperature:", round(AvgTemperature, 1), "°F")
  )

# Create the combined line graph
p <- ggplot() +
  # Individual year lines
  geom_line(data = data_long,
            aes(x = Date, y = Temperature, color = `Water Year`, group = `Water Year`,
            alpha = 0.5) +
  # Average temperature line
  geom_line(data = avg_temp,
            aes(x = Date, y = AvgTemperature),
            color = "black", size = 1.2) +
  scale_x_date(date_labels = "%b", date_breaks = "1 month") +
  scale_color_viridis_d(option = "plasma") +  # Color-blind friendly palette
```

```
  labs(title = "Average Daily Temperature 2004-2024",
       x = "Month",
       y = "Temperature (Fahrenheit)",
       color = "Water Year") +
  theme_minimal() +
  theme(legend.position = "right",
        axis.text.x = element_text(angle = 45, hjust = 1))
```

```
## Warning in geom_line(data = data_long, aes(x = Date, y = Temperature, color =
## `Water Year`, : Ignoring unknown aesthetics: text
```

```
# Convert to interactive plotly object with custom hover
p_interactive <- ggplotly(p, tooltip = "text")

# Modify hover template and mode
for (i in 1:length(p_interactive$x$data)) {
  p_interactive$x$data[[i]]$hoverinfo <- "text"
  p_interactive$x$data[[i]]$hoverlabel <- list(bgcolor = "white")
}

p_interactive <- p_interactive %>%
  layout(hovermode = "closest")

# Display the plot
p_interactive
```

library(tidyr) library(ggplot2) library(readr) library(dplyr) library(tidyverse) library(lubridate) library(viridis) library(plotly)

df1 <- read_delim("_book/dailyPrecip.csv", delim = "|")

data <- df1 %>% rename(Year = "Water Year")

data_long <- data %>% pivot_longer(cols = -c(Year, Day), names_to = "Month", values_to = "Precip")

data_long <- data_long %>% mutate(MonthNum = match(Month, month.abb), Date = make_date(Year, MonthNum, Day), MonthNum = NULL) %>% mutate(Date = ymd(Date))

Chapter 10

Create a function to reorder months from Oct to Sep

reorder_month <- function(x) { factor(x, levels = c("Oct", "Nov", "Dec", "Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug", "Sep")) }

Chapter 11

Prepare the data for plotting

data_plot <- data_long %>% mutate(WaterYear = ifelse(month(Date) >= 10, Year, Year - 1), Month = reorder_month(Month)) %>% filter(Day == days_in_month(Date)) %>% arrange(WaterYear, Month)

Chapter 12

Calculate average cumulative precipitation

avg_precip <- data_plot %>% group_by(Month) %>% summarize(AvgPrecip = mean(Precip, na.rm = TRUE))

data_plot$WaterYear < -as.factor(data_plot$WaterYear)

Chapter 13

Create the plot

p <- ggplot() + geom_line(data = data_plot, aes(x = Month, y = Precip, group = WaterYear, color = WaterYear), linewidth = 1) + geom_line(data = avg_precip, aes(x = Month, y = AvgPrecip, group = 1), linewidth = 1.5, color = "black") + geom_point(data = avg_precip, aes(x = Month, y = AvgPrecip), size = 1, color = "black") + scale_x_discrete(limits = levels(reorder_month(avg_precip$Month))) + scale_color_viridis(discrete = TRUE, option = "plasma", name = "Water Year") + labs(title = "Average Cumulative Precipitation 2004-2024", x = "Month", y = "Cumulative Precipitation (Inches)") + theme_minimal() + theme(legend.position = "right", axis.text.x = element_text(angle = 45, hjust = 1), panel.grid.minor = element_blank(), legend.key = element_rect(fill = "white", colour = NA), legend.key.size = unit(0.8, "cm"))

plotly_plot <- ggplotly(p)

Bibliography

Yihui Xie. *Dynamic Documents with R and knitr*. Chapman and Hall/CRC, Boca Raton, Florida, 2nd edition, 2015. URL http://yihui.org/knitr/. ISBN 978-1498716963.

Yihui Xie. *bookdown: Authoring Books and Technical Documents with R Markdown*, 2024. URL https://github.com/rstudio/bookdown. R package version 0.40.