Run this in R:

```
unlink("08-lab-spatial2_student_files", recursive = TRUE)
unlink("08-lab-spatial2_student_cache", recursive = TRUE)
unlink("fig", recursive = TRUE)
```

Lab: Spatial data 2: Working with OBA data (Student Version)

Conservation/ecology Topics

- Species distributions

Computational Topics - Convert a data frame to a spatial object. - Plot multiple spatial layers.

Lab part 1: Oregon bee atlas data exploration

- 1a. Import the OBA data. (remember it's in the main data folder of the book and not in the labs folder, so you have to move back a folder)

```
oba <- read.csv("~/Downloads/ds-environ-main/labs/data/OBA_2018-2024.csv")
```

- 1b. Find the columns related to genus and species and paste them together (with a space between) using the function paste(). Name the new column GenusSpecies.

```
oba$GenusSpecies <- paste(oba$genus, oba$specificEpithet)
head(oba$GenusSpecies)
```

```
## [1] "Andrena prunorum"       "Andrena "
## [3] "Andrena hippotes"       "Andrena angustitarsata"
## [5] "Bombus vosnesenskii"    "Bombus vosnesenskii"
```

- 1c. Use `sort()` and `unique()` to print the unique values of GenusSpecies in alphabetical order. How many species are there? ANSWER: says there are 586 species according to this set

```
sort(unique(oba$GenusSpecies))
```

```
##   [1] " "                          "Agapostemon "
##   [3] "Agapostemon  femoratus"     "Agapostemon  subtilior"
##   [5] "Agapostemon  virescens "    "Agapostemon femoratus"
##   [7] "Agapostemon melliventris"   "Agapostemon subtilior"
##   [9] "Agapostemon virescens"      "Andrena "
##  [11] "Andrena  "                  "Andrena amphibola"
##  [13] "Andrena angustitarsata"     "Andrena anisochlora"
##  [15] "Andrena annectens"          "Andrena astragali"
##  [17] "Andrena barbilabris"        "Andrena bendensis"
##  [19] "Andrena birtwelli"          "Andrena candida"
##  [21] "Andrena candidiformis"      "Andrena cerasifolii"
##  [23] "Andrena chapmanae"          "Andrena chlorogaster"
```

```
##  [25] "Andrena citrinihirta"          "Andrena cleodora"
##  [27] "Andrena colletina"             "Andrena columbiana"
##  [29] "Andrena commoda"               "Andrena crataegi"
##  [31] "Andrena cressonii"             "Andrena cuneilabris"
##  [33] "Andrena cupreotincta"          "Andrena cyanophila"
##  [35] "Andrena erythrogaster"         "Andrena evoluta"
##  [37] "Andrena fuscicauda"            "Andrena hippotes"
##  [39] "Andrena hirticincta"           "Andrena hypoleuca"
##  [41] "Andrena illinoiensis"          "Andrena lawrencei"
##  [43] "Andrena macoupinensis"         "Andrena mariae"
##  [45] "Andrena medionitens"           "Andrena melanochroa"
##  [47] "Andrena merriami"              "Andrena microchlora"
##  [49] "Andrena miranda"               "Andrena miserabilis"
##  [51] "Andrena nevadensis"            "Andrena nigrocaerulea"
##  [53] "Andrena nivalis"               "Andrena nothocalaidis"
##  [55] "Andrena orthocarpi"            "Andrena pallidifovea"
##  [57] "Andrena pensilis"              "Andrena perarmata"
##  [59] "Andrena perplexa"              "Andrena piperi"
##  [61] "Andrena prunorum"              "Andrena quintiliformis"
##  [63] "Andrena salicifloris"          "Andrena scurra"
##  [65] "Andrena scutellinitens"        "Andrena semipunctata"
##  [67] "Andrena sladeni"               "Andrena striatifrons"
##  [69] "Andrena subaustralis"          "Andrena sulcata"
##  [71] "Andrena surda"                 "Andrena topazana"
##  [73] "Andrena transnigra"            "Andrena trevoris"
##  [75] "Andrena vicina"                "Andrena vicinoides"
##  [77] "Andrena w-scripta"             "Andrena walleyi"
##  [79] "Andrena wheeleri"              "Anthidiellum robertsoni"
##  [81] "Anthidium "                    "Anthidium  "
##  [83] "Anthidium  banningense"        "Anthidium  formosum"
##  [85] "Anthidium  illustre"           "Anthidium  palliventre"
##  [87] "Anthidium atrifrons"           "Anthidium atripes"
##  [89] "Anthidium banningense"         "Anthidium clypeodentatum"
##  [91] "Anthidium edwardsii"           "Anthidium emarginatum"
##  [93] "Anthidium formosum"            "Anthidium illustre"
##  [95] "Anthidium maculosum"           "Anthidium manicatum"
##  [97] "Anthidium mormonum"            "Anthidium oblongatum"
##  [99] "Anthidium palliventre"         "Anthidium placitum"
## [101] "Anthidium tenuiflorae"         "Anthidium utahense"
## [103] "Anthophora "                   "Anthophora affabilis"
## [105] "Anthophora albata"             "Anthophora bomboides"
## [107] "Anthophora californica"        "Anthophora crotchii"
## [109] "Anthophora curta"              "Anthophora edwardsii"
## [111] "Anthophora exigua"             "Anthophora maculifrons"
## [113] "Anthophora pacifica"           "Anthophora peritomae"
## [115] "Anthophora porterae"           "Anthophora terminalis"
## [117] "Anthophora urbana"             "Anthophora ursina"
## [119] "Anthophorula "                 "Anthophorula chionura"
## [121] "Apis mellifera"                "Ashmeadiella "
## [123] "Ashmeadiella  difugita"        "Ashmeadiella altadenae"
## [125] "Ashmeadiella aridula"          "Ashmeadiella bucconis"
## [127] "Ashmeadiella cactorum"         "Ashmeadiella californica"
## [129] "Ashmeadiella cubiceps"         "Ashmeadiella difugita"
## [131] "Ashmeadiella foveata"          "Ashmeadiella foxiella"
```

```
## [133] "Ashmeadiella meliloti"         "Ashmeadiella prosopidis"
## [135] "Ashmeadiella timberlakei"      "Atoposmia "
## [137] "Atoposmia abjecta"             "Atoposmia anthodyta"
## [139] "Atoposmia copelandica"         "Atoposmia elongata"
## [141] "Atoposmia oregona"             "Atoposmia triodonta"
## [143] "Biastes "                      "Biastes fulviventris"
## [145] "Bombus "                       "Bombus appositus"
## [147] "Bombus caliginosus"            "Bombus centralis"
## [149] "Bombus fervidus"               "Bombus flavidus"
## [151] "Bombus flavidus "              "Bombus flavifrons"
## [153] "Bombus griseocollis"           "Bombus huntii"
## [155] "Bombus impatiens"              "Bombus insularis"
## [157] "Bombus melanopygus"            "Bombus mixtus"
## [159] "Bombus morrisoni"              "Bombus nevadensis"
## [161] "Bombus occidentalis"           "Bombus rufocinctus"
## [163] "Bombus sitkensis"              "Bombus sitkensis "
## [165] "Bombus sylvicola"              "Bombus sylvicola "
## [167] "Bombus vagans"                 "Bombus vancouverensis"
## [169] "Bombus vandykei"               "Bombus vosnesenskii"
## [171] "Brachymelecta californica"     "Calliopsis "
## [173] "Calliopsis anthidia"           "Calliopsis coloradensis"
## [175] "Calliopsis edwardsii"          "Calliopsis fracta"
## [177] "Calliopsis michenerella"       "Calliopsis obscurella"
## [179] "Calliopsis personata"          "Calliopsis puellae"
## [181] "Calliopsis scitula"            "Calliopsis scutellaris"
## [183] "Calliopsis xenus"              "Centris "
## [185] "Ceratina "                     "Ceratina acantha"
## [187] "Ceratina acantha "             "Ceratina arizonensis"
## [189] "Ceratina dallatorreana"        "Ceratina hurdi"
## [191] "Ceratina micheneri"            "Ceratina nanula"
## [193] "Ceratina neomexicana"          "Ceratina pacifica"
## [195] "Ceratina sequoiae"             "Ceratina tejonensis"
## [197] "Chelostoma "                   "Chelostoma californicum"
## [199] "Chelostoma minutum"            "Chelostoma phaceliae"
## [201] "Coelioxys "                    "Coelioxys alternatus"
## [203] "Coelioxys apacheorum"          "Coelioxys banksi"
## [205] "Coelioxys deani"               "Coelioxys edita"
## [207] "Coelioxys erysimi"             "Coelioxys funerarius"
## [209] "Coelioxys grindeliae"          "Coelioxys hirsutissimus"
## [211] "Coelioxys moestus"             "Coelioxys novomexicanus"
## [213] "Coelioxys octodentatus"        "Coelioxys porterae"
## [215] "Coelioxys rufitarsis"          "Coelioxys serricaudatus"
## [217] "Coelioxys sodalis"             "Colletes "
## [219] "Colletes  "                    "Colletes compactus"
## [221] "Colletes consors"              "Colletes fulgidus"
## [223] "Colletes gypsicolens"          "Colletes kincaidii"
## [225] "Colletes ligatus"              "Colletes nigrifrons"
## [227] "Colletes phaceliae"            "Colletes simulans"
## [229] "Colletes slevini"              "Diadasia "
## [231] "Diadasia angusticeps"          "Diadasia australis"
## [233] "Diadasia bituberculata"        "Diadasia consociata"
## [235] "Diadasia diminuta"             "Diadasia enavata"
## [237] "Diadasia lutzi"                "Diadasia nigrifrons"
## [239] "Diadasia nitidifrons"          "Diadasia ochracea"
```

```
## [241] "Dianthidium "                "Dianthidium curvatum"
## [243] "Dianthidium dubium"          "Dianthidium heterulkei"
## [245] "Dianthidium parvum"          "Dianthidium platyurum"
## [247] "Dianthidium plenum"          "Dianthidium pudicum"
## [249] "Dianthidium singulare"       "Dianthidium subparvum"
## [251] "Dianthidium ulkei"           "Dioxys "
## [253] "Dioxys aurifuscus"           "Dioxys pacificus"
## [255] "Dioxys pomonae"              "Dioxys productus"
## [257] "Dufourea "                   "Dufourea holocyanea"
## [259] "Dufourea trochantera"        "Dufourea versatilis"
## [261] "Epeolus "                    "Epeolus compactus"
## [263] "Epeolus novomexicanus"       "Epeolus olympiellus"
## [265] "Epimelissodes obliqua"       "Eucera "
## [267] "Eucera acerba"               "Eucera actuosa"
## [269] "Eucera amsinckiae"           "Eucera cordleyi"
## [271] "Eucera edwardsii"            "Eucera frater"
## [273] "Eucera fulvitarsis"          "Eucera hurdi"
## [275] "Eucera lunata"               "Eucera speciosa"
## [277] "Eucera virgata"              "Habropoda "
## [279] "Habropoda  "                 "Habropoda cineraria"
## [281] "Habropoda dammersi"          "Habropoda depressa"
## [283] "Habropoda miserabilis"       "Habropoda tristissima"
## [285] "Halictus "                   "Halictus  confusus"
## [287] "Halictus  confusus "         "Halictus  farinosus"
## [289] "Halictus  ligatus"           "Halictus  rubicundus"
## [291] "Halictus  tripartitus"       "Halictus  tripartitus "
## [293] "Halictus confusus"           "Halictus farinosus"
## [295] "Halictus farinosus "         "Halictus ligatus"
## [297] "Halictus rubicundus"         "Halictus tripartitus"
## [299] "Halictus virgatellus"        "Heriades "
## [301] "Heriades carinata"           "Heriades cressoni"
## [303] "Heriades variolosa"          "Hesperapis carinata"
## [305] "Holcopasites pulchellus"     "Hoplitis "
## [307] "Hoplitis  "                  "Hoplitis albifrons"
## [309] "Hoplitis boharti"            "Hoplitis emarginata"
## [311] "Hoplitis fulgida"            "Hoplitis grinnelli"
## [313] "Hoplitis hypocrita"          "Hoplitis louisae"
## [315] "Hoplitis orthognatha"        "Hoplitis plagiostoma"
## [317] "Hoplitis producta"           "Hoplitis remotula"
## [319] "Hoplitis robusta"            "Hoplitis sambuci"
## [321] "Hoplitis uvulalis"           "Hoplitis viridimicans"
## [323] "Hylaeus "                    "Hylaeus basalis"
## [325] "Hylaeus mesillae"            "Hylaeus Mesillae"
## [327] "Hylaeus nunenmacheri"        "Lasioglossum "
## [329] "Lasioglossum  "              "Lasioglossum  anhypops"
## [331] "Lasioglossum  helianthi"     "Lasioglossum  trizonatum "
## [333] "Lasioglossum aberrans"       "Lasioglossum albipenne"
## [335] "Lasioglossum albohirtum"     "Lasioglossum allonotus"
## [337] "Lasioglossum anhypops"       "Lasioglossum argemonis"
## [339] "Lasioglossum aspilurum"      "Lasioglossum boreale"
## [341] "Lasioglossum brunneiventre"  "Lasioglossum buccale"
## [343] "Lasioglossum californicum"   "Lasioglossum cembrilacus"
## [345] "Lasioglossum colatum"        "Lasioglossum cooleyi"
## [347] "Lasioglossum cordleyi"       "Lasioglossum cressonii"
```

```
## [349] "Lasioglossum dashwoodi"        "Lasioglossum diatretum"
## [351] "Lasioglossum diversopunctatum" "Lasioglossum ebmerellum"
## [353] "Lasioglossum egregium"         "Lasioglossum glabriventre"
## [355] "Lasioglossum helianthi"        "Lasioglossum hudsoniellum"
## [357] "Lasioglossum hyalinum"         "Lasioglossum incompletum"
## [359] "Lasioglossum incompletum "     "Lasioglossum inconditum"
## [361] "Lasioglossum kincaidii"        "Lasioglossum knereri"
## [363] "Lasioglossum laevissimum"      "Lasioglossum lusoria"
## [365] "Lasioglossum lusorium"         "Lasioglossum macoupinense"
## [367] "Lasioglossum macroprosopum"    "Lasioglossum marinense"
## [369] "Lasioglossum megastictus"      "Lasioglossum mellipes"
## [371] "Lasioglossum nevadense"        "Lasioglossum nigrum"
## [373] "Lasioglossum novascotiae"      "Lasioglossum occultum"
## [375] "Lasioglossum occulturn"        "Lasioglossum olympiae"
## [377] "Lasioglossum orthocarpi"       "Lasioglossum ovaliceps"
## [379] "Lasioglossum pacatum"          "Lasioglossum pacificum"
## [381] "Lasioglossum pacificum "       "Lasioglossum pavonotus"
## [383] "Lasioglossum prasinogaster"    "Lasioglossum pruinosum"
## [385] "Lasioglossum pulveris"         "Lasioglossum punctatoventre"
## [387] "Lasioglossum quebecense"       "Lasioglossum robustum"
## [389] "Lasioglossum ruidosense"       "Lasioglossum sandhousiellum"
## [391] "Lasioglossum sedi"             "Lasioglossum sequoiae"
## [393] "Lasioglossum sisymbrii"        "Lasioglossum tegulariforme"
## [395] "Lasioglossum tenax"            "Lasioglossum testaceum"
## [397] "Lasioglossum titusi"           "Lasioglossum titusi "
## [399] "Lasioglossum trizonatum"       "Lasioglossum tuolumnense"
## [401] "Lasioglossum villosulum"       "Lasioglossum yukonae"
## [403] "Lasioglossum zephyrus"         "Lasioglossum zonulus"
## [405] "Megachile "                    "Megachile  perihirta"
## [407] "Megachile addenda"             "Megachile angelarum"
## [409] "Megachile anograe"             "Megachile apicalis"
## [411] "Megachile brevis"              "Megachile centuncularis"
## [413] "Megachile cleomis"             "Megachile coquilletti"
## [415] "Megachile fidelis"             "Megachile frigida"
## [417] "Megachile gemula"              "Megachile gentilis"
## [419] "Megachile gravita"             "Megachile inermis"
## [421] "Megachile inimica"             "Megachile lapponica"
## [423] "Megachile lippiae"             "Megachile manifesta"
## [425] "Megachile melanophaea"         "Megachile mellitarsis"
## [427] "Megachile montivaga"           "Megachile nevadensis"
## [429] "Megachile onobrychidis"        "Megachile parallela"
## [431] "Megachile perihirta"           "Megachile pseudonigra"
## [433] "Megachile pugnata"             "Megachile relativa"
## [435] "Megachile rotundata"           "Megachile subnigra"
## [437] "Megachile texana"              "Megachile umatillensis"
## [439] "Megachile wheeleri"            "Melecta "
## [441] "Melecta edwardsii"             "Melecta pacifica"
## [443] "Melecta separata"              "Melecta thoracica"
## [445] "Melissodes "                   "Melissodes agilis"
## [447] "Melissodes bimatris"           "Melissodes clarkiae"
## [449] "Melissodes communis"           "Melissodes dagosus"
## [451] "Melissodes glenwoodensis"      "Melissodes lupinus"
## [453] "Melissodes lustrus"            "Melissodes metenuus"
## [455] "Melissodes microstictus"       "Melissodes pallidisignatus"
```

```
## [457] "Melissodes rivalis"           "Melissodes robustior"
## [459] "Melissodes semilupinus"       "Micralictoides ruficaudus"
## [461] "Neolarra "                    "Neolarra vandykei"
## [463] "Neolarra vigilans"            "Nomada "
## [465] "Nomia "                       "Nomia melanderi"
## [467] "Oreopasites "                 "Oreopasites vanduzeei"
## [469] "Osmia "                       "Osmia  "
## [471] "Osmia  densa"                 "Osmia  kincaidii"
## [473] "Osmia  lignaria"              "Osmia  longula"
## [475] "Osmia  montana"               "Osmia  nemoris"
## [477] "Osmia  obliqua"               "Osmia aglaia"
## [479] "Osmia albolateralis"          "Osmia ashmeadii"
## [481] "Osmia atriventris"            "Osmia atrocyanea"
## [483] "Osmia bella"                  "Osmia brevis"
## [485] "Osmia bruneri"                "Osmia bucephala"
## [487] "Osmia caerulescens"           "Osmia californica"
## [489] "Osmia calla"                  "Osmia cara"
## [491] "Osmia caraformis"             "Osmia cobaltina"
## [493] "Osmia coloradensis"           "Osmia cornifrons"
## [495] "Osmia cyanella"               "Osmia cyaneonitens"
## [497] "Osmia densa"                  "Osmia dolerosa"
## [499] "Osmia ednae"                  "Osmia enixa"
## [501] "Osmia exigua"                 "Osmia gabrielis"
## [503] "Osmia gaudiosa"               "Osmia giliarum"
## [505] "Osmia glauca"                 "Osmia grinnelli"
## [507] "Osmia inermis"                "Osmia integra"
## [509] "Osmia inurbana"               "Osmia juxta"
## [511] "Osmia kincaidii"              "Osmia laeta"
## [513] "Osmia lanei"                  "Osmia lignaria"
## [515] "Osmia longula"                "Osmia malina"
## [517] "Osmia marginipennis"          "Osmia melanopleura"
## [519] "Osmia montana"                "Osmia nanula"
## [521] "Osmia nemoris"                "Osmia nifoata"
## [523] "Osmia nigrifrons"             "Osmia obliqua"
## [525] "Osmia odontogaster"           "Osmia paradisica"
## [527] "Osmia pentstemonis"           "Osmia pikei"
## [529] "Osmia proxima"                "Osmia pusilla"
## [531] "Osmia raritatis"              "Osmia rawlinsi"
## [533] "Osmia regulina"               "Osmia ribifloris"
## [535] "Osmia sanrafaelae"            "Osmia sculleni"
## [537] "Osmia simillima"              "Osmia subaustralis"
## [539] "Osmia tanneri"                "Osmia tarsata"
## [541] "Osmia tersula"                "Osmia texana"
## [543] "Osmia thysanisca"             "Osmia trevoris"
## [545] "Osmia tristella"              "Osmia unca"
## [547] "Osmia vandykei"               "Panurginus "
## [549] "Peponapis pruinosa"           "Perdita "
## [551] "Perdita albipennis"           "Perdita nevadensis"
## [553] "Protandrena "                 "Protohalonia venusta"
## [555] "Protosmia rubifloris"         "Pseudoanthidium nanum"
## [557] "Sphecodes "                   "Sphecodes arvensiformis"
## [559] "Sphecodes davisii"            "Sphecodes kincaidii"
## [561] "Sphecodes olympicus"          "Sphecodes pecosensis"
## [563] "Stelis "                      "Stelis ashmeadiellae"
```

```
## [565] "Stelis carnifex"                "Stelis laticincta"
## [567] "Stelis monticola"               "Stelis rubi"
## [569] "Stelis subemarginata"           "Tetraloniella pomonae"
## [571] "Trachusa timberlakei"           "Triepeolus "
## [573] "Triepeolus argyreus"            "Triepeolus californicus"
## [575] "Triepeolus concavus"            "Triepeolus helianthi"
## [577] "Triepeolus lunatus"             "Triepeolus melanarius"
## [579] "Triepeolus paenepectoralis"     "Triepeolus utahensis"
## [581] "Triepeolus verbesinae complex" "Xenoglossodes "
## [583] "Xylocopa "                      "Xylocopa californica"
## [585] "Xylocopa tabaniformis"          "Xylocopa virginica"
## [587] "Zacosmia maculata"
```

Some specimens are not identified to species, only genus. How is this reflected in the data?

- 1d. So many bees, so little time. Count up the occurrences of each bee species, and subset the data to bees that have been seen at least two times. You can use the tidyverse or any other functions in R that you like. How many "species" are there?

```
oba_counts <- oba %>%
  group_by(GenusSpecies) %>%
  summarise(count = n()) %>%
  filter(count >= 2)

glimpse(oba_counts)
```

```
## Rows: 531
## Columns: 2
## $ GenusSpecies <chr> " ", "Agapostemon ", "Agapostemon  femoratus", "~
## $ count        <int> 88745, 366, 372, 149, 44, 375, 36, 1064, 636, 86~
```

- 1e. Google a few bee names (that have been seen > 2 times) and find one with an a look that resonates with you.

What is the name of your bee? - Osmia proxima

Import the photos into Rmarkdown below (hint: googling bee name "discover life" or "inat" can often get you a photo. Many bees will no have any photos :(use the forma

Lab part 2: Plotting the distribution of your spirit bee.

Now that have chosen your spirit bee, we would like to plot it's distribution. What is the crs of the data? Annoyingly it is not described anywhere in the spreadsheet (always list your crs in your data) but it is the same as what inat uses because all bees have a georeferenced plant host. If the data is in lat long, it is "unprojected" so only a datum will be listed.

DATUM: WGS84, unprojected lat long. EPSG code: 4326

```
crs("EPSG:4326")
```

```
## [1] "GEOGCRS[\"WGS 84\",\n    ENSEMBLE[\"World Geodetic System 1984 ensemble\",\n        MEMBER[\"Wo
```

```
st_crs(4326)
```

```
## Coordinate Reference System:
##   User input: EPSG:4326
##   wkt:
## GEOGCRS["WGS 84",
##     ENSEMBLE["World Geodetic System 1984 ensemble",
##         MEMBER["World Geodetic System 1984 (Transit)"],
##         MEMBER["World Geodetic System 1984 (G730)"],
##         MEMBER["World Geodetic System 1984 (G873)"],
##         MEMBER["World Geodetic System 1984 (G1150)"],
##         MEMBER["World Geodetic System 1984 (G1674)"],
##         MEMBER["World Geodetic System 1984 (G1762)"],
##         MEMBER["World Geodetic System 1984 (G2139)"],
##         MEMBER["World Geodetic System 1984 (G2296)"],
##         ELLIPSOID["WGS 84",6378137,298.257223563,
##             LENGTHUNIT["metre",1]],
##         ENSEMBLEACCURACY[2.0]],
##     PRIMEM["Greenwich",0,
##         ANGLEUNIT["degree",0.0174532925199433]],
##     CS[ellipsoidal,2],
##         AXIS["geodetic latitude (Lat)",north,
##             ORDER[1],
##             ANGLEUNIT["degree",0.0174532925199433]],
##         AXIS["geodetic longitude (Lon)",east,
##             ORDER[2],
##             ANGLEUNIT["degree",0.0174532925199433]],
##     USAGE[
##         SCOPE["Horizontal component of 3D system."],
##         AREA["World."],
##         BBOX[-90,-180,90,180]],
##     ID["EPSG",4326]]
```

- 2a. Extract the X and Y locations for your species only from the data and create a spatial object. Don't forget to set the CRS! Hint 1: consider what other data you would like to keep as attributes, for example what flower they were foraging on. Hint 2: Remember the lat is y and long is x. Hint 3: You may want to rename the column names you can use, `colnames()` or `rename()` from dplyr and reassign the names. This is only if you don't love the names they already have.

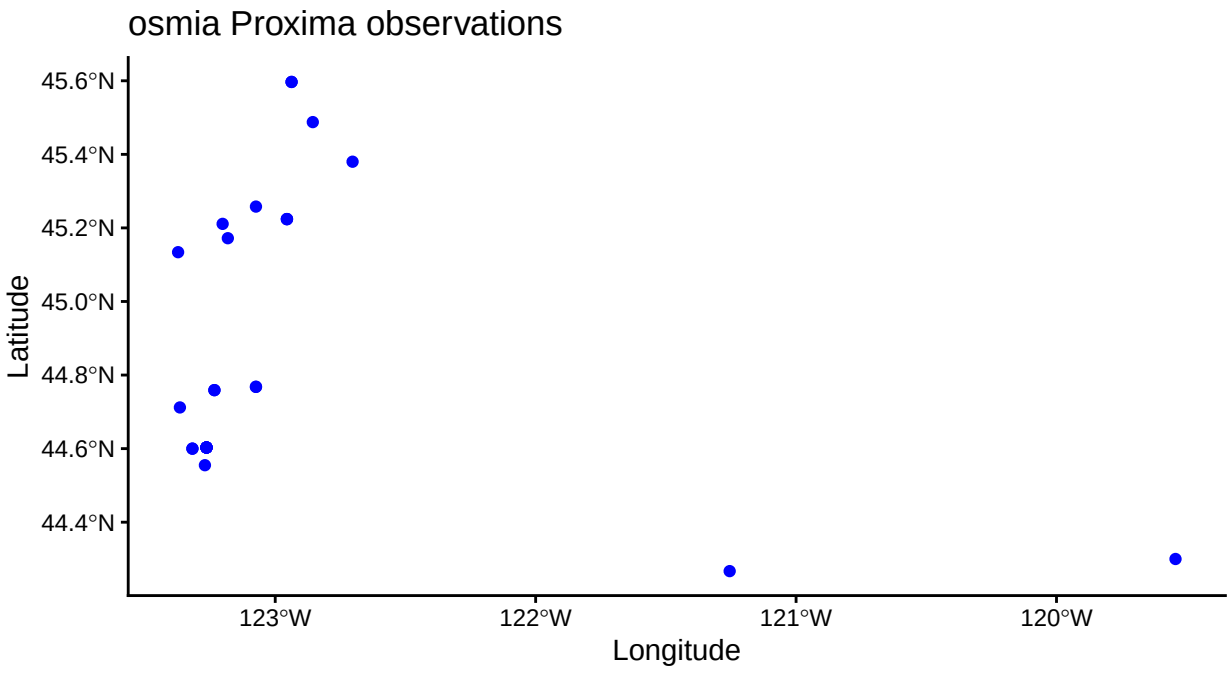
```
osmiaproxima_df <- oba %>%
  filter(GenusSpecies == "Osmia proxima") %>%
  select(GenusSpecies, speciesPlant, locality, decimalLongitude, decimalLatitude)


osmiaproxima_df <- osmiaproxima_df  %>%
  rename(
    long = decimalLongitude,
    lat = decimalLatitude,
```

```
    flower = speciesPlant
  )

osmiaproxima_sf <- st_as_sf(osmiaproxima_df,
                            coords = c("long", "lat"),
                            crs = 4326)

glimpse(osmiaproxima_so)
```

```
## Rows: 28
## Columns: 4
## $ GenusSpecies <chr> "Osmia proxima", "Osmia proxima", "Osmia proxima~
## $ flower       <chr> "Penstemon hesperius", "Penstemon hesperius", "P~
## $ locality     <chr> "Oregon", "Oregon", "Oregon", "Tualatin 2661 SW ~
## $ geometry     <POINT [°]> POINT (-122.955 45.224), POINT (-122.955 4~
```

- 2b. Plot your exciting bee data!

```
ggplot() +
  geom_sf(data = osmiaproxima_sf,
          color = "blue") +
  theme_classic() +
  labs(title = "osmia Proxima observations",
       x = "Longitude", y = "Latitude")
```



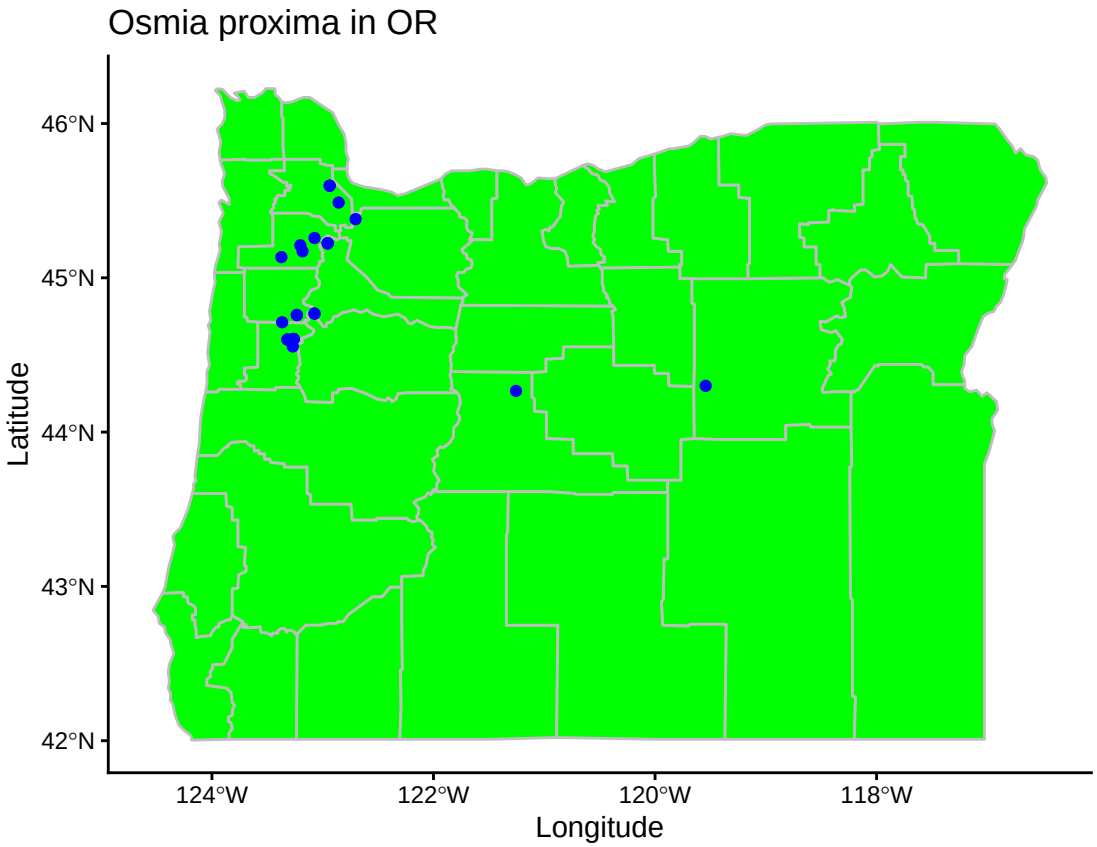
Not so exciting without some kind of background…

Luckily we can download basemaps into R using the map_data function in ggplot (among many others). There is an example for retrieving the Oregon county polygons.

```
or <- map_data("county", "oregon") %>%
  select(lon = long, lat, group, id = subregion)
```

- 2c. Add your species's points to your choice or an Oregon basemap.

```
# Bee data as sf object
osmiaproxima_sf <- oba %>%
  filter(GenusSpecies == "Osmia proxima") %>%
  st_as_sf(coords = c("decimalLongitude", "decimalLatitude"), crs = 4326)

# Plot
ggplot() +
  geom_polygon(data = or, aes(x = lon, y = lat, group = group),
               fill = "green", color = "gray") +
  geom_sf(data = osmiaproxima_sf, color = "blue") +
  labs(title = "Osmia proxima in OR", x = "Longitude", y = "Latitude") +
  theme_classic()
```



Lab part 3: Cartography

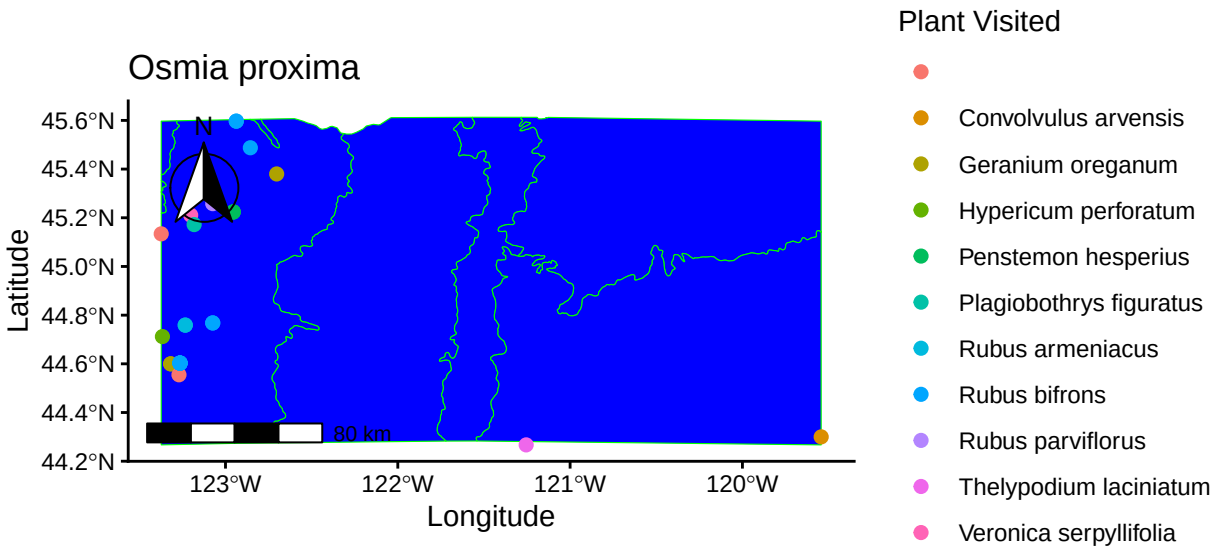
- 3a. Here is your moment to explore your cartographic skills.

1. Add the ecoregion shape file (in data/OR-ecoregions) and tweek the Oregon map in anyway that is useful/visually appealing. You may need to crop that layer to the extent of your species's distribution if it is only in a few ecoregions.
2. Color your points according to some data attribute and add a legend (month collected, county, collector, associated plant, whatever you think is interesting). You may need to circle back to 2.1 to save additional attributes when you converted the dataframe to a spatial object.
3. Fine-tune your map: add a title, make sure the legend label makes sense, add a scale bar (google "add scale bar map ggplot" and choose your favorite package). All maps must always have a scale bar. You can add a N arrow as well, though some cartographers argue that is only necessary if N isn't at the top of the map.

```
ecoregions <- st_read( "~/Downloads/ds-environ-main/labs/data/OR-ecoregions/Ecoregions_OregonConservati
```

```
## Reading layer `Ecoregions_OregonConservationStrategy' from data source
##   `/Users/vgarfield03/Downloads/ds-environ-main/labs/data/OR-ecoregions/Ecoregions_OregonConservatio
##   using driver `ESRI Shapefile'
## Simple feature collection with 9 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 183871.7 ymin: 88600.88 xmax: 2345213 ymax: 1675043
## Projected CRS: NAD83 / Oregon GIC Lambert (ft)
```

```
osmiaproxima_sf <- oba %>%
  filter(GenusSpecies == "Osmia proxima") %>%
  st_as_sf(coords = c("decimalLongitude", "decimalLatitude"), crs = 4326) %>%
  select(GenusSpecies, speciesPlant,locality)
# cropping eco regions to match CRS, also looked this up
ecoregions <- st_transform(ecoregions, st_crs(osmiaproxima_sf))


## croppping, didnt know how to do this, so I looked it up.
bbox <- st_bbox(osmiaproxima_sf)
ecoregions_crop <- st_crop(ecoregions, bbox)

#graphing
ggplot() +
  geom_sf(data = ecoregions_crop, fill = "blue", color = "green") +
  geom_sf(data = osmiaproxima_sf, aes(color = speciesPlant), size = 2) +  # fixed parentheses
  labs(title = "Osmia proxima", x = "Longitude", y = "Latitude", color = "Plant Visited") +
  theme_classic() +
  # scale bar at bottom left
  annotation_scale(location = "bl", width_hint = 0.3) +
  annotation_north_arrow(location = "tl", style = north_arrow_fancy_orienteering())
```



4. Write a figure caption for your map explaining any interesting trends you see. This graph abocve is the ditribution of osmia Proxima across oregon. Points shown are colored by plant species. Most of these observations are based in the western part of Oregon, where in the eastern part of oregon we see a decrease in osmia proxima. This could be because of an abundance of identifiers in this area of Oregon, or habitat avilability in this area. We have a map that includes ecoregios, a scale bar and a northern arrow for spatial assesmen.

5. Export your cropped layer to a .shp so you can use it again for your final project.

```
# Save the cropped ecoregions for future use
st_write(ecoregions_crop, "data/OR-ecoregions-cropped-v2.shp", append = TRUE)
```

```
## Updating layer `OR-ecoregions-cropped-v2' to data source `data/OR-ecoregions-cropped-v2.shp' using di
## Updating existing layer OR-ecoregions-cropped-v2
## Writing 6 features with 6 fields and geometry type Unknown (any).
```

We are looking forward to seeing the maps you create!

Lab part 4: Spatial summary statistics For your final projects, you will likely need to come up with summary statistics that describes the areas around where bees are captured.

- 4a. Using the distribution of your chosen bee and the a raster spatial layer from Oregon Geohub, extract a meaningful summary statistics from your spatial layer within a buffer of 500, 750 1000 m.
- 4b. Create a plot that illustrates this summary data (box plot, barplot, scatter plot, historgram).

- 4c. Create a map of your cropped spatial data.

```
raster_layer <- rast(" ~/Downloads/ds-environ-main/labs/data/Annual_NLCD_LndCov_2020_CU_C1V1.tif")

buffers <- c(500,750,1000)

osmiaproxima_sf <- st_transform(osmiaproxima_sf, crs = crs(raster_layer))

buffers <- bind_rows(
  st_buffer(osmiaproxima_sf, dist = 500)  %>% mutate(buffer_size = 500),
  st_buffer(osmiaproxima_sf, dist = 750)  %>% mutate(buffer_size = 750),
  st_buffer(osmiaproxima_sf, dist = 1000) %>% mutate(buffer_size = 1000)
)

raster_values <- extract(raster_layer, vect(buffers), fun = mean, na.rm = TRUE)



buffers <- osmiaproxima_sf %>%
  st_buffer(dist = 500) %>%
  mutate(buffer_size = 500) %>%
  rbind(
    st_buffer(osmiaproxima_sf, dist = 750) %>% mutate(buffer_size = 750),
    st_buffer(osmiaproxima_sf, dist = 1000) %>% mutate(buffer_size = 1000)
  )

buffers_summary <- bind_cols(buffers, raster_values)

head(buffers_summary)
```

```
## Simple feature collection with 6 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -2134729 ymin: 2709569 xmax: -2062899 ymax: 2780303
## Projected CRS: AEA        WGS84
##    GenusSpecies        speciesPlant                    locality
## 1 Osmia proxima Penstemon hesperius                      Oregon
## 2 Osmia proxima Penstemon hesperius                      Oregon
## 3 Osmia proxima Penstemon hesperius                      Oregon
## 4 Osmia proxima   Geranium oreganum Tualatin 2661 SW Borland Rd
## 5 Osmia proxima   Geranium oreganum     Corvallis, NW Covey Run
## 6 Osmia proxima   Geranium oreganum     Corvallis, NW Covey Run
##   buffer_size ID Annual_NLCD_LndCov_2020_CU_C1V1
## 1         500  1                         78.07094
## 2         500  2                         78.07094
## 3         500  3                         78.07094
## 4         500  4                         34.80778
## 5         500  5                         56.80161
## 6         500  6                         56.80161
##                          geometry
## 1 POLYGON ((-2086703 2768646,...
## 2 POLYGON ((-2086703 2768646,...
## 3 POLYGON ((-2086703 2768646,...
## 4 POLYGON ((-2062899 2779803,...
```

```
## 5 POLYGON ((-2133729 2710069,...
## 6 POLYGON ((-2133729 2710069,...
```

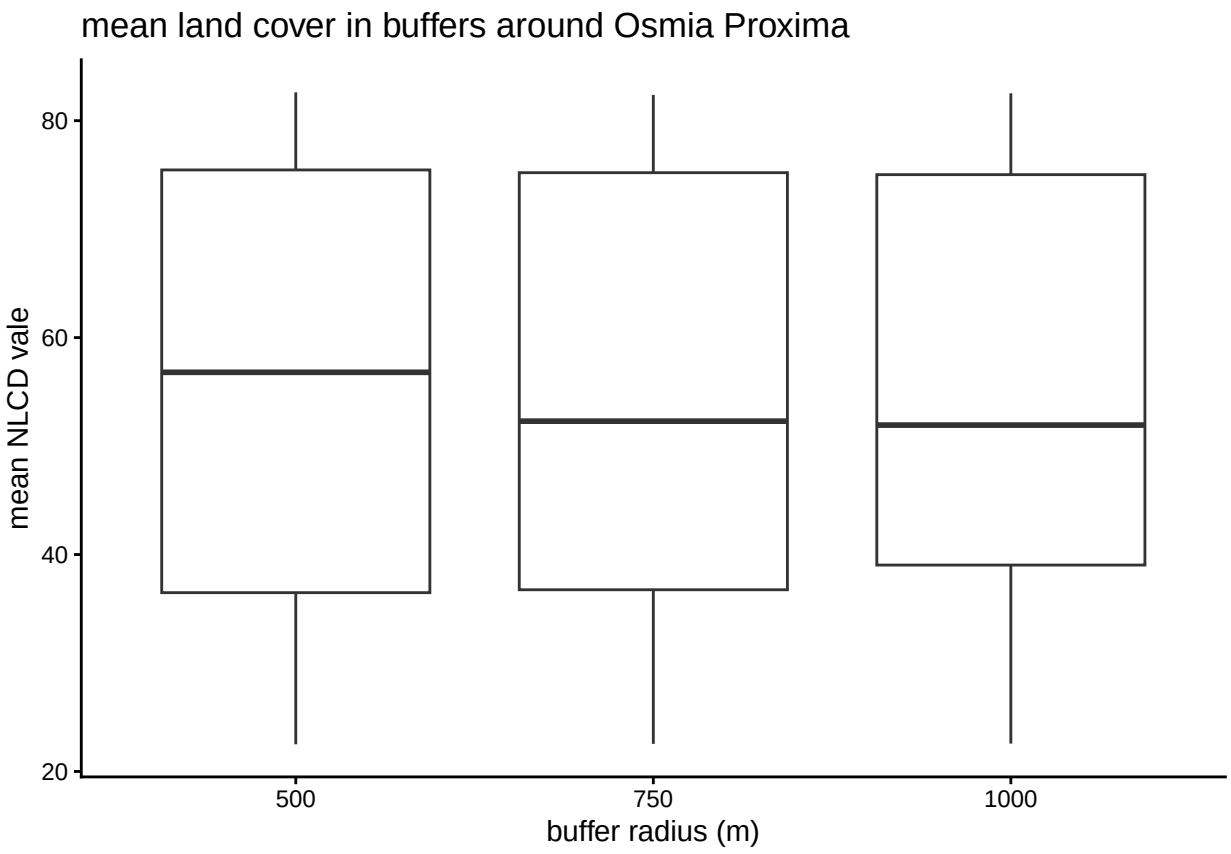
```
names(raster_layer)
```

```
## [1] "Annual_NLCD_LndCov_2020_CU_C1V1"
```

```
raster_values <- extract(raster_layer, vect(buffers), fun = mean, na.rm = TRUE)
buffers_summary <- cbind(buffers, raster_values)

head(buffers_summary)
```

```
## Simple feature collection with 6 features and 6 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -2134729 ymin: 2709569 xmax: -2062899 ymax: 2780303
## Projected CRS: AEA        WGS84
##    GenusSpecies        speciesPlant                    locality
## 1 Osmia proxima Penstemon hesperius                      Oregon
## 2 Osmia proxima Penstemon hesperius                      Oregon
## 3 Osmia proxima Penstemon hesperius                      Oregon
## 4 Osmia proxima   Geranium oreganum Tualatin 2661 SW Borland Rd
## 5 Osmia proxima   Geranium oreganum     Corvallis, NW Covey Run
## 6 Osmia proxima   Geranium oreganum     Corvallis, NW Covey Run
##   buffer_size ID Annual_NLCD_LndCov_2020_CU_C1V1
## 1         500  1                         78.07094
## 2         500  2                         78.07094
## 3         500  3                         78.07094
## 4         500  4                         34.80778
## 5         500  5                         56.80161
## 6         500  6                         56.80161
##                          geometry
## 1 POLYGON ((-2086703 2768646,...
## 2 POLYGON ((-2086703 2768646,...
## 3 POLYGON ((-2086703 2768646,...
## 4 POLYGON ((-2062899 2779803,...
## 5 POLYGON ((-2133729 2710069,...
## 6 POLYGON ((-2133729 2710069,...
```

```
ggplot(buffers_summary, aes(x = factor(buffer_size), y = Annual_NLCD_LndCov_2020_CU_C1V1
)) +
  geom_boxplot() +
  labs(
    x = "buffer radius (m)",
    y = "mean NLCD vale",
    title = "mean land cover in buffers around Osmia Proxima"
  ) +
  theme_classic()
```




```
bbox <- st_bbox(osmiaproxima_sf)
raster_crop <- crop(raster_layer, bbox)
```

```
## |---------|---------|---------|---------|=======================================
```

4c.

```
bbox <- st_bbox(osmiaproxima_sf)
raster_crop <- crop(raster_layer, bbox)
```

```
## |---------|---------|---------|---------|=======================================
```

```
#. raster to dataframe so i can ggplot
raster_df <- as.data.frame(raster_crop, xy = TRUE)
colnames(raster_df) <- c("x", "y", "value")
```

```
# had to recreate raster_df as coordinate
raster_df <- as.data.frame(raster_crop, xy = TRUE, na.rm = TRUE)
colnames(raster_df) <- c("x", "y", "value")
```

```
# Downsample (fact = 10 is ideal)
raster_small <- terra::aggregate(raster_crop, fact = 10)
```

```r
# Convert
raster_df <- as.data.frame(raster_small, xy = TRUE, na.rm = TRUE)

# Fix column name
names(raster_df)[3] <- "value"

# Plot
ggplot() +
  geom_raster(data = raster_df, aes(x = x, y = y, fill = value)) +
  scale_fill_viridis_c() +
  theme_minimal()
```