Regression Code Along

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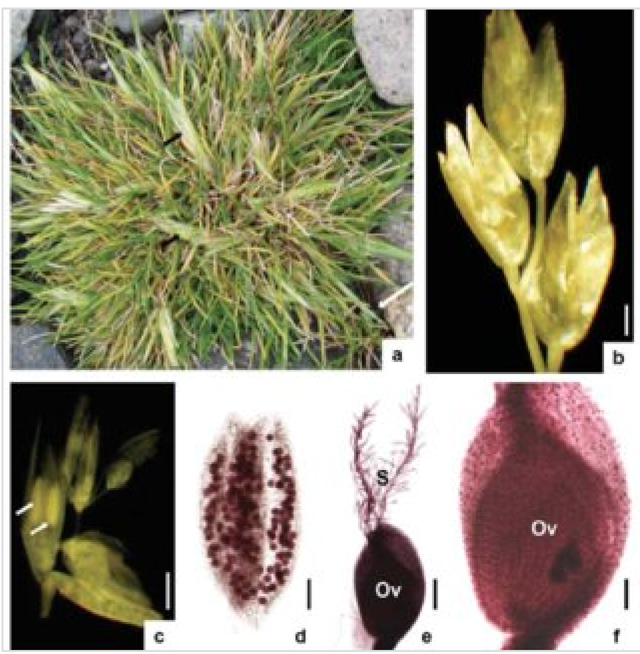
Statistical inference and regression analyses

Setting up the scenario

We want to build a road to our fishing site, while minimizing our impact on the delicate antarctic ecosystem. For today's lesson, we are going to focus on antarctic hair grass, one of only two flowering species of plants on the continent.

https://www.researchgate.net/figure/Morphology-of-Antarctic-hair-grass-Deschampsia-antarctica-a-A-small-cluster-of-D_fig1_304660866 (https://www.researchgate.net/figure/Morphology-of-Antarctic-hair-grass-Deschampsia-antarctica-a-A-small-cluster-of-D_fig1_304660866)



hair grass plant and flowering structures

We want to know what environmental conditions are associated with hair grass, so we can build a road where those conditions are not. It would take far too long to survey every square inch of land between our base and our fishing spot, so we are going to build a model based on some samples of where hair grass is found to predict where else it might be.

We collected data for one month on key components of the hair grass' environment

- soil pH : most plants prefer mildly acidic to neutral environments
- nitrogen content (as percentage per 100 mL soil sample) : important for plant growth and tissue building
- phosphorous content (as percentage per 100 mL soil sample) : important for plant growth and tissue building
- percent soil rock : rockiness of soil impacts water drainage and temperature
- max windpseed knots : extreme wind can pose a challenge to plants of all types

- average UV index : plants can get sunburned too
- average summer temperature
- average winter temperature
- penguin density within 100 m : the number of penguins per 5 m sq within 100 m of the sample quadrant for hair grass
- hair grass density (measured as number of individual clumps of hair grass within 1 square meter)

(This data is based on this article: I.Yu. Parnikoza, N.Yu. Miryuta, D.N. Maidanyuk, S.A. Loparev, S.G. Korsun, I.G. Budzanivska, T.P. Shevchenko, V.P. Polischuk, V.A. Kunakh, I.A. Kozeretska, Habitat and leaf cytogenetic characteristics of Deschampsia antarctica Desv. in the Maritime Antarctica, Polar Science, Volume 1, Issues 2–4, 2007, Pages 121-128, ISSN 1873-9652, https://doi.org/10.1016/j.polar.2007.10.002 (https://doi.org/10.1016/j.polar.2007.10.002).)

Exploring and analyzing our first variables of interest

There are many environmental conditions that may be associated with hair grass density. For today's code along, we are going to focus on two: soil pH and nitrogen content.

Let's look at nitrogen content first.

We always should start with a data visualization and some descriptive statistics.

```
# load in the tidyverse
library("tidyverse")
```

```
# load in the data
hairgrass <- read_csv("hairgrass_data.csv")
```

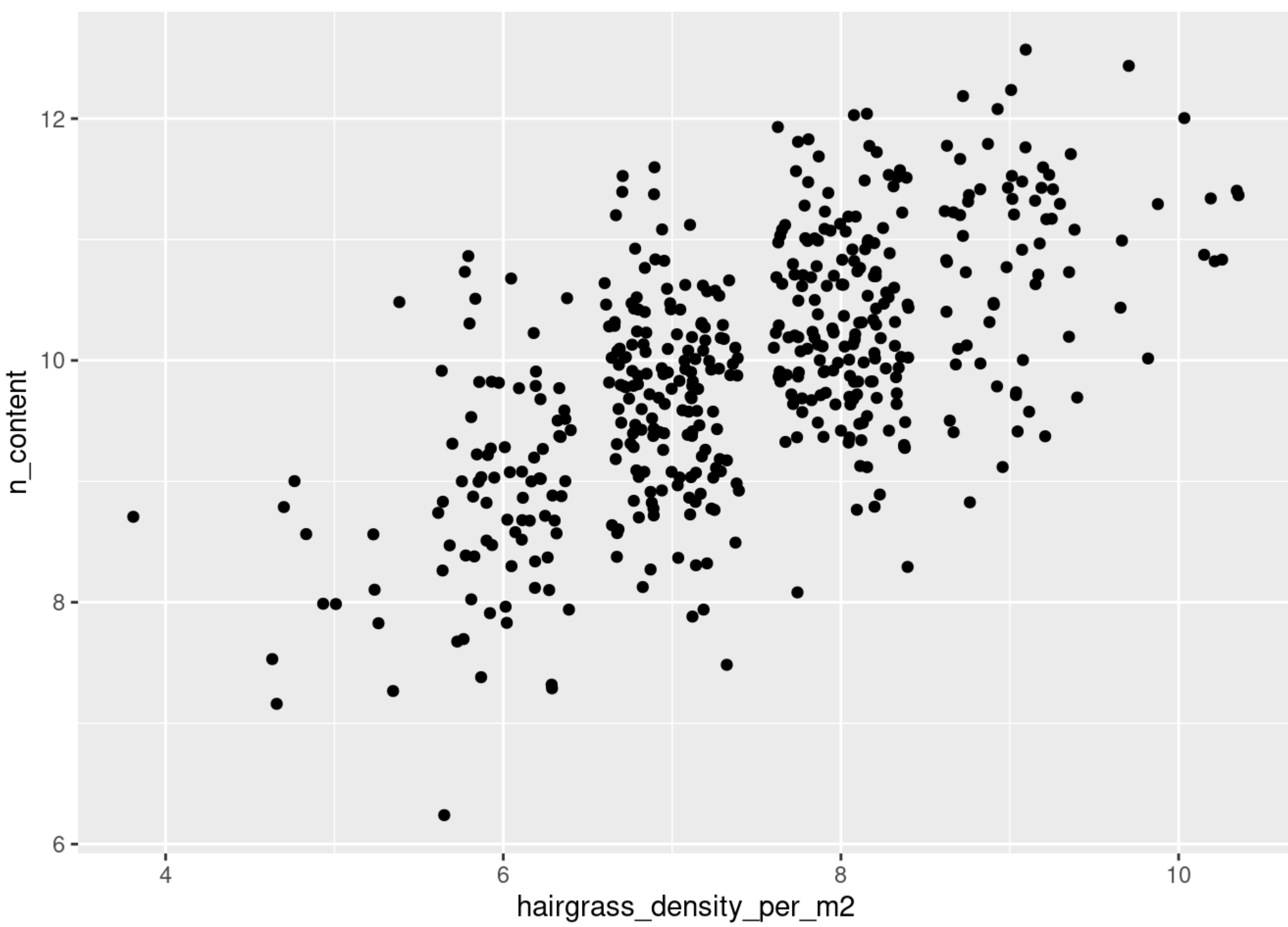
Since all the data is hair grass, we can just use `summarize()` to generate descriptive statistics (i.e. nothing to `group_by()`)

```
hairgrass %>% summarize(max(n_content),
                        min(n_content),
                        mean(n_content),
                        sd(n_content))
```

```
## # A tibble: 1 × 4
##   `max(n_content)` `min(n_content)` `mean(n_content)` `sd(n_
content)`
##              <dbl>            <dbl>             <dbl>
<dbl>
## 1             12.6              6.2              9.93
1.02
```

And now let's use `geom_point()` and `geom_jitter()` to visualize the data

```
ggplot(data=hairgrass, mapping=aes(x=hairgrass_density_per_m2,
y=n_content))+
  geom_jitter()
```



Now let's actually calculate the correlation coefficient, r. As a reminder, the correlation coefficient is a number between -1 and 1 that kooks at the relationship between two numeric variables. The greater the magnitude of the correlation coefficient, the stronger the correlation (All the points fall exactly on the line of best fit if r = 1 or -1).

```
r=cor(x=hairgrass$hairgrass_density_per_m2, y=hairgrass$n_conte
nt)
```

We often think about the correlation in terms of r-squared. All we have to do is square the value we calculated above. How do we interpret r-squared for this relationship?

```
r^2
```

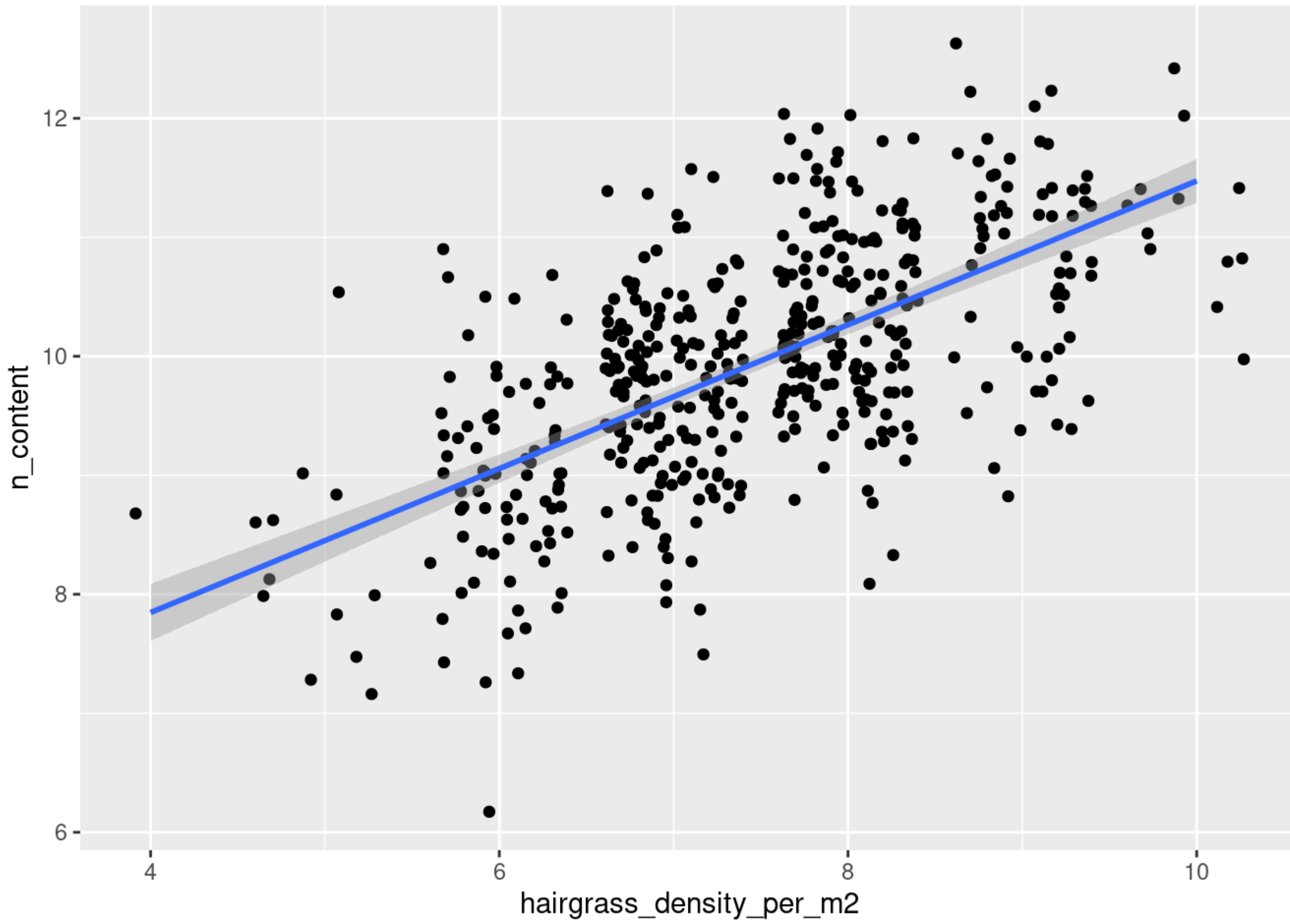
```
## [1] 0.400296
```

```
# means 40% of variation in hairgrass density can be explained
by
# variation in nitrogen content
```

Adding our line of best fit to the data

```
ggplot(data=hairgrass, mapping=aes(x=hairgrass_density_per_m2,
y=n_content))+
  geom_jitter()+
  geom_smooth(method="lm")
```

```
## `geom_smooth()` using formula = 'y ~ x'
```



If we want to add statistical rigor, we need to use regression analysis. A regression analysis approximates the relationship between a dependent variable and one or more independent variables and evaluates the strength of that relationship (giving us a p-value).

We will use linear regressions in this unit. This simply means that the model will take the form of y = mx + b, where y is the dependent variable, x is the dependent variable, a is the slope, and b is the y-intercept.

What would the model for our question about nitrogen content be? (it's okay that we haven't yet calculated the values)

```
# y=ax+b

# hair grass density = m * n_content + b
```

What is the null hypothesis? What is the alternative hypothesis?

```
#null: There is no relationship between hair grass density and
nitrogen content
#alternative: There is a relationship between hair grass densit
y and nitrogen content
```

R can actually calculate what this model would be for us. The formula for the line of best fit (y = mx+b) aims to minimize the distance between each observation (point) and the line. What is the model?

```
summary(lm(data=hairgrass, hairgrass_density_per_m2 ~ n_conten
t))
```

```
##
## Call:
## lm(formula = hairgrass_density_per_m2 ~ n_content, data = ha
irgrass)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.82079 -0.55590 -0.02612  0.57654  2.51032
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.86739    0.37000   2.344   0.0195 *
## n_content    0.66223    0.03707  17.862   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1
##
## Residual standard error: 0.8294 on 478 degrees of freedom
## Multiple R-squared:  0.4003, Adjusted R-squared:  0.399
## F-statistic: 319.1 on 1 and 478 DF,  p-value: < 2.2e-16
```

```
#model hair grass density = 0.66* n_content + 0.87
```

So what can we conclude about soil pH and hair grass density?

```
# Because the p-value associated with the F-statistic (319) is
2.2*10^-16,
# we reject the null hypothesis that there is no relationship b
etween n_content and hairgrass density. The slope of the line i
s unlikely to be 0.
#
```

Moving on to soil pH

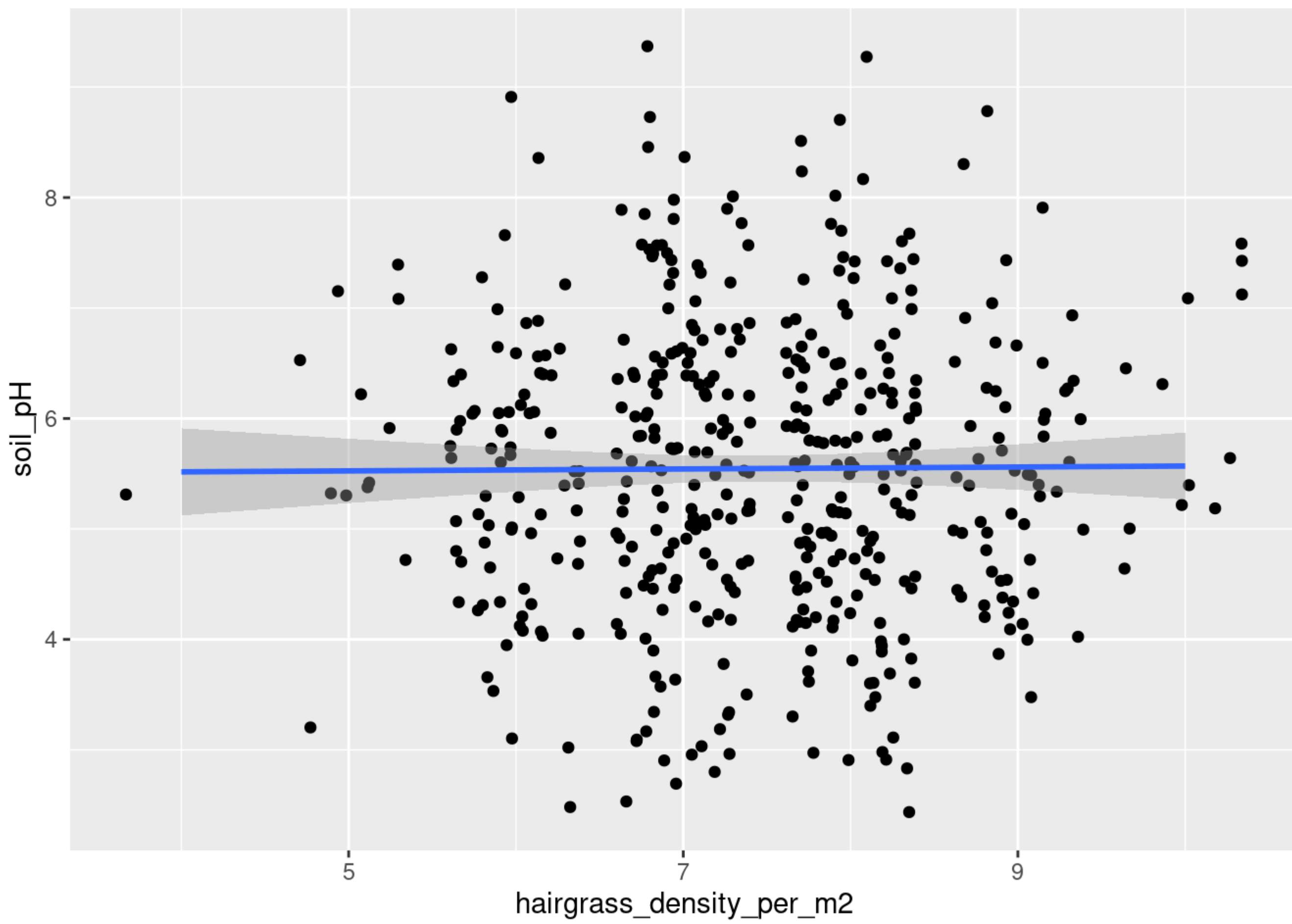
Data visualization, with the line of best fit, and summary statistics for soil pH

```
hairgrass %>% summarize(max(soil_pH),
                        min(soil_pH),
                        mean(soil_pH),
                        sd(soil_pH))
```

```
## # A tibble: 1 × 4
##   `max(soil_pH)` `min(soil_pH)` `mean(soil_pH)` `sd(soil_pH)
`
##            <dbl>          <dbl>           <dbl>         <dbl
>
## 1           9.37           2.44            5.55          1.3
0
```

```
ggplot(data=hairgrass, mapping=aes(x=hairgrass_density_per_m2,
y=soil_pH))+
  geom_jitter()+
  geom_smooth(method="lm")
```

```
## `geom_smooth()` using formula = 'y ~ x'
```



What is the correlation coefficient?

```
cor(x=hairgrass$hairgrass_density_per_m2, y=hairgrass$soil_pH)
```

```
## [1] 0.007200444
```

What is the model for our question about soil pH, without values?

```
# hairgrass density = m *  soil_pH + b
```

Create the model in R and calculate the values for m (slope) and b (y-intercept).

```
summary(lm(hairgrass_density_per_m2 ~ soil_pH, data = hairgras
s))
```

```
##
## Call:
## lm(formula = hairgrass_density_per_m2 ~ soil_pH, data = hair
grass)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.4403 -0.4491 -0.4271  0.5631  2.5637
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 7.408859   0.214051  34.613   <2e-16 ***
## soil_pH     0.005915   0.037570   0.157    0.875
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1
##
## Residual standard error: 1.071 on 478 degrees of freedom
## Multiple R-squared:  5.185e-05,  Adjusted R-squared:  -0.002
04
## F-statistic: 0.02478 on 1 and 478 DF,  p-value: 0.875
```

```
# model: hairgrass density =  0.006 * soil pH + 7.4
```

At alpha = 0.05, what do we conclude about the relationship between soil pH and hair grass density and why?

```
# Because the p-value associated with the F statistic was 0.87
5, we accept the null hypothesis that there is no relationship
between soil pH and hairgrass density. The slope of the line is
likely 0.
```

What does this mean for the road we are building?

```
# we shouldn't worry about soil pH as we think about where to b
uild our road
```