

vsv_all_occurrence_mean_yearly_interval_by_state.R

melanie

2025-09-03

```
##
##
## SCRIPT NAME: vsv_all_occurrence_mean_yearly_interval_by_state
##
##

### Set working environment ----

# install (if necessary) and load packages

if ("pacman" %in% rownames(installed.packages()) == FALSE) {
  install.packages("pacman")
}
library("pacman")
library("devtools")
```

```
## Loading required package: usethis
```

```
## Warning: package 'usethis' was built under R version 4.3.3
```

```

if (Sys.info()[["sysname"]] == "Windows") {
  options(devtools.path = "C:/Users/melanie/AppData/Local/R/R-dev")
} else {
  options(devtools.path = "/home/melanie.veron/R/R-dev")
}

p_load(tidyverse,
       raster,
       terra,
       sf,
       tmap,
       ragg,
       viridis,
       pryr)

# get citation and version information about loaded packages
sink(
  "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/loaded_packages_info.txt"
)
print(
  loaded_packages_info <- list(
    citation = sapply(p_loaded(), p_cite, copy2clip = FALSE),
    version = sapply(p_loaded(), p_ver, simplify = FALSE)
  ) %>% list_transpose()
)
sink()

# define absolute working directory (that includes environmental data directory)
if (Sys.info()[["sysname"]] == "Windows") {
  main_path <- "D:/Documents/WORK/Maxent/"
} else {
  main_path <-
    "/project/disease_ecology/melanie.veron/vs_vectors_sdm/"
}

# create and assign temp directory for raster objects
if (dir.exists("outputs/vsv_all_occurrence_mean_yearly_interval_by_state/raster_tempdir") == FALSE) {
  dir.create("outputs/vsv_all_occurrence_mean_yearly_interval_by_state/raster_tempdir")
}
raster_tempdir <-
  "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/raster_tempdir/"

### Prepare presence locations ----

# import and check case occurrence data
occurrence <-
  read.csv(
    "data/occurrence_data/VSV_Mexico_merged_012621_fixed.csv",
    fileEncoding = readr::guess_encoding("data/occurrence_data/VSV_Mexico_merged_012621_fixed.csv")[[1, 1]]
  ) %>%
  filter(!is.na(Year)) %>% # exclude records with no year
  filter(!is.na(Occurrence)) %>% # exclude records with no confirmed occurrence of VS
  rename(
    year = Year,
    infection_type = Inf_.type,
    latitude = Lat,
    longitude = Long
  ) %>%
  mutate(State = str_to_title(State))
head(occurrence)

```



```
# save data frame as csv file
write.csv(
  occurrence,
  file = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/occurrence.csv",
  row.names = FALSE,
  fileEncoding = readr::guess_encoding("data/occurrence_data/VSV_Mexico_merged_012621_fixed.csv")[[1, 1]]
)

### Calculate state mean yearly case intervals ----

# for each state, calculate the yearly interval between records

occurrence_year_diff <-
  occurrence %>% dplyr::select(State, year) %>% dplyr::arrange(State, year)
occurrence_year_diff
```

##	State	year
## 1	Aguascalientes	1983
## 2	Aguascalientes	1983
## 3	Aguascalientes	1983
## 4	Aguascalientes	1983
## 5	Aguascalientes	1983
## 6	Aguascalientes	1983
## 7	Aguascalientes	1983
## 8	Aguascalientes	1983
## 9	Aguascalientes	1983
## 10	Aguascalientes	1985
## 11	Aguascalientes	1985
## 12	Aguascalientes	1993
## 13	Aguascalientes	2003
## 14	Baja California Sur	1985
## 15	Campeche	1987
## 16	Campeche	1987
## 17	Campeche	1987
## 18	Campeche	1988
## 19	Campeche	1988
## 20	Campeche	2005
## 21	Campeche	2006
## 22	Campeche	2011
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## 36	Campeche	2011
## 37	Campeche	2012
## 38	Campeche	2017
## 39	Chiapas	1981
## 40	Chiapas	1981
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## 1846      Veracruz 2020
## 1847      Veracruz 2020
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## 1849      Zacatecas 1983
## 1850      Zacatecas 1983
## 1851      Zacatecas 1983
## 1852      Zacatecas 1985
## 1853      Zacatecas 1985
## 1854      Zacatecas 2012
## 1855      Zacatecas 2014
## 1856      Zacatecas 2015
## 1857      Zacatecas 2015
## 1858      Zacatecas 2015
## 1859      Zacatecas 2015
## 1860      Zacatecas 2015
```

```
occurrence_year_diff$year_diff <-
  with(occurrence_year_diff,
    ave(
      as.numeric(year),
      State,
      FUN = function(x)
        c(0, diff(x))
    ))
occurrence_year_diff
```

##	State	year	year_diff
## 1	Aguascalientes	1983	0
## 2	Aguascalientes	1983	0
## 3	Aguascalientes	1983	0
## 4	Aguascalientes	1983	0
## 5	Aguascalientes	1983	0
## 6	Aguascalientes	1983	0
## 7	Aguascalientes	1983	0
## 8	Aguascalientes	1983	0
## 9	Aguascalientes	1983	0
## 10	Aguascalientes	1985	2
## 11	Aguascalientes	1985	0
## 12	Aguascalientes	1993	8
## 13	Aguascalientes	2003	10
## 14	Baja California Sur	1985	0
## 15	Campeche	1987	0
## 16	Campeche	1987	0
## 17	Campeche	1987	0
## 18	Campeche	1988	1
## 19	Campeche	1988	0
## 20	Campeche	2005	17
## 21	Campeche	2006	1
## 22	Campeche	2011	5
## 23	Campeche	2011	0
## 24	Campeche	2011	0
## 25	Campeche	2011	0
## 26	Campeche	2011	0
## 27	Campeche	2011	0
## 28	Campeche	2011	0
## 29	Campeche	2011	0
## 30	Campeche	2011	0
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## 32	Campeche	2011	0
## 33	Campeche	2011	0
## 34	Campeche	2011	0
## 35	Campeche	2011	0
## 36	Campeche	2011	0
## 37	Campeche	2012	1
## 38	Campeche	2017	5
## 39	Chiapas	1981	0
## 40	Chiapas	1981	0
## 41	Chiapas	1981	0
## 42	Chiapas	1981	0
## 43	Chiapas	1981	0
## 44	Chiapas	1981	0
## 45	Chiapas	1981	0
## 46	Chiapas	1982	1
## 47	Chiapas	1982	0
## 48	Chiapas	1982	0
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## 55	Chiapas	1983	0
## 56	Chiapas	1984	1
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## 61	Chiapas	1984	0
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## 71	Chiapas 1987	1
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## 491	Chihuahua 1994	9
## 492	Chihuahua 1994	0
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## 497	Chihuahua 2013	4
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## 1843 Veracruz 2020 0
## 1844 Veracruz 2020 0
## 1845 Veracruz 2020 0
## 1846 Veracruz 2020 0
## 1847 Veracruz 2020 0
## 1848 Veracruz 2020 0
## 1849 Zacatecas 1983 0
## 1850 Zacatecas 1983 0
## 1851 Zacatecas 1983 0
## 1852 Zacatecas 1985 2
## 1853 Zacatecas 1985 0
## 1854 Zacatecas 2012 27
## 1855 Zacatecas 2014 2
## 1856 Zacatecas 2015 1
## 1857 Zacatecas 2015 0
## 1858 Zacatecas 2015 0
## 1859 Zacatecas 2015 0
## 1860 Zacatecas 2015 0
```

```
summary(occurrence_year_diff)
```

```
##      State      year      year_diff
## Length:1860   Min.   :1981   Min.    : 0.0000
## Class :character 1st Qu.:1987   1st Qu.: 0.0000
## Mode  :character Median :1998   Median : 0.0000
##              Mean  :1998   Mean   : 0.4306
##              3rd Qu.:2009   3rd Qu.: 0.0000
##              Max.   :2020   Max.    :27.0000
```

```
# exclude first-year records for each state (since there are no earlier records for comparison to calculate their corresponding yearly interval)
occurrence_year_diff_first_year_removed <-
  occurrence_year_diff %>%
  group_by(State) %>%
  dplyr::filter(year != min(year))
occurrence_year_diff_first_year_removed
```

```
## # A tibble: 1,732 × 3
## # Groups:   State [25]
##   State      year year_diff
##   <chr>    <int>    <dbl>
## 1 Aguascalientes 1985      2
## 2 Aguascalientes 1985      0
## 3 Aguascalientes 1993      8
## 4 Aguascalientes 2003     10
## 5 Campeche      1988      1
## 6 Campeche      1988      0
## 7 Campeche      2005     17
## 8 Campeche      2006      1
## 9 Campeche      2011      5
## 10 Campeche     2011      0
## # i 1,722 more rows
```

```
# for each state, change all values of zero to match the non-zero value per year (to correct the stepwise interval calculations)
```

```
occurrence_year_diff_first_year_removed_with_fixed_values <-
  occurrence_year_diff_first_year_removed %>%
  group_by(State, year) %>%
  dplyr::mutate(year_diff = max(year_diff))
occurrence_year_diff_first_year_removed_with_fixed_values
```

```
## # A tibble: 1,732 × 3
## # Groups:   State, year [315]
##   State      year year_diff
##   <chr>    <int>    <dbl>
## 1 Aguascalientes 1985      2
## 2 Aguascalientes 1985      2
## 3 Aguascalientes 1993      8
## 4 Aguascalientes 2003     10
## 5 Campeche      1988      1
## 6 Campeche      1988      1
## 7 Campeche      2005     17
## 8 Campeche      2006      1
## 9 Campeche      2011      5
## 10 Campeche     2011      5
## # i 1,722 more rows
```

```
occurrence_year_diff_old <- occurrence_year_diff
```

```
occurrence_year_diff <-
  occurrence_year_diff_first_year_removed_with_fixed_values
```

```
# save data frame as csv file
```

```
write.csv(
  occurrence_year_diff,
  file = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/occurrence_year_diff.csv",
  row.names = FALSE,
  fileEncoding = readr::guess_encoding("data/occurrence_data/VSV_Mexico_merged_012621_fixed.csv")[[1, 1]]
)
```

```
# calculate mean yearly intervals for all multi-year states
```

```
occurrence_state_mean_yearly_intervals <- occurrence_year_diff %>%
  group_by(State) %>%
  summarize(mean_year_diff = mean(year_diff))
occurrence_state_mean_yearly_intervals
```

```
## # A tibble: 25 × 2
##   State      mean_year_diff
##   <chr>      <dbl>
## 1 Aguascalientes      5.5
## 2 Campeche            4.81
## 3 Chiapas             1.00
## 4 Chihuahua           3.18
## 5 Colima              3.1
## 6 Distrito Federal    10
## 7 Durango             2.58
## 8 Guanajuato          6.32
## 9 Guerrero            1.30
## 10 Hidalgo           1.65
## # i 15 more rows
```

```
summary(occurrence_state_mean_yearly_intervals)
```

```
##   State      mean_year_diff
## Length:25      Min.   : 1.002
## Class :character 1st Qu.: 1.690
## Mode  :character Median : 3.100
##                      Mean  : 4.092
##                      3rd Qu.: 5.500
##                      Max.   :11.000
```

```
# isolate and summarize records from single-year states
occurrence_single_year_states <-
  occurrence_year_diff_old %>%
  group_by(State) %>%
  distinct(year, .keep_all = TRUE) %>%
  add_tally(name = "num_years") %>%
  dplyr::filter(num_years == 1) %>%
  summarize(mean_year_diff = mean(year_diff)) %>%
  dplyr::mutate(mean_year_diff = NA)

# insert single-year state rows into mean yearly intervals data frame
occurrence_state_mean_yearly_intervals_with_single_year_states <-
  occurrence_state_mean_yearly_intervals %>%
  dplyr::union(occurrence_single_year_states) %>%
  dplyr::arrange(State) %>%
  # dplyr::mutate(mean_year_diff = ifelse(mean_year_diff == 1000, "NA (only one year available)", mean_year_diff))
occurrence_state_mean_yearly_intervals_with_single_year_states
```

```
## # A tibble: 28 × 2
##   State      mean_year_diff
##   <chr>      <dbl>
## 1 Aguascalientes      5.5
## 2 Baja California Sur    NA
## 3 Campeche            4.81
## 4 Chiapas             1.00
## 5 Chihuahua           3.18
## 6 Coahuila            NA
## 7 Colima              3.1
## 8 Distrito Federal    10
## 9 Durango             2.58
## 10 Guanajuato          6.32
## # i 18 more rows
```



```
occurrence_state_mean_yearly_intervals_old <-
  occurrence_state_mean_yearly_intervals

occurrence_state_mean_yearly_intervals <-
  occurrence_state_mean_yearly_intervals_with_single_year_states
occurrence_state_mean_yearly_intervals
```

```
## # A tibble: 28 × 2
##   State          mean_year_diff
##   <chr>          <dbl>
## 1 Aguascalientes      5.5
## 2 Baja California Sur    NA
## 3 Campeche            4.81
## 4 Chiapas             1.00
## 5 Chihuahua           3.18
## 6 Coahuila            NA
## 7 Colima              3.1
## 8 Distrito Federal     10
## 9 Durango             2.58
## 10 Guanajuato          6.32
## # i 18 more rows
```

```
# save data frame as csv file
write.csv(
  occurrence_state_mean_yearly_intervals,
  file = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/occurrence_state_mean_yearly_intervals.csv",
  row.names = FALSE,
  fileEncoding = readr::guess_encoding("data/occurrence_data/VSV_Mexico_merged_012621_fixed.csv")[[1, 1]]
)
```

```
### Define study area ----
```

```
# Load elevation raster
elevation <-
  raster::raster(
    str_c(
      main_path,
      "environmental_data/NEW_environmental_data/EarthEnv_Topography/final/elevation_4KMmd_GMTEDmd.tif"
    )
  )
elevation
```

```
## class      : RasterLayer
## dimensions : 886, 1542, 1366212  (nrow, ncol, ncell)
## resolution : 0.050908, 0.050908  (x, y)
## extent      : -138.1643, -59.66418, 14.55969, 59.66418  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : elevation_4KMmd_GMTEDmd.tif
## names       : elevation_4KMmd_GMTEDmd
## values      : -81.04566, 4402.234  (min, max)
```

```

# prepare reference vector layers
boundaries_countries <- read_sf(
  str_c(
    main_path,
    "environmental_data/study_areas/reference_boundaries/Global_Countries.gpkg"
  )
) %>%
  st_transform(st_crs(elevation)) %>%
  st_make_valid() %>%
  dplyr::select(GEOUNIT)
boundaries_states_provinces <- read_sf(
  str_c(
    main_path,
    "environmental_data/study_areas/reference_boundaries/Global_States_Provinces.gpkg"
  )
) %>%
  st_transform(st_crs(elevation)) %>%
  st_make_valid() %>%
  filter(geonunit == "Canada" |
    geonunit == "Mexico" |
    geonunit == "United States of America") %>%
  dplyr::select(name)

# import vector mask layer representing the study area (derived from ecoregions intersecting and surrounding presence locations)
study_area_mask <-
  read_sf(
    "data/study_areas/Ecoregions_Study_Area_VSV_Mexico_Endemic_All_Extended_Convex_Hull_Mask.gpkg"
  ) %>%
  st_transform(st_crs(elevation)) %>%
  st_make_valid()

### Mapping endemicity ----

# import SWD object (which includes filtered presence data) from main script as data frame
data <-
  read.csv("outputs/vsv_all_dynamic_nestedcv_final_reduced_vars/data.csv")

# define presence localities that were included in the SWD object (i.e., excluding points dropped due to missing environmental data)
presence_final <-
  data %>% dplyr::filter(pa == 1) %>%
  dplyr::select(X, Y) %>%
  rename(longitude = X,
    latitude = Y)

# make sf object versions for final presence coords
presence_final_sf <- st_as_sf(
  x = presence_final,
  coords = c("longitude", "latitude"),
  crs = st_crs(elevation)
)

boundaries_mexico_states <- read_sf(
  str_c(
    main_path,
    "environmental_data/study_areas/reference_boundaries/Global_States_Provinces.gpkg"
  )
) %>%
  st_transform(st_crs(elevation)) %>%
  st_make_valid() %>%
  filter(geonunit == "Mexico") %>%
  dplyr::select(name)

```

```

# add mean yearly interval data to mexico state boundaries object
boundaries_mexico_states_occ_mean_yearly_intervals <-
  boundaries_mexico_states %>%
  full_join(occurrence_state_mean_yearly_intervals, by = c("name" = "State"))

# create plot layer from country and state/province boundaries
boundaries_alt_plot_layer <- {
  tm_shape(
    boundaries_countries,
    projection = st_crs(boundaries_mexico_states_occ_mean_yearly_intervals),
    bbox = st_bbox(boundaries_mexico_states_occ_mean_yearly_intervals)
  ) +
  tm_polygons(alpha = 0, border.alpha = 0) + # transparent copy of polygon (baseline)
  tm_graticules(alpha = 0.2,
    ticks = FALSE) +
  tm_layout(inner.margins = 0,
    bg.color = "white") + # add graticules (long-lat lines) first
  tm_shape(
    boundaries_countries,
    projection = st_crs(boundaries_mexico_states_occ_mean_yearly_intervals),
    bbox = st_bbox(boundaries_mexico_states_occ_mean_yearly_intervals)
  ) +
  tm_polygons(col = "white", border.alpha = 0) + # opaque grey copy of polygon (to hide graticules under polygon)
  tm_shape(
    boundaries_countries,
    projection = st_crs(boundaries_mexico_states_occ_mean_yearly_intervals),
    bbox = st_bbox(boundaries_mexico_states_occ_mean_yearly_intervals)
  ) +
  tm_polygons(
    alpha = 0.15,
    border.alpha = 1,
    border.col = "black",
    lwd = 1
  ) + # visible copy of country boundaries
  tm_shape(
    boundaries_states_provinces,
    projection = st_crs(boundaries_mexico_states_occ_mean_yearly_intervals),
    bbox = st_bbox(boundaries_mexico_states_occ_mean_yearly_intervals)
  ) +
  tm_polygons(
    alpha = 0,
    border.alpha = 1,
    border.col = "black",
    lwd = 0.8
  ) # visible copy of state/province boundaries
}

# create mean yearly interval maps
mexico_states_occ_mean_yearly_intervals_map_no_points_layer <-
{
  tm_shape(
    boundaries_mexico_states_occ_mean_yearly_intervals,
    projection = st_crs(boundaries_mexico_states_occ_mean_yearly_intervals),
    bbox = st_bbox(boundaries_mexico_states_occ_mean_yearly_intervals)
  ) + tm_polygons(
    col = "mean_year_diff",
    palette = viridis(
      256,
      option = "magma",
      begin = 0.05,
      end = 0.95,
      direction = -1
    ),
    alpha = 1,

```

```

title = "Mean yearly interval\nbetween VS cases\n(1981-2020)",
legend.reverse = TRUE,
interval.closure = "left",
legend.format = list(scientific = TRUE, format = "f"),

# # VARIANT 1
# style = "fixed",
# breaks = seq(1, max(
#   summary(
#     boundaries_mexico_states_occ_mean_yearly_intervals$mean_year_diff
#   )
# ), 1)

# # VARIANT 2
# style = "fixed",
# breaks = seq(1, max(
#   summary(
#     boundaries_mexico_states_occ_mean_yearly_intervals$mean_year_diff
#   )
# ), 2)

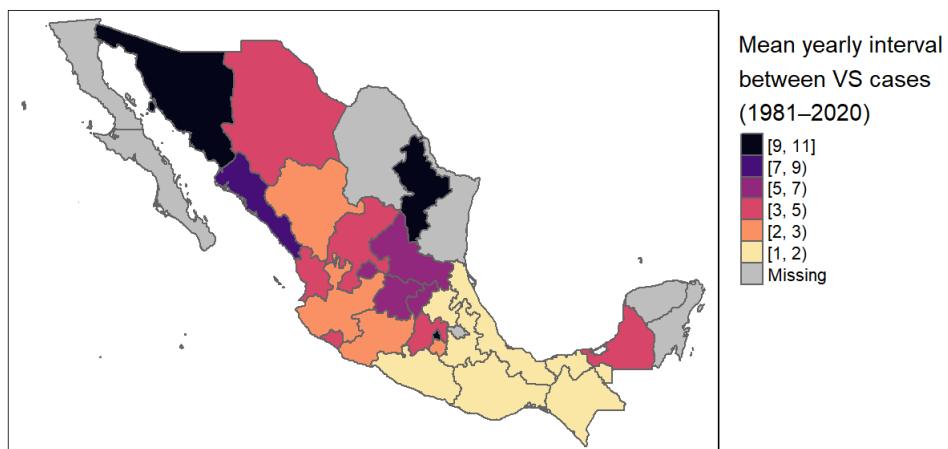
# VARIANT 3
style = "fixed",
breaks = c(seq(1, 2, 1),
  seq(3, max(
    summary(
      boundaries_mexico_states_occ_mean_yearly_intervals$mean_year_diff
    )
  ), 2))

# # VARIANT 4
# style = "cont"

# # VARIANT 5
# style = "cont",
# breaks = seq(1, max(
#   summary(
#     boundaries_mexico_states_occ_mean_yearly_intervals$mean_year_diff
#   )
# ), 2)

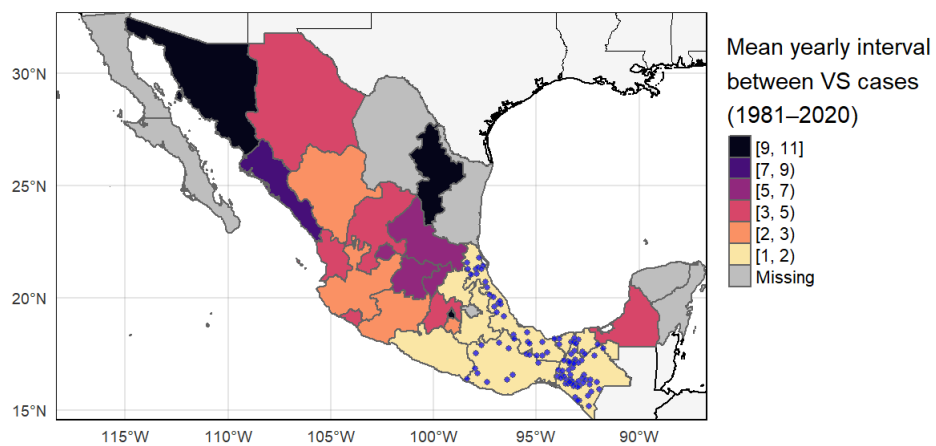
) + tm_legend(legend.outside = TRUE)
}
mexico_states_occ_mean_yearly_intervals_map_no_points_layer

```

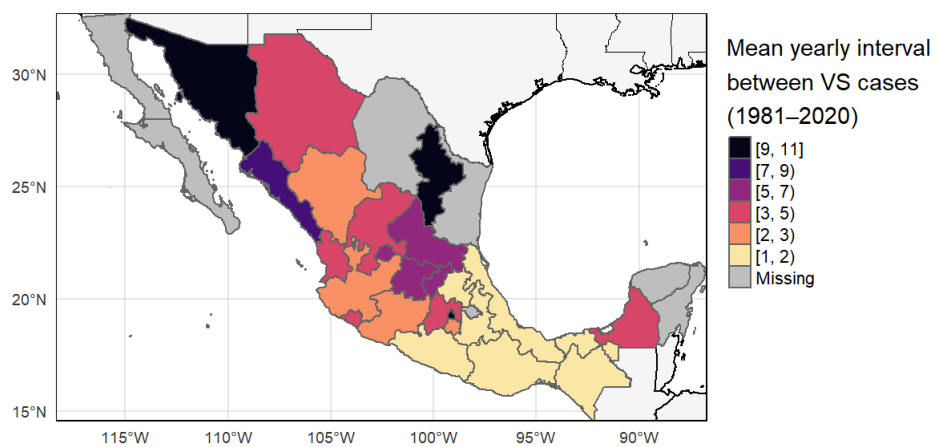


```
mexico_states_occ_mean_yearly_intervals_map_layer <- {
  mexico_states_occ_mean_yearly_intervals_map_no_points_layer + tm_shape(presence_final_sf) + tm_dots(
    size = 0.08,
    shape = 21,
    col = "blue",
    alpha = 0.7,
    border.lwd = 0.55,
    border.alpha = 0.9
  )
}

(
  mexico_states_occ_mean_yearly_intervals_map <-
    boundaries_alt_plot_layer + mexico_states_occ_mean_yearly_intervals_map_layer
)
```



```
(
  mexico_states_occ_mean_yearly_intervals_map_no_points <-
    boundaries_alt_plot_layer + mexico_states_occ_mean_yearly_intervals_map_no_points_layer
)
```



```
# save the image output
tmap_save(
  mexico_states_occ_mean_yearly_intervals_map,
  filename = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/mexico_states_occ_mean_yearly_intervals_map_v3.png",
  scale = 1.7
)
```

```
## Map saved to D:\Documents\WORK\Maxent\projects\mexico_vsv\outputs\vsv_all_occurrence_mean_yearly_interval_by_state\mexico_states_occ_mean_yearly_intervals_map_v3.png
```

```
## Resolution: 2653.869 by 1661.725 pixels
```

```
## Size: 8.84623 by 5.539083 inches (300 dpi)
```

```
# save the image output
tmap_save(
  mexico_states_occ_mean_yearly_intervals_map_no_points,
  filename = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/mexico_states_occ_mean_yearly_intervals_map_no_points_v3.png",
  scale = 1.7
)
```

```
## Map saved to D:\Documents\WORK\Maxent\projects\mexico_vsv\outputs\vsv_all_occurrence_mean_yearly_interval_by_state\mexico_states_occ_mean_yearly_intervals_map_no_points_v3.png
```

```
## Resolution: 2653.869 by 1661.725 pixels
```

```
## Size: 8.84623 by 5.539083 inches (300 dpi)
```

```
#### With study area overlay ----
```

```
# build an larger extent for next set of maps
```

```
bbox_extended <-
```

```
  st_bbox(boundaries_mexico_states_occ_mean_yearly_intervals)
```

```
bbox_extended[4] <- st_bbox(study_area_mask)[4]
```

```
# create plot layer from country and state/province boundaries
```

```
boundaries_alt_with_study_area_plot_layer <- {
```

```
  tm_shape(
```

```
    boundaries_countries,
```

```
    projection = st_crs(bbox_extended),
```

```
    bbox = st_bbox(bbox_extended)
```

```
) +
```

```
  tm_polygons(alpha = 0, border.alpha = 0) + # transparent copy of polygon (baseline)
```

```
  tm_graticules(alpha = 0.2,
```

```
    ticks = FALSE) +
```

```
  tm_layout(inner.margins = 0,
```

```
    bg.color = "white") + # add graticules (long-lat lines) first
```

```
  tm_shape(
```

```
    boundaries_countries,
```

```
    projection = st_crs(bbox_extended),
```

```
    bbox = st_bbox(bbox_extended)
```

```
) +
```

```
  tm_polygons(col = "white", border.alpha = 0) + # opaque grey copy of polygon (to hide graticules under polygon)
```

```
  tm_shape(
```

```
    boundaries_countries,
```

```
    projection = st_crs(bbox_extended),
```

```
    bbox = st_bbox(bbox_extended)
```

```
) +
```

```
  tm_polygons(
```

```
    alpha = 0.15,
```

```
    border.alpha = 1,
```

```
    border.col = "black",
```

```
    lwd = 1
```

```
) + # visible copy of country boundaries
```

```
  tm_shape(
```

```
    boundaries_states_provinces,
```

```
    projection = st_crs(bbox_extended),
```

```
    bbox = st_bbox(bbox_extended)
```

```
) +
```

```
  tm_polygons(
```

```
    alpha = 0,
```

```
    border.alpha = 1,
```

```
    border.col = "black",
```

```
    lwd = 0.8
```

```
) # visible copy of state/province boundaries
```

```
}
```

```
# create plot layer from study area mask
```

```
study_area_mask_alt_plot_layer <- {
```

```
  tm_shape(
```

```
    study_area_mask,
```

```
    projection = st_crs(bbox_extended),
```

```
    bbox = st_bbox(bbox_extended),
```

```
    is.master = TRUE
```

```
) +
```

```
  tm_polygons(
```

```
    col = "cornsilk",
```

```
    alpha = 0.2,
```

```
    border.alpha = 0.5,
```

```
    lwd = 1.8
```

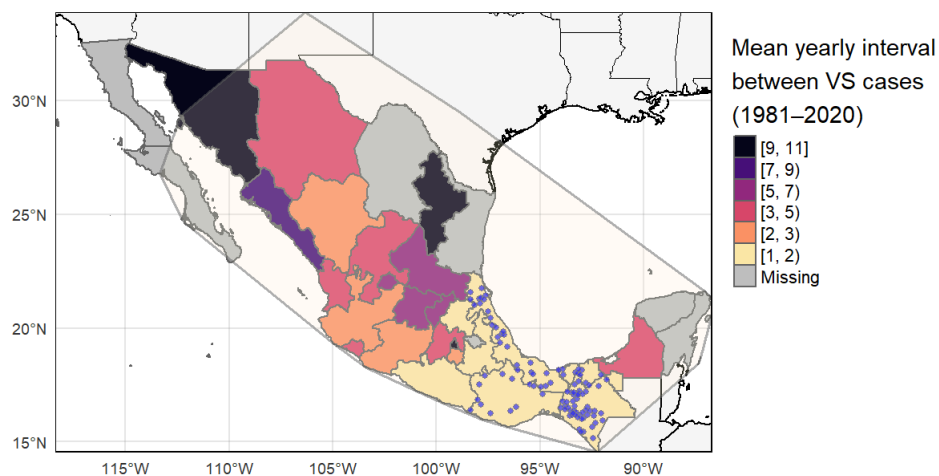
```
)
```

```
}
```

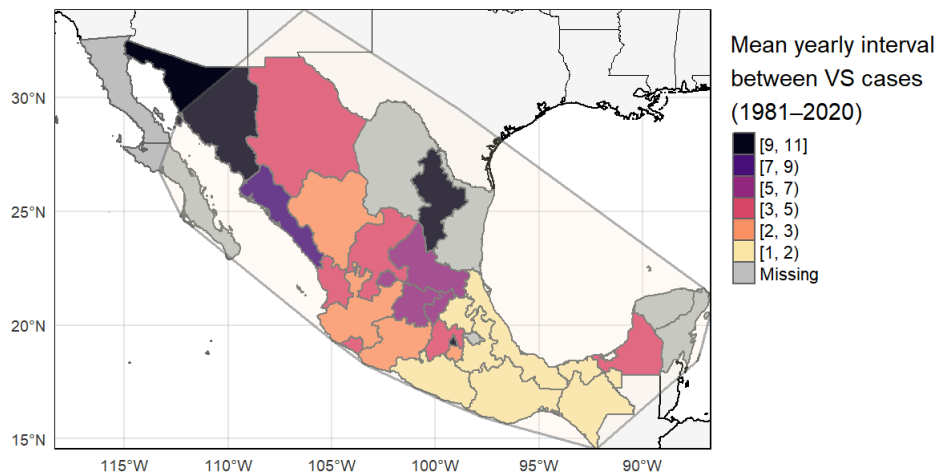


```
# create mean yearly interval maps
```

```
(
  mexico_states_occ_mean_yearly_intervals_map_with_study_area <-
    boundaries_alt_with_study_area_plot_layer + mexico_states_occ_mean_yearly_intervals_map_layer + study_area_mask_alt_plot_layer
)
```



```
(
  mexico_states_occ_mean_yearly_intervals_map_with_study_area_no_points <-
    boundaries_alt_with_study_area_plot_layer + mexico_states_occ_mean_yearly_intervals_map_no_points_layer +
    study_area_mask_alt_plot_layer
)
```



```
# save the image output
tmap_save(
  mexico_states_occ_mean_yearly_intervals_map_with_study_area,
  filename = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/mexico_states_occ_mean_yearly_intervals_map_with_st
udy_area_v3.png",
  scale = 1.7
)
```

```
## Map saved to D:\Documents\WORK\Maxent\projects\mexico_vsv\outputs\vsv_all_occurrence_mean_yearly_interval_by_state\mexi
co_states_occ_mean_yearly_intervals_map_with_study_area_v3.png
```

```
## Resolution: 2566.706 by 1718.155 pixels
```

```
## Size: 8.555687 by 5.727185 inches (300 dpi)
```

```
# save the image output
tmap_save(
  mexico_states_occ_mean_yearly_intervals_map_with_study_area_no_points,
  filename = "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/mexico_states_occ_mean_yearly_intervals_map_with_st
udy_area_no_points_v3.png",
  scale = 1.7
)
```

```
## Map saved to D:\Documents\WORK\Maxent\projects\mexico_vsv\outputs\vsv_all_occurrence_mean_yearly_interval_by_state\mexi
co_states_occ_mean_yearly_intervals_map_with_study_area_no_points_v3.png
```

```
## Resolution: 2566.706 by 1718.155 pixels
```

```
## Size: 8.555687 by 5.727185 inches (300 dpi)
```

```
## Save all objects in R environment ----
```

```
# save all objects in R environment
```

```
save.image(
```

```
  "outputs/vsv_all_occurrence_mean_yearly_interval_by_state/vsv_all_occurrence_mean_yearly_interval_by_state.RData"
```

```
)
```