

Homework_3

2026-02-24

Set-up

```
suppressPackageStartupMessages({  
  library(tidyverse) # reads in tidyverse package  
  library(here) # reads in here package  
  library(janitor) # reads in janitor package  
  library(readxl) # reads in readxl package  
  library(performance)}) # reads in performance package  
# Stores the salinity data as an object called salinity  
salinity <- read.csv(here('data',"salinity-pickleweed.csv"))  
# Stores my personal data as an object called my_data  
my_data <- read.csv(here('data',"193DS data - stress (3).csv"))
```

Here is my GitHub Repository: https://github.com/samantha-gibson05/ENVS-193DS_homework-03

Problems

Problem 1. Slough soil salinity

You are working at a restoration site where you are managing planting of California pickleweed (*Salicornia virginica*) along a brackish slough (i.e. there is a mixture of fresh water and salt water).

You decide to measure plant growth for individual pickleweed plants by plucking an individual out of the ground and measuring the biomass (in g). You also measure salinity (as electrical conductivity in units of millisiemens per centimeter, or mS/cm) at the location in which the individual was growing. Admittedly, this isn't a perfect study, but it's what you can do with the time and resources you have!

a. An appropriate test

In 1-3 sentences, name the appropriate test(s) to determine the **strength of the relationship between salinity and California pickleweed biomass** (hint: there are two). Describe the differences between the two tests.

Be specific in your response to demonstrate your understanding of the variables in this question.

An appropriate parametric test is **Pearson's correlation coefficient (r)**, which assesses the strength and direction of a linear relationship between two continuous variables (soil salinity (mS/cm) and California pickleweed biomass (g)) assuming approximately normal distributions and independent observations. A non-parametric alternative is **Spearman's rank correlation (ρ)**, which evaluates the strength of a monotonic relationship using ranked values of salinity and biomass and does not require normality. Pearson's r tests linear association on raw data, whereas Spearman's ρ tests monotonic association based on ranks and is more flexible to non-normality and outliers.

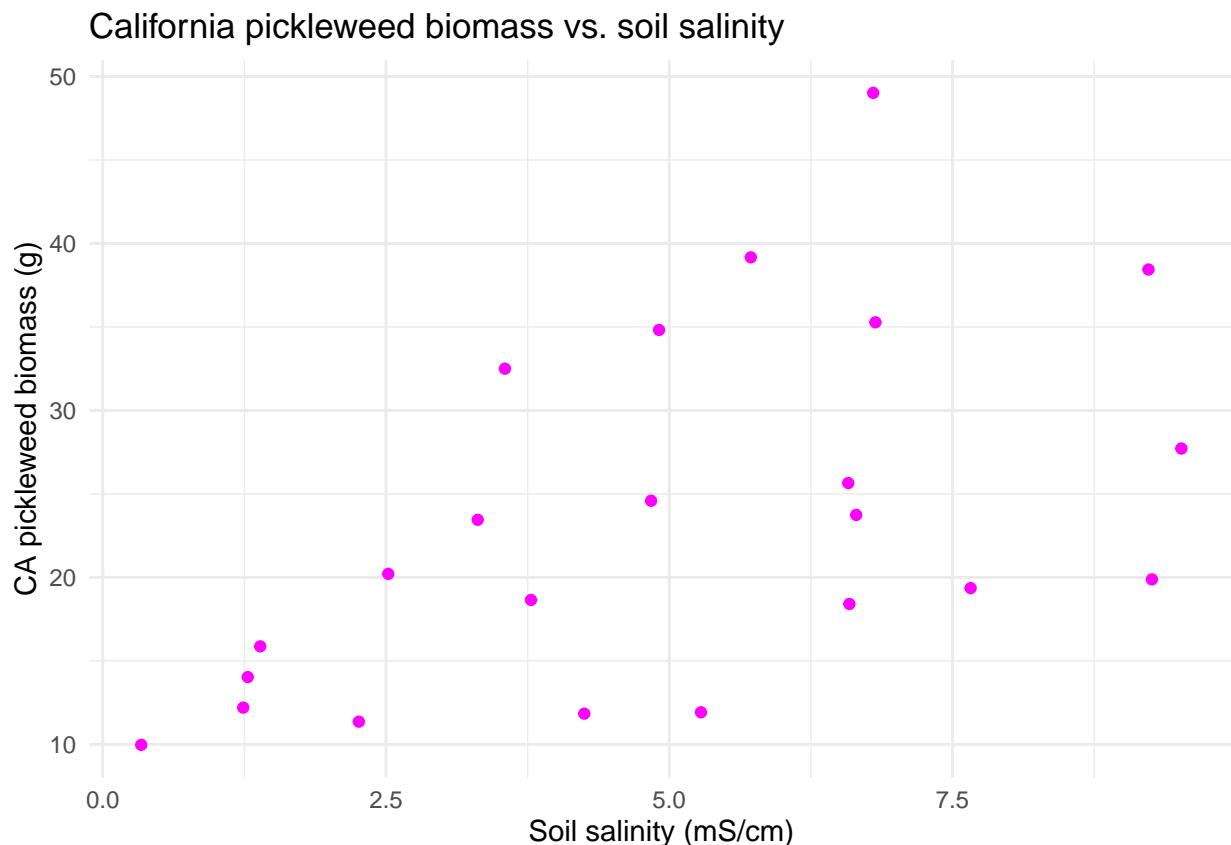
b. Create a visualization

Create a visualization that would be appropriate for showing the relationship between soil salinity (in mS/cm) and California pickleweed biomass (in g).

In addition to using the correct geometries, be sure to:

- relabel the x- and y-axes and include units
- use different colors from the `ggplot()` defaults
- use a different theme from the `ggplot()` default

```
# xxx check during OH xxx
ggplot(data = salinity, # uses salinity data
        aes(x = salinity_mS_cm, # x is soil salinity
            y = pickleweed)) + # y is soil pickleweed biomass
  geom_point(color = 'magenta') + # changes color from default
  labs(title = "California pickleweed biomass vs. soil salinity", # creates title
       x = "Soil salinity (mS/cm)", # relabels x-axis
       y = "CA pickleweed biomass (g)") + # relabels y-axis
  theme_minimal() # changes from default theme
```



c. Check your assumptions and run your test.

In the order that is appropriate, create separate sections using subheaders to:

- check your assumptions
- run your test

In each section, write the code to check your assumptions and run your test as you see fit.

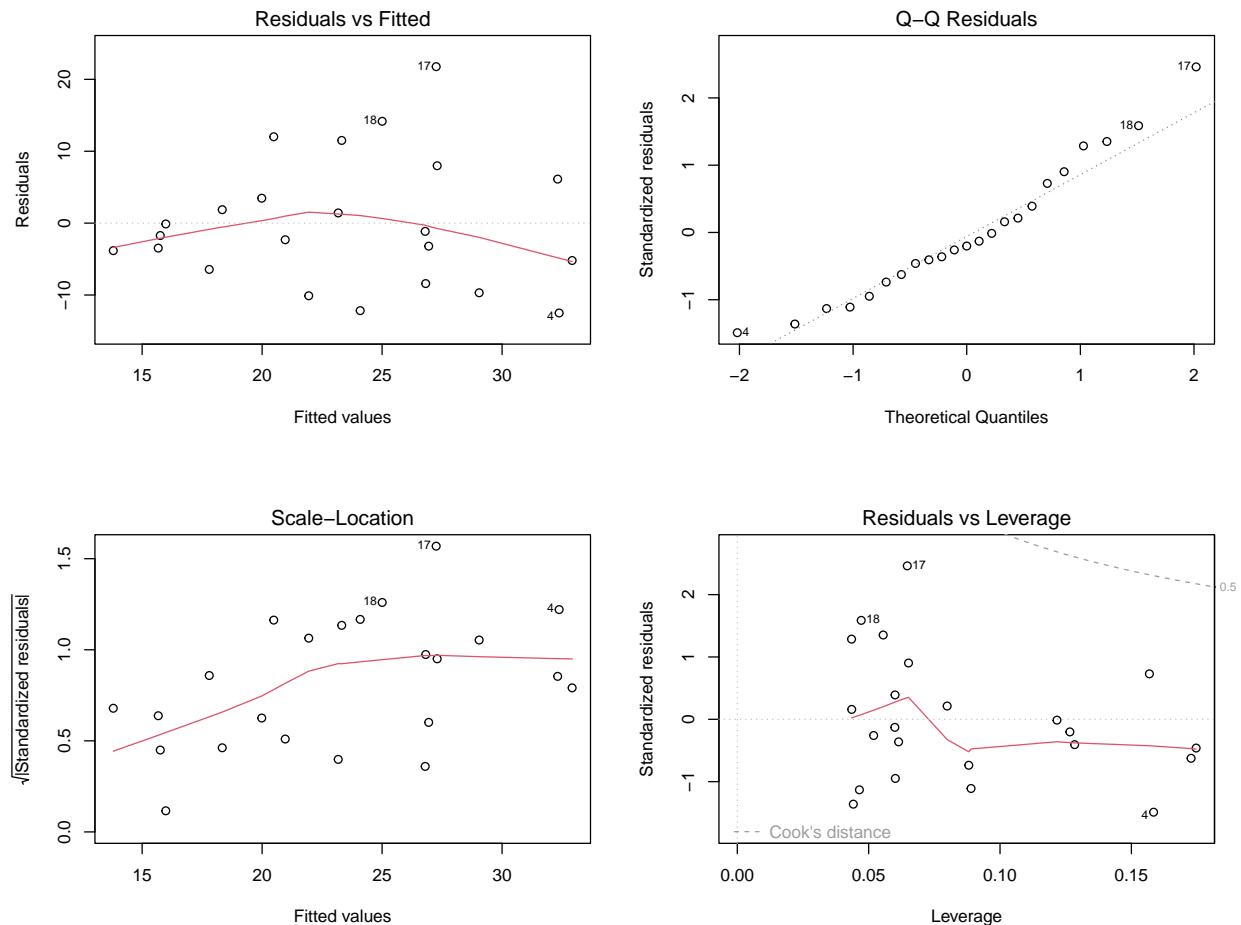
In the section in which you check your assumptions, write 1-3 sentences describing:

- which assumptions you checked
- how you checked your assumptions
- your assessment of your assumption checks

Part 1: Checking My Assumptions

```
# Fit linear model
salinity_model <- lm(pickleweed ~ salinity_mS_cm,
                      # response (biomass) ~ predictor (salinity)
                      data = salinity)
                     # uses salinity data

# Diagnostic plots
par(mfrow = c(2, 2)) # arrange plots in a 2x2 grid
plot(salinity_model) # generate plots based on salinity_model
```



I checked the assumptions needed for Pearson's correlation by fitting the linear model `salinity_model`, evaluating the 4 diagnostic plots, and ultimately deciding that the assumptions were met. Based on the Residuals vs Fitted + Scale-Location plots, residuals seem homoscedastic (mild evidence of increasing variance but consistent enough across values) and linear as well as normally distributed based on the Q-Q plot (the points mostly follow the reference line). By looking at the Residuals vs Leverage (Cook's distance) plot I determined there were no outliers that might influence model estimates or prediction.

Part 2: Running My Test

```
# Parametric Pearson's correlation test
cor.test(salinity$pickleweed, # pickleweed biomass variable from salinity df
          salinity$salinity_mS_cm, # salinity variable from salinity df
          method = "pearson") # specifies Pearson (linear assumption met)

##
##  Pearson's product-moment correlation
##
## data: salinity$pickleweed and salinity$salinity_mS_cm
## t = 2.8979, df = 21, p-value = 0.008605
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1568265 0.7757682
## sample estimates:
##        cor
## 0.5344778
```

d. Write about your methods and results.

In 1-3 sentences each, write about:

- which test you used, and why

I used Pearson's product-moment correlation because both soil salinity (mS/cm) and pickleweed biomass (g) are continuous variables, and the goal was to determine the strength of the relationship between these variables. The diagnostic plots indicated that assumptions of linear relationship between variables, normally distributed variables, and independent observations were reasonably met with some minor deviations from homoscedasticity. This made Pearson's correlation appropriate for evaluating this linear relationship.

- your interpretation of your test (along with the appropriate summary of the test in parentheses)

I found a moderate relationship (positive + linear) between soil salinity (in mS/cm) and California pickleweed biomass (in g) (Pearson's $r = 0.53$, $t(21) = 2.9$, $p = 0.01$, $\alpha = 0.05$). This indicates that pickleweed biomass tends to increase as salinity increases, suggesting that individuals may perform better under higher salinity conditions.

e. Write about the implications of your test.

You're working on a team of people at this restoration site who are also concerned about pickleweed planting. In 2-3 sentences, write what you would communicate to them about the results of this test and what it means for pickleweed planting success at your site.

Be cognizant of your audience as you are writing: what would they need to know to take action?

My analysis indicated a moderate positive relationship between soil salinity and pickleweed biomass (Pearson's $r = 0.53$, $t(21) = 2.9$, $p = 0.01$, $\alpha = 0.05$), meaning that plants in higher-salinity areas tended to be larger in the data sample. This suggests that pickleweed is performing well under the more saline conditions typical of the brackish portions of the slough, so prioritizing planting in areas with moderate to higher salinity may improve establishment and growth.

f. Double check your own work.

In part a, you outlined *two* potential tests to answer this question about the strength of the relationship between soil salinity and pickleweed biomass. In part c, you chose a test, checked your assumptions, and ran one.

Try running the *other* test you listed in part a. Include the annotated code and output.

```
# Non-Parametric Spearman's correlation test
cor.test(salinity$pickleweed, # pickleweed biomass variable from salinity df
          salinity$salinity_mS_cm, # salinity variable from salinity df
          method = "spearman") # specifies Spearman (no linear assumption)

##
##  Spearman's rank correlation rho
##
## data: salinity$pickleweed and salinity$salinity_mS_cm
## S = 824, p-value = 0.003426
## alternative hypothesis: true rho is not equal to 0
## sample estimates:
##      rho
## 0.5928854
```

In 1-3 sentences, describe whether or not the two tests would have led you to make the same decision (about the null hypothesis) and interpret the results the same way (about the relationship between soil salinity and pickleweed biomass).

In your description, be specific about the tests, their components, and their relation to the variables.

Yes, both Pearson's r and Spearman's ρ reject the null hypothesis of no association (Pearson's $r = 0.53$, $t(21) = 2.9$, $p = 0.009$, $\alpha = 0.05$; Spearman's $\rho = 0.59$, $S = 824$, $p < 0.003$, $\alpha = 0.05$). Both tests indicate a moderate positive relationship between soil salinity (mS/cm) and pickleweed biomass (g). The Spearman result is slightly stronger which is consistent with the diagnostics showing mild heteroscedasticity.

Problem 2. Personal data

a. Updating your visualizations

Revisit the visualizations you created in homework 2.

Provide the code and output for *updated* plots with your most recent observations.

Note: if you think that a *different* plot type or *different* variables would be more interesting to visualize, then change your plots!

You should have the annotated code and output for *two* plots.

For each plot, be sure to:

- label the x- and y- axes and provide units
- include the date of the most recent observation as a *subtitle*
- clean up the visual clutter (e.g. grids, backgrounds)
- use colors that are different from the `ggplot()` defaults

Visualization 1 (categorical predictor variable)

```
# Clean data
my_data_clean <- my_data |> # starts with the raw personal dataset
  clean_names() |> # standardizes column names (lowercase + underscores)
  # converts day_of_week to an ordered factor + display days in order (Mon-Sun)
  mutate(day_of_week = factor(day_of_week,
    levels = c("Monday", "Tuesday", "Wednesday", "Thursday",
              "Friday", "Saturday", "Sunday")))) |>
  # convert the column to Date format with the correct format string
  mutate(date = as.Date(date_mm_dd_yyyy, format = "%m/%d/%Y"))

# Collect the most recent date for the subtitle
most_recent_date <- my_data_clean |> # uses cleaned data set
  summarise(max_date = max(date)) |> # computes most recent obs date
  pull(max_date) # extracts most recent obs date

# Defines a list of colors to be used for each day of the week in the plot
week_colors <- c(
  "Monday"      = 'coral',
  "Tuesday"     = 'steelblue',
  "Wednesday"   = 'lavender',
  "Thursday"    = "pink",
  "Friday"      = 'limegreen',
  "Saturday"    = "yellow",
  "Sunday"      = "lightblue")
# ggplot base layer
ggplot(my_data_clean, # uses cleaned data
       aes(x = day_of_week, # categorical predictor (day of week) on x-axis
            y = time_stressed_min)) + # response (time stressed (min)) on y-axis
  # creates boxplot
  geom_boxplot( # creates boxplots by day
    aes(fill = day_of_week), # fills color by day of week
    width = 0.65, # sets box width
    alpha = 0.50, # sets transparency so points are visible
    outlier.shape = NA) + # hide default outlier dots
  geom_jitter( # adds jitter points of individual observations
    aes(color = day_of_week), # designates point color by day of week
    width = 0.12, # jitters horizontally to reduce overlap
    height = 0, # no vertical jitter
    alpha = 0.65, # sets transparency for readability
    size = 2) + # sets point size
  # creates scatter points for each day of the week
  scale_fill_manual(values = week_colors) + # applies custom fill colors
  scale_color_manual(values = week_colors, # applies custom point colors
                     guide = "none") + # hides legend
  labs(title = "Time stressed varies across days of the week", # creates title
       subtitle = paste("Most recent observation:", most_recent_date),
```

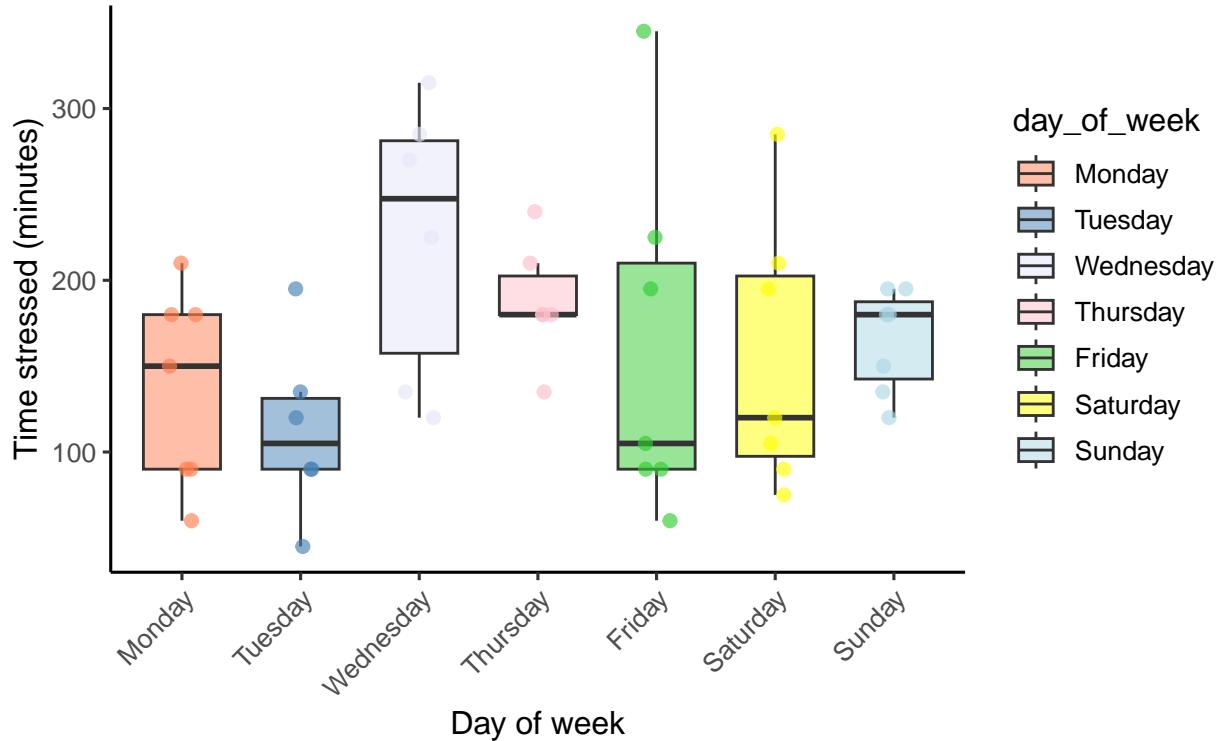
```

# creates subtitle with latest date
x = "Day of week", # creates x-axis label
y = "Time stressed (minutes)" + # creates y-axis label + units
theme_classic(base_size = 12) + # cleaner theme
theme(axis.text.x = element_text(angle = 45, hjust = 1), # rotate x-axis labels
legend.position = "right") # keep legend on right

```

Time stressed varies across days of the week

Most recent observation: 2026–02–23

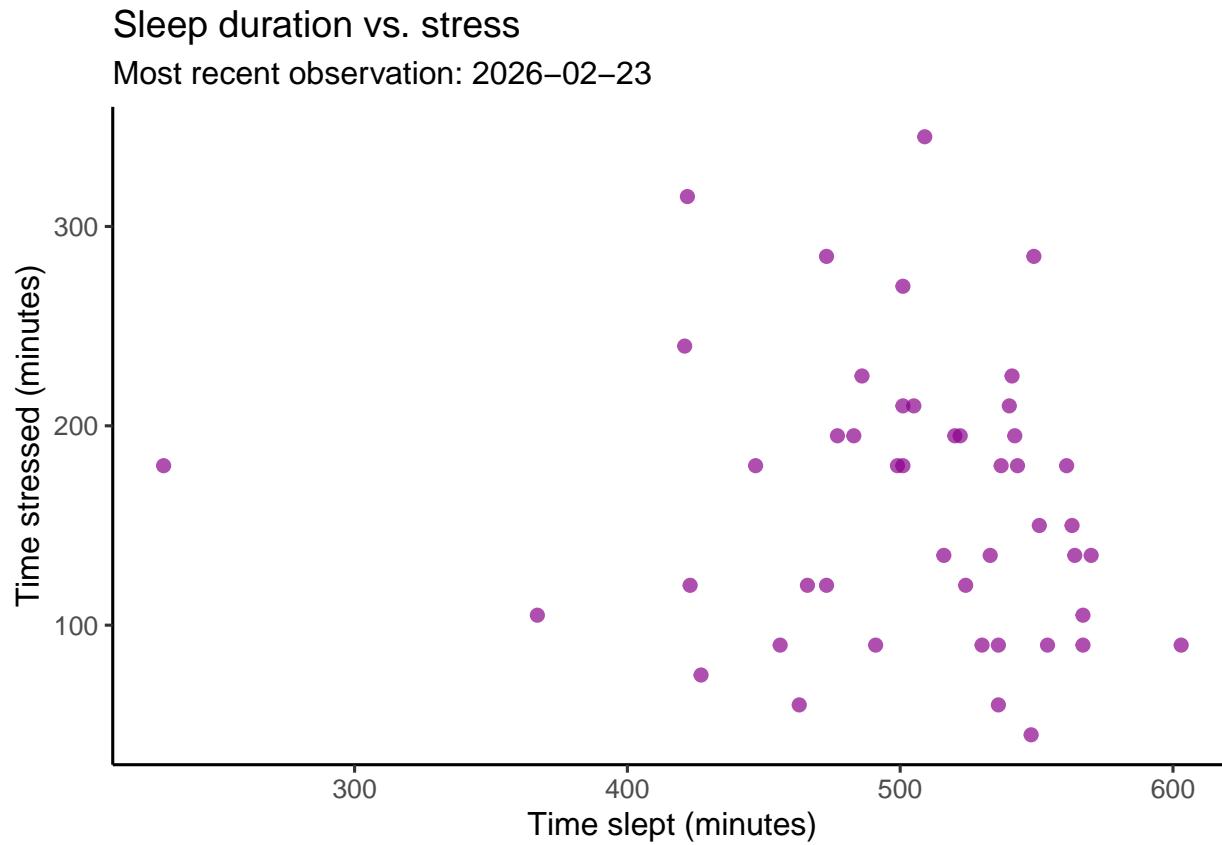


Visualization 2 (continuous predictor variable)

```

ggplot(data = my_data_clean, # uses cleaned data
       aes(x = time_slept_minutes, # continuous predictor (time slept (min)) on x-axis
            y = time_stressed_min)) + # response (time stressed (min)) on y-axis
geom_point( # plots individual days
            color = "magenta4", # changes color to purple
            alpha = 0.7, # sets transparency so points are visible
            size = 2) + # sets size of points
labs(title = "Sleep duration vs. stress", # creates title
      subtitle = paste("Most recent observation:", most_recent_date),
      # creates subtitle with latest date
      x = "Time slept (minutes)", # creates x-axis label
      y = "Time stressed (minutes)" + # creates y-axis label + units
      theme_classic(base_size = 12) # cleaner theme

```



b. Captions

In text (not in code), write captions for both your figures.

Figure 1. Time stressed varies across days of the week. Colored boxplots represent the distribution of daily time stressed (minutes) for each day of the week (Monday–Sunday). Boxes display the interquartile range (IQR), horizontal lines indicate medians, and whiskers extend to 1.5 times the IQR. Semi-transparent colored points represent individual daily observations which are jittered horizontally within each day to reduce overlap. The subtitle indicates the most recent observation included in the dataset. Data represent personal daily tracking records collected between January–February 2026 using an Oura ring .

Figure 2. Sleep duration is variably associated with daily stress levels. Purple circles represent individual daily observations of time slept (minutes) plotted against time stressed (minutes). Each point corresponds to a single recorded day. The subtitle indicates the most recent observation included in the dataset. Data represent personal daily tracking records collected between January–February 2026 using an Oura ring .