

# R Code for “Rosegate Projectile Points in the Fremont Region”

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## Abstract

This is the R code used for analysis and to create many of the figures in the paper “Rosegate Projectile Points in the Fremont Region” by Robert J. Bischoff and James R. Allison.

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## 1 Code to reproduce analysis and figures

Note: spatial analysis and data cannot be made publicly available. Please contact the authors for more information.

## 1.1 Load packages

```
library(tidyverse)
library(magrittr)
library(ggthemes)
library(rio)
library(officer)
library(flextable)
library(huxtable)
library(Bchron)
library(osfr)
library(Momocs)
library(umap)
```

## 1.2 Customize ggplot themes

This is a custom theme to style the dot plot.

```
theme_dotplot <- theme_bw(14) +
  theme(axis.text.y = element_text(size = rel(.75)),
        axis.ticks.y = element_blank(),
        axis.title.x = element_text(size = rel(.75)),
        panel.grid.major.x = element_blank(),
        panel.grid.major.y = element_line(size = .25, linetype = "dotted",
                                           color = "darkgray"),
        panel.grid.minor.x = element_blank())
theme_set(theme_gdocs())
```

## 1.3 Download the data from OSF

```
# download all files from repository
project <- osf_retrieve_node("3ufte") %>%
  osf_ls_files() %>%
  osf_download(conflicts = 'skip')
```

## 1.4 Load projectile point data

```
# load
projData <- import("Fremont Projectile Point Data.xlsx",
                  setclass = "tibble")
# add percentages
projData %>%
  mutate(`Total Dart Points` = case_when(is.na(`Total Dart Points`) ~ 0,
                                          TRUE ~ `Total Dart Points`),
        ArrowPoints = `Total Projectile Points` - `Total Dart Points`,
        `Rosegate % of All Points` =
          round(`Total Rosegate Points`/`Total Projectile Points`,3)*100,
```

```
`Rosegate % of Arrow Points` =  
  round(`Total Rosegate Points`/ArrowPoints,3)*100)
```

## 1.5 Radiocarbon Analysis

```
radiocarbonData <- import("Rosegate Supplemental Table 1.xlsx")  
  
# calibrate  
calib <- with(radiocarbonData,  
  BchronCalibrate(  
    ages = `Radiocarbon Age`,  
    ageSds = Error,  
    calCurves = rep('intcal20',  
                     nrow(radiocarbonData)),  
    ids = `Lab Number`))  
# get summary statistics and join to original table  
date_samples <- sampleAges(calib)  
sampleMedians <- apply(date_samples,2,median)  
# table to combine projData with radiocarbonData  
key <- structure(  
  list(  
    `Site Name` = c(  
      "Bull Creek",  
      "Backhoe Village",  
      "Baker Village",  
      "Block 49",  
      "East Fork Village",  
      "Five-Finger Ridge",  
      "Hinckley Mounds",  
      "Hinckley Mounds",  
      "Hunchback Shelter",  
      "Kays Cabin",  
      "Mosquito Willie",  
      "Paragonah",  
      "Scorpio Site",  
      "South Temple",  
      "Spotten Cave",  
      "Evans Mound",  
      "Wolf Village 1",  
      "Wolf Village 2",  
      "Woodard Mound"  
    ),  
    Site = c(  
      "Bull Creek",  
      "Backhoe Village (42SV662)",  
      "Baker Village (26WP63)",  
      "Block 49 (42SL98)",  
      "East Fork Village (42MD974)",  
      "Five Finger Ridge (42SV1686)",  
      "Hinckley Mounds 1 (42UT111)",  
      "Hinckley Mounds 2 (42UT111)",
```

```

    "Hunchback Shelter (42BE751)",
    "Kay's Cabin (42UT813)",
    "Mosquito Willie (42T0137)",
    "Paragonah (42IN43)",
    "Scorpio Site (42WS2434)",
    "South Temple (42SL285)",
    "Spotten Cave (42UT104)",
    "Summit (42IN40)",
    "Wolf Village 1 (42UT273)",
    "Wolf Village 2 (42UT273)",
    "Woodard Mound (42UT102)"
  )
),
row.names = c(NA,-19L),
class = c("tbl_df",
          "tbl", "data.frame")
)
dateEstimates <- apply(date_samples, 2, quantile,
                      prob=c(0.025,0.975)) %>%
  t() %>%
  as_tibble(row.names = "LabNumber") %>%
  mutate(ADStart = 1950 - `97.5%` %>% round(0),
         ADEnd = 1950 - `2.5%` %>% round(0),
         ADMedian = 1950 - sampleMedians %>% round(0)) %>%
  left_join(radiocarbonData %>% rename(LabNumber = `Lab Number`)) %>%
  # join to original table -- some names are different based on the names
  # given to the radiocarbon dates
  left_join(key) %>%
  left_join(projData) %>%
  relocate(Site, .after = `Site Name`) %>%
  # Determine whether material is a short-lived species
  mutate(Annual = case_when(
    str_detect(Material,
                "maize|corn|human|annual|bean") == T ~ T,
    TRUE ~ F
  ))

```

```
## Joining, by = "LabNumber"
```

```
## Joining, by = "Site Name"
```

```
## Joining, by = "Site"
```

```

# examine differences between annual dates
AnnualDiffs <- dateEstimates %>%
  group_by(Annual, `Site Name`) %>%
  summarize(ADMedian = mean(ADMedian)) %>%
  arrange(`Site Name`)

```

```
## 'summarise()' regrouping output by 'Annual' (override with '.groups' argument)
```

```

dateEstimatesMedian <- dateEstimates %>%
  group_by(`Site Name`) %>%
  summarize(ADMedian = median(ADMedian),
            `Rosegate % of Arrow Points` =
              median(`Rosegate % of Arrow Points`)) %>%
  mutate(Annual = F) %>%
  bind_rows(
    dateEstimates %>%
      filter(Annual == T) %>%
      group_by(`Site Name`, Annual) %>%
      summarize(ADMedian = median(ADMedian),
                `Rosegate % of Arrow Points` =
                  median(`Rosegate % of Arrow Points`))
  ) %>%
  mutate(Annual = case_when(Annual == T ~ 'Annual',
                            Annual == F ~ 'Combined')) %>%
  arrange(Annual) %>%
  group_by(`Site Name`) %>%
  distinct(ADMedian, .keep_all = T)

```

```
## 'summarise()' ungrouping output (override with '.groups' argument)
```

```
## 'summarise()' regrouping output by 'Site Name' (override with '.groups' argument)
```

```

dateEstimates %<>%
  mutate(Annual = case_when(Annual == T ~ 'Annual',
                            Annual == F ~ 'Combined')) %>%
  arrange(Annual) %>%
  group_by(`Site Name`) %>%
  distinct(ADMedian, .keep_all = T)
# linear regression
datesLM <- lm(ADMedian ~ `Rosegate % of Arrow Points`, data = dateEstimatesMedian)
summary(datesLM)

```

```

##
## Call:
## lm(formula = ADMedian ~ `Rosegate % of Arrow Points`, data = dateEstimatesMedian)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -232.776  -60.781   -9.002   83.883  167.449
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1147.5555     38.2202   30.02 < 2e-16 ***
## `Rosegate % of Arrow Points`    -2.1896     0.6996   -3.13  0.00487 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 98.52 on 22 degrees of freedom
## Multiple R-squared:  0.3081, Adjusted R-squared:  0.2766
## F-statistic: 9.795 on 1 and 22 DF, p-value: 0.004873

```

## 1.6 Morphometrics

### 1.6.1 Demonstration of point outline creation

```
# create temporary directory to unzip images
fn = tempdir()
unzip("JPGs.zip", exdir = fn)
ls = list.files(paste0(fn, "/JPGs"), pattern = "jpg",
               full.names = T)
# import images from jpgs
imgs = import_jpg(ls)

## Extracting 242.jpg outlines...

## [ 1 / 242 ] Baker Village_Rosegate 1.jpg
## [ 2 / 242 ] Baker Village_Rosegate 2.jpg
## [ 3 / 242 ] Baker Village_Rosegate 3.jpg
## [ 4 / 242 ] Baker Village_Rosegate 4.jpg
## [ 5 / 242 ] Baker Village_Rosegate 5.jpg
## [ 6 / 242 ] Baker Village_Rosegate 6.jpg
## [ 7 / 242 ] Baker Village_side notch 1.jpg
## [ 8 / 242 ] Baker Village_side notch 2.jpg
## [ 9 / 242 ] Baker Village_side notch 3.jpg
## [ 10 / 242 ] Baker Village_side notch 4.jpg
## [ 11 / 242 ] Baker Village_side notch 5.jpg
## [ 12 / 242 ] Baker Village_unclassified 1.jpg
## [ 13 / 242 ] Holmer and Weder_Eastgate 1.jpg
## [ 14 / 242 ] Holmer and Weder_Eastgate 2.jpg
## [ 15 / 242 ] Holmer and Weder_Parowan 1.jpg
## [ 16 / 242 ] Holmer and Weder_Parowan 2.jpg
## [ 17 / 242 ] Holmer and Weder_Parowan 3.jpg
## [ 18 / 242 ] Holmer and Weder_Rose Spring 1.jpg
## [ 19 / 242 ] Holmer and Weder_Rose Spring 2.jpg
## [ 20 / 242 ] Holmer and Weder_Rose Spring 3.jpg
## [ 21 / 242 ] Hunchback Shelter_Eastgate 1.jpg
## [ 22 / 242 ] Hunchback Shelter_Eastgate 2.jpg
## [ 23 / 242 ] Hunchback Shelter_Eastgate 3.jpg
## [ 24 / 242 ] Hunchback Shelter_Eastgate 4.jpg
## [ 25 / 242 ] Hunchback Shelter_Eastgate 5.jpg
## [ 26 / 242 ] Hunchback Shelter_Eastgate 6.jpg
## [ 27 / 242 ] Hunchback Shelter_Elko Corner 1.jpg
## [ 28 / 242 ] Hunchback Shelter_Elko Corner 2.jpg
## [ 29 / 242 ] Hunchback Shelter_Elko Corner 3.jpg
## [ 30 / 242 ] Hunchback Shelter_Elko Corner 4.jpg
## [ 31 / 242 ] Hunchback Shelter_Elko Side 1.jpg
## [ 32 / 242 ] Hunchback Shelter_Elko Side 2.jpg
## [ 33 / 242 ] Hunchback Shelter_Elko Side 3.jpg
## [ 34 / 242 ] Hunchback Shelter_Elko Side 4.jpg
## [ 35 / 242 ] Hunchback Shelter_Elko Side 5.jpg
## [ 36 / 242 ] Hunchback Shelter_Gypsum 1.jpg
## [ 37 / 242 ] Hunchback Shelter_Parowan Basal 1.jpg
## [ 38 / 242 ] Hunchback Shelter_Parowan Basal 2.jpg
```

## [ 39 / 242 ] Hunchback Shelter\_Parowan Basal 3.jpg  
 ## [ 40 / 242 ] Hunchback Shelter\_Parowan Basal 4.jpg  
 ## [ 41 / 242 ] Hunchback Shelter\_Parowan Basal 5.jpg  
 ## [ 42 / 242 ] Hunchback Shelter\_Rose Spring 1.jpg  
 ## [ 43 / 242 ] Hunchback Shelter\_Rose Spring 10.jpg  
 ## [ 44 / 242 ] Hunchback Shelter\_Rose Spring 11.jpg  
 ## [ 45 / 242 ] Hunchback Shelter\_Rose Spring 12.jpg  
 ## [ 46 / 242 ] Hunchback Shelter\_Rose Spring 13.jpg  
 ## [ 47 / 242 ] Hunchback Shelter\_Rose Spring 14.jpg  
 ## [ 48 / 242 ] Hunchback Shelter\_Rose Spring 15.jpg  
 ## [ 49 / 242 ] Hunchback Shelter\_Rose Spring 16.jpg  
 ## [ 50 / 242 ] Hunchback Shelter\_Rose Spring 17.jpg  
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 ## [ 53 / 242 ] Hunchback Shelter\_Rose Spring 2.jpg  
 ## [ 54 / 242 ] Hunchback Shelter\_Rose Spring 20.jpg  
 ## [ 55 / 242 ] Hunchback Shelter\_Rose Spring 21.jpg  
 ## [ 56 / 242 ] Hunchback Shelter\_Rose Spring 22.jpg  
 ## [ 57 / 242 ] Hunchback Shelter\_Rose Spring 23.jpg  
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 ## [ 59 / 242 ] Hunchback Shelter\_Rose Spring 25.jpg  
 ## [ 60 / 242 ] Hunchback Shelter\_Rose Spring 26.jpg  
 ## [ 61 / 242 ] Hunchback Shelter\_Rose Spring 27.jpg  
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 ## [ 64 / 242 ] Hunchback Shelter\_Rose Spring 3.jpg  
 ## [ 65 / 242 ] Hunchback Shelter\_Rose Spring 30.jpg  
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 ## [ 69 / 242 ] Hunchback Shelter\_Rose Spring 34.jpg  
 ## [ 70 / 242 ] Hunchback Shelter\_Rose Spring 35.jpg  
 ## [ 71 / 242 ] Hunchback Shelter\_Rose Spring 36.jpg  
 ## [ 72 / 242 ] Hunchback Shelter\_Rose Spring 37.jpg  
 ## [ 73 / 242 ] Hunchback Shelter\_Rose Spring 38.jpg  
 ## [ 74 / 242 ] Hunchback Shelter\_Rose Spring 39.jpg  
 ## [ 75 / 242 ] Hunchback Shelter\_Rose Spring 4.jpg  
 ## [ 76 / 242 ] Hunchback Shelter\_Rose Spring 40.jpg  
 ## [ 77 / 242 ] Hunchback Shelter\_Rose Spring 41.jpg  
 ## [ 78 / 242 ] Hunchback Shelter\_Rose Spring 42.jpg  
 ## [ 79 / 242 ] Hunchback Shelter\_Rose Spring 43.jpg  
 ## [ 80 / 242 ] Hunchback Shelter\_Rose Spring 44.jpg  
 ## [ 81 / 242 ] Hunchback Shelter\_Rose Spring 45.jpg  
 ## [ 82 / 242 ] Hunchback Shelter\_Rose Spring 46.jpg  
 ## [ 83 / 242 ] Hunchback Shelter\_Rose Spring 47.jpg  
 ## [ 84 / 242 ] Hunchback Shelter\_Rose Spring 48.jpg  
 ## [ 85 / 242 ] Hunchback Shelter\_Rose Spring 49.jpg  
 ## [ 86 / 242 ] Hunchback Shelter\_Rose Spring 5.jpg  
 ## [ 87 / 242 ] Hunchback Shelter\_Rose Spring 50.jpg  
 ## [ 88 / 242 ] Hunchback Shelter\_Rose Spring 51.jpg  
 ## [ 89 / 242 ] Hunchback Shelter\_Rose Spring 52.jpg  
 ## [ 90 / 242 ] Hunchback Shelter\_Rose Spring 53.jpg  
 ## [ 91 / 242 ] Hunchback Shelter\_Rose Spring 54.jpg  
 ## [ 92 / 242 ] Hunchback Shelter\_Rose Spring 55.jpg

## [ 93 / 242 ] Hunchback Shelter\_Rose Spring 56.jpg  
## [ 94 / 242 ] Hunchback Shelter\_Rose Spring 57.jpg  
## [ 95 / 242 ] Hunchback Shelter\_Rose Spring 58.jpg  
## [ 96 / 242 ] Hunchback Shelter\_Rose Spring 59.jpg  
## [ 97 / 242 ] Hunchback Shelter\_Rose Spring 6.jpg  
## [ 98 / 242 ] Hunchback Shelter\_Rose Spring 60.jpg  
## [ 99 / 242 ] Hunchback Shelter\_Rose Spring 61.jpg  
## [ 100 / 242 ] Hunchback Shelter\_Rose Spring 62.jpg  
## [ 101 / 242 ] Hunchback Shelter\_Rose Spring 63.jpg  
## [ 102 / 242 ] Hunchback Shelter\_Rose Spring 7.jpg  
## [ 103 / 242 ] Hunchback Shelter\_Rose Spring 8.jpg  
## [ 104 / 242 ] Hunchback Shelter\_Rose Spring 9.jpg  
## [ 105 / 242 ] Hunchback Shelter\_Rosegate 1.jpg  
## [ 106 / 242 ] Hunchback Shelter\_Rosegate 2.jpg  
## [ 107 / 242 ] Hunchback Shelter\_Rosegate 3.jpg  
## [ 108 / 242 ] Hunchback Shelter\_Rosegate 4.jpg  
## [ 109 / 242 ] Hunchback Shelter\_Rosegate 5.jpg  
## [ 110 / 242 ] Hunchback Shelter\_Rosegate 6.jpg  
## [ 111 / 242 ] Justice\_Eastgate 01.jpg  
## [ 112 / 242 ] Justice\_Eastgate 02.jpg  
## [ 113 / 242 ] Justice\_Eastgate 03.jpg  
## [ 114 / 242 ] Justice\_Eastgate 04.jpg  
## [ 115 / 242 ] Justice\_Eastgate 05.jpg  
## [ 116 / 242 ] Justice\_Eastgate 06.jpg  
## [ 117 / 242 ] Justice\_Eastgate 07.jpg  
## [ 118 / 242 ] Justice\_Eastgate 08.jpg  
## [ 119 / 242 ] Justice\_Eastgate 09.jpg  
## [ 120 / 242 ] Justice\_Eastgate 10.jpg  
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## [ 123 / 242 ] Justice\_Eastgate\_01.jpg  
## [ 124 / 242 ] Justice\_Eastgate\_02.jpg  
## [ 125 / 242 ] Justice\_Eastgate\_03.jpg  
## [ 126 / 242 ] Justice\_Eastgate\_04.jpg  
## [ 127 / 242 ] Justice\_Eastgate\_05.jpg  
## [ 128 / 242 ] Justice\_Eastgate\_06.jpg  
## [ 129 / 242 ] Justice\_Eastgate\_07.jpg  
## [ 130 / 242 ] Justice\_Eastgate\_08.jpg  
## [ 131 / 242 ] Justice\_Eastgate\_09.jpg  
## [ 132 / 242 ] Justice\_Eastgate\_10.jpg  
## [ 133 / 242 ] Justice\_Eastgate\_11.jpg  
## [ 134 / 242 ] Justice\_Eastgate\_12.jpg  
## [ 135 / 242 ] Justice\_Rose Spring 01.jpg  
## [ 136 / 242 ] Justice\_Rose Spring 02.jpg  
## [ 137 / 242 ] Justice\_Rose Spring 03.jpg  
## [ 138 / 242 ] Justice\_Rose Spring 04.jpg  
## [ 139 / 242 ] Justice\_Rose Spring 05.jpg  
## [ 140 / 242 ] Justice\_Rose Spring 06.jpg  
## [ 141 / 242 ] Justice\_Rose Spring 07.jpg  
## [ 142 / 242 ] Justice\_Rose Spring 08.jpg  
## [ 143 / 242 ] Justice\_Rose Spring 09.jpg  
## [ 144 / 242 ] Justice\_Rose Spring 10.jpg  
## [ 145 / 242 ] Justice\_Rose Spring 11.jpg  
## [ 146 / 242 ] Justice\_Rose Spring 12.jpg



```

## [ 147 / 242 ] Justice_Rose Spring 13.jpg
## [ 148 / 242 ] Justice_Rose Spring 14.jpg
## [ 149 / 242 ] Justice_Rose Spring_01.jpg
## [ 150 / 242 ] Justice_Rose Spring_02.jpg
## [ 151 / 242 ] Justice_Rose Spring_03.jpg
## [ 152 / 242 ] Justice_Rose Spring_04.jpg
## [ 153 / 242 ] Justice_Rose Spring_05.jpg
## [ 154 / 242 ] Justice_Rose Spring_06.jpg
## [ 155 / 242 ] Justice_Rose Spring_07.jpg
## [ 156 / 242 ] Justice_Rose Spring_08.jpg
## [ 157 / 242 ] Justice_Rose Spring_09.jpg
## [ 158 / 242 ] Justice_Rose Spring_10.jpg
## [ 159 / 242 ] Justice_Rose Spring_11.jpg
## [ 160 / 242 ] Justice_Rose Spring_12.jpg
## [ 161 / 242 ] Justice_Rose Spring_13.jpg
## [ 162 / 242 ] Justice_Rose Spring_14.jpg
## [ 163 / 242 ] Parowan Valley_Eastgate 1.jpg
## [ 164 / 242 ] Parowan Valley_Eastgate 2.jpg
## [ 165 / 242 ] Parowan Valley_Parowan 1.jpg
## [ 166 / 242 ] Parowan Valley_Parowan 2.jpg
## [ 167 / 242 ] Parowan Valley_Parowan 3.jpg
## [ 168 / 242 ] Parowan Valley_Parowan 4.jpg
## [ 169 / 242 ] Parowan Valley_Parowan 5.jpg
## [ 170 / 242 ] Parowan Valley_Parowan 6.jpg
## [ 171 / 242 ] Parowan Valley_Parowan 7.jpg
## [ 172 / 242 ] Parowan Valley_Parowan 8.jpg
## [ 173 / 242 ] Parowan Valley_Parowan 9.jpg
## [ 174 / 242 ] Parowan Valley_Rose Spring 1.jpg
## [ 175 / 242 ] Parowan Valley_Rose Spring 2.jpg
## [ 176 / 242 ] Parowan Valley_Rose Spring 3.jpg
## [ 177 / 242 ] Parowan Valley_Rose Spring 4.jpg
## [ 178 / 242 ] Parowan Valley_Rose Spring 5.jpg
## [ 179 / 242 ] Parowan Valley_Rose Spring 6.jpg
## [ 180 / 242 ] Parowan Valley_Rosegate 1.jpg
## [ 181 / 242 ] Parowan Valley_Rosegate 2.jpg
## [ 182 / 242 ] Radford Roost_Parowan 1.jpg
## [ 183 / 242 ] Radford Roost_Parowan 2.jpg
## [ 184 / 242 ] Radford Roost_Rosegate 1.jpg
## [ 185 / 242 ] Radford Roost_Rosegate 10.jpg
## [ 186 / 242 ] Radford Roost_Rosegate 11.jpg
## [ 187 / 242 ] Radford Roost_Rosegate 12.jpg
## [ 188 / 242 ] Radford Roost_Rosegate 13.jpg
## [ 189 / 242 ] Radford Roost_Rosegate 2.jpg
## [ 190 / 242 ] Radford Roost_Rosegate 3.jpg
## [ 191 / 242 ] Radford Roost_Rosegate 4.jpg
## [ 192 / 242 ] Radford Roost_Rosegate 5.jpg
## [ 193 / 242 ] Radford Roost_Rosegate 6.jpg
## [ 194 / 242 ] Radford Roost_Rosegate 7.jpg
## [ 195 / 242 ] Radford Roost_Rosegate 8.jpg
## [ 196 / 242 ] Radford Roost_Rosegate 9.jpg
## [ 197 / 242 ] South Temple_Cottonwood 1.jpg
## [ 198 / 242 ] South Temple_Cottonwood 2.jpg
## [ 199 / 242 ] South Temple_Desert 1.jpg
## [ 200 / 242 ] South Temple_Desert 2.jpg

```

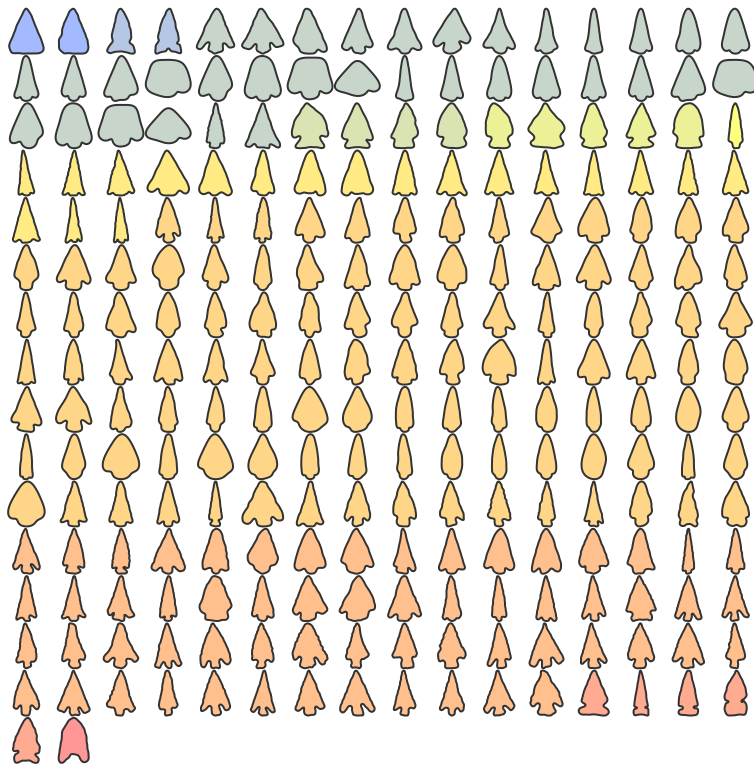
```
## [ 201 / 242 ] South Temple_Rose Spring 1.jpg
## [ 202 / 242 ] South Temple_Rose Spring 2.jpg
## [ 203 / 242 ] South Temple_Rose Spring 3.jpg
## [ 204 / 242 ] South Temple_Rose Spring 4.jpg
## [ 205 / 242 ] South Temple_Rose Spring 5.jpg
## [ 206 / 242 ] South Temple_Rose Spring 6.jpg
## [ 207 / 242 ] South Temple_Rose Spring 7.jpg
## [ 208 / 242 ] South Temple_Rose Spring 8.jpg
## [ 209 / 242 ] South Temple_Rose Spring 9.jpg
## [ 210 / 242 ] Wolf Village_Rosegate 1.jpg
## [ 211 / 242 ] Wolf Village_Rosegate 10.jpg
## [ 212 / 242 ] Wolf Village_Rosegate 11.jpg
## [ 213 / 242 ] Wolf Village_Rosegate 12.jpg
## [ 214 / 242 ] Wolf Village_Rosegate 13.jpg
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## [ 219 / 242 ] Wolf Village_Rosegate 18.jpg
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## [ 221 / 242 ] Wolf Village_Rosegate 2.jpg
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## [ 227 / 242 ] Wolf Village_Rosegate 25.jpg
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## [ 229 / 242 ] Wolf Village_Rosegate 27.jpg
## [ 230 / 242 ] Wolf Village_Rosegate 28.jpg
## [ 231 / 242 ] Wolf Village_Rosegate 29.jpg
## [ 232 / 242 ] Wolf Village_Rosegate 3.jpg
## [ 233 / 242 ] Wolf Village_Rosegate 30.jpg
## [ 234 / 242 ] Wolf Village_Rosegate 32.jpg
## [ 235 / 242 ] Wolf Village_Rosegate 33.jpg
## [ 236 / 242 ] Wolf Village_Rosegate 34.jpg
## [ 237 / 242 ] Wolf Village_Rosegate 4.jpg
## [ 238 / 242 ] Wolf Village_Rosegate 5.jpg
## [ 239 / 242 ] Wolf Village_Rosegate 6.jpg
## [ 240 / 242 ] Wolf Village_Rosegate 7.jpg
## [ 241 / 242 ] Wolf Village_Rosegate 8.jpg
## [ 242 / 242 ] Wolf Village_Rosegate 9.jpg
```

```
## Done in 3.6 secs
```

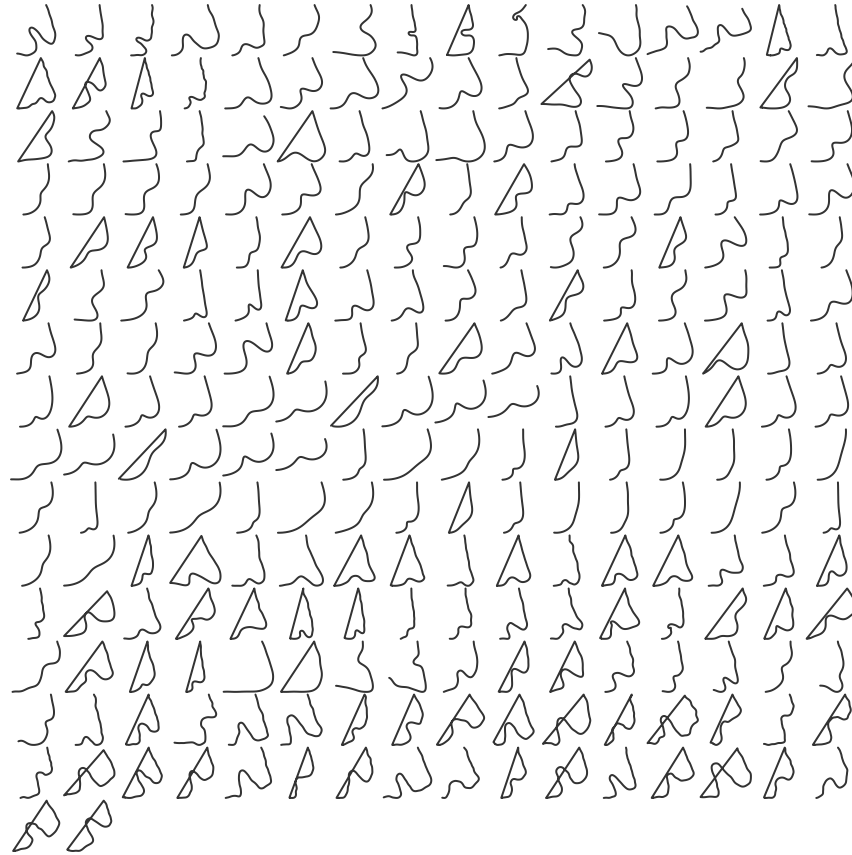
```
# add metadata
fac <- tibble(Name = names(ings),
              Type = names(ings) %>%
                str_remove_all('[0-9]') %>%
                trimws()) %>%
  separate(Type, c("Origin", "Type"), sep = "_") %>%
  mutate(Type = case_when(Type == "Parowan Basal" ~ "Parowan", TRUE ~ Type)) %>%
  mutate_all(factor)
```

```
## Warning: Expected 2 pieces. Additional pieces discarded in 26 rows [123, 124,
## 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 149, 150, 151, 152, 153, 154,
## 155, 156, ...].
```

```
outlines = imgs %>%
  # convert to Momocs Out object
  Out(fac = fac) %>%
  # center all outlines
  coo_center() %>%
  # smooth outlines
  coo_smooth(100)
# display results
outlines %>%
  Momocs::arrange(Type) %>%
  panel(fac = "Type", palette = col_spring)
```



```
# obtain corners
corners = outlines %>%
  # extract bottom portion
  coo_down() %>%
  # extract right portion
  coo_right()
# visualize
corners %>% panel
```



```
file.remove(ls)
```

```
## [1] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [16] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [31] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [46] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [61] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [76] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
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## [136] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [151] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [166] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [181] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [196] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [211] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [226] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [241] TRUE TRUE
```

As you may observe there are cases where a point on the base is shown connected to point at the top of the remaining portion of the blade. This is problematic and is caused by slight variations in the origin point for the outlines when they are created. This problem has been manually fixed for all points used in subsequent analyses.

## 1.6.2 Analysis

```
# load modified outlines
outlines <- readRDS('AllpointscornerCombined.Rds')
# set number of points to use
n <- 35
outlinesPCA <- outlines %>%
  coo_sample(n) %>%
  Ldk() %>%
  Momocs::fgProcrustes() %>%
  PCA()
```

```
## iteration: 1    gain: 1228400
## iteration: 2    gain: 64.636
## iteration: 3    gain: 11.835
## iteration: 4    gain: 1.7792
## iteration: 5    gain: 10.262
## iteration: 6    gain: 3.5208
## iteration: 7    gain: 1.5338
## iteration: 8    gain: 0.29681
## iteration: 9    gain: 1.0588
## iteration: 10   gain: 0.70247
## iteration: 11   gain: 0.13943
## iteration: 12   gain: 0.0070079
## iteration: 13   gain: 0.025988
## iteration: 14   gain: 0.058245
## iteration: 15   gain: 0.051543
## iteration: 16   gain: 0.0088052
## iteration: 17   gain: 0.021638
## iteration: 18   gain: 0.024221
## iteration: 19   gain: 0.013105
## iteration: 20   gain: 0.0019754
## iteration: 21   gain: 0.0042918
## iteration: 22   gain: 0.0055256
## iteration: 23   gain: 0.0035034
## iteration: 24   gain: 0.0007007
## iteration: 25   gain: 0.0010955
## iteration: 26   gain: 0.0014646
## iteration: 27   gain: 0.00093205
## iteration: 28   gain: 0.00020981
## iteration: 29   gain: 0.00025777
## iteration: 30   gain: 0.00037022
## iteration: 31   gain: 0.00024702
## iteration: 32   gain: 6.3535e-05
## iteration: 33   gain: 6.0963e-05
## iteration: 34   gain: 9.4512e-05
## iteration: 35   gain: 6.5441e-05
## iteration: 36   gain: 1.8752e-05
## iteration: 37   gain: 1.4129e-05
## iteration: 38   gain: 2.3968e-05
## iteration: 39   gain: 1.7293e-05
## iteration: 40   gain: 5.4693e-06
## iteration: 41   gain: 3.2117e-06
```

```
## iteration: 42    gain: 6.0637e-06
## iteration: 43    gain: 4.5615e-06
## iteration: 44    gain: 1.5761e-06
## iteration: 45    gain: 7.1014e-07
## iteration: 46    gain: 1.5279e-06
## iteration: 47    gain: 1.2005e-06
## iteration: 48    gain: 4.4985e-07
## iteration: 49    gain: 1.5102e-07
## iteration: 50    gain: 3.8339e-07
## iteration: 51    gain: 3.1525e-07
## iteration: 52    gain: 1.2731e-07
## iteration: 53    gain: 3.0237e-08
## iteration: 54    gain: 9.5748e-08
## iteration: 55    gain: 8.2582e-08
## iteration: 56    gain: 3.5764e-08
## iteration: 57    gain: 5.4442e-09
## iteration: 58    gain: 2.3784e-08
## iteration: 59    gain: 2.1579e-08
## iteration: 60    gain: 9.9799e-09
## iteration: 61    gain: 7.6943e-10
## iteration: 62    gain: 5.8726e-09
## iteration: 63    gain: 5.6234e-09
## iteration: 64    gain: 2.7685e-09
## iteration: 65    gain: 2.8194e-11
```

```
# linear discriminant analysis
outlinesLDA <- LDA(outlinesPCA, 'Type', retain = 10)
```

```
## 10 PC retained
```

```
valid <- outlinesLDA$CV.tab %>% as.data.frame() %>%
  mutate(valid = actual == classified) %>%
  uncount(Freq) %>%
  summarise(valid = sum(valid) / n())
# predictions table
tablePredictions <- outlinesLDA$CV.tab %>% as.data.frame() %>%
  pivot_wider(names_from = 'classified', values_from = 'Freq') %>%
  mutate(accuracy = map_chr(outlinesLDA$CV.ce, ~ paste0(round(.x * 100, 0), "%")))
# clustering with UMAP
set.seed(1010) # for reproducibility
outlinesRose <- outlinesPCA %>%
  Momocs::filter(Type %in% c("Eastgate", "Rose Spring"))
outlinesUMAP <- umap::umap(outlinesRose$x,
  labels = rownames(outlinesRose$x[, 1:10]))
outlinesUMAPdf <- outlinesUMAP$layout %>% as.data.frame() %>%
  rownames_to_column('Name') %>%
  as_tibble() %>%
  mutate(clusterUMAP = factor(kmeans(outlinesUMAP$layout, 2)$cluster),
    clusterPCA = factor(kmeans(outlinesRose$x, 2)$cluster)) %>%
  left_join(outlinesRose$fac)
```

```
## Joining, by = "Name"
```

## 1.7 Table 1. Fremont Projectile Point Data from this Study

```
#footnotes
a <-
  '$^a$Bull Creek incorporates several site numbers: 42WN226, 42WN230, 42WN231, 42WN261, 42WN326, 42WN330'
b <-
  '$^b$This site is composed of several mounds that were excavated and reported at different times.'
footers <- c('Bull Creek','Hinckley Mounds 1 (42UT111)')
c1 <- which(projData$Site == footers[1]) + 1
c2 <- which(projData$Site == footers[2]) + 1
t1 <- projData %>%
  select(
    Site,
    Period,
    `Total Projectile Points`,
    `Total Rosegate Points`,
    `Total Dart Points`,
    References
  ) %>%
  as_hux(add_colnames = T) %>%
  set_contents(c1,1,paste0(footers[1],"$^a$")) %>%
  set_contents(c2,1,paste0(footers[2],"$^b$")) %>%
  theme_article() %>%
# add notes
huxtable::add_footnote(a) %>%
huxtable::add_footnote(b, border = 0) %T>%
quick_xlsx(file = "Rosegate Table 1.xlsx") %T>%
quick_docx(file = "Rosegate Table 1.docx")
```

## 1.8 Table 2. Numerical Summary of Rosegate Projectile Points by Period

```
# Create table showing numerical descriptors by period.
t2 <- projData %>%
  rename(r = `Rosegate % of Arrow Points`, t = `Total Rosegate Points`) %>%
  group_by(Period) %>%
  summarize(`Number of sites` = n(),
    `Total Rosegate points` = sum(t),
    `Total Rosegate %` = sum(t)/sum(ArrowPoints)*100,
    `Mean site %` = mean(r),
    `Median site %` = median(r),
    `Minimum site %` = min(r),
    `Maximum site %` = max(r)) %>%
  gather(Statistic, Value, -Period) %>%
  arrange(Period) %>%
  spread(Period,Value) %>%
  mutate_if(is.numeric,round,0) %>%
  slice(c(5,7,6,2,3,4,1)) %>%
  as_hux(add_colnames = TRUE) %>%
  theme_article() %>%
  set_align(1:8,2:4,"right") %>%
  set_contents(1,1,"") %>%
```

```
set_number_format(everywhere,4,fmt_pretty()) %T>%
quick_xlsx(file = "Rosegate Table 2.xlsx") %T>%
quick_docx(file = "Rosegate Table 2.docx")
```

## 'summarise()' ungrouping output (override with '.groups' argument)

## 1.9 Table 4. Actual vs Predicted Results from a Linear Discriminants Analysis

```
t4 <- tablePredictions %>%
  as_hux() %>%
  insert_row(c('', 'predicted type'), after = 0, fill = "") %>%
  insert_column(c('', '', 'actual type'), after = 0, fill = "") %>%
  set_contents(2,2,"") %>%
  merge_cells(1,3:(ncol(tablePredictions) + 1)) %>%
  merge_cells(3:(nrow(tablePredictions) + 1),1) %>%
  set_align(1, 2:ncol(tablePredictions), "center") %>%
  set_align(2:nrow(tablePredictions), 1, "center") %>%
  set_bold(1, 2:ncol(tablePredictions)) %>%
  set_bold(2:nrow(tablePredictions), 1) %>%
  set_rotation(2:(nrow(tablePredictions) + 2), 1,90) %>%
  theme_article() %>%
  set_right_border(3:(nrow(tablePredictions) + 2), 1) %>%
  set_bottom_border(nrow(tablePredictions) + 2, 1) %>%
  set_bottom_border(1,3:(ncol(tablePredictions) + 1)) %T>%
  quick_xlsx(file = 'Rosegate Table 4.xlsx') %T>%
  quick_docx(file = 'Rosegate Table 4.docx')
```

## 1.10 Supplemental Table 1

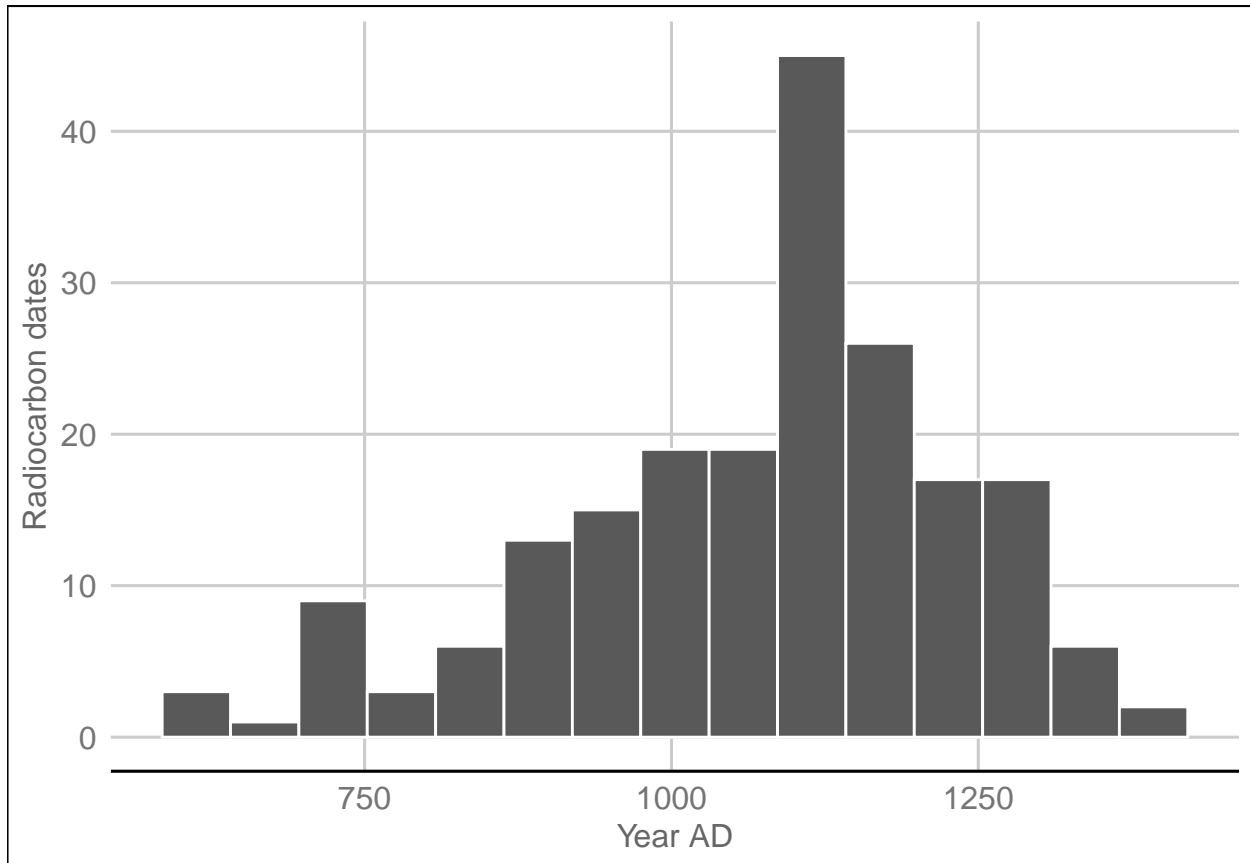
```
# Save Radiocarbon table
r = nrow(radiocarbonData) + 1
n = ncol(radiocarbonData)
s1 <- as_hux(radiocarbonData, add_colnames = TRUE) %>%
  set_top_border(1,1:n,1) %>%
  set_bottom_border(1,1:n,1) %>%
  set_bottom_border(r,1:n,1) %>%
  set_align(1:r,2:n, "right") %T>%
  quick_xlsx(file = "Rosegate Supplemental Table 1.xlsx") %T>%
  quick_docx(file = "Rosegate Supplemental Table 1.docx")
```

## 1.11 Figure 4. Histogram of radiocarbon dates used in this study.

```
# histogram
dateEstimates %>%
  ggplot() +
  aes(ADMedian) +
  geom_histogram(bins = 15, color = 'white') +
```



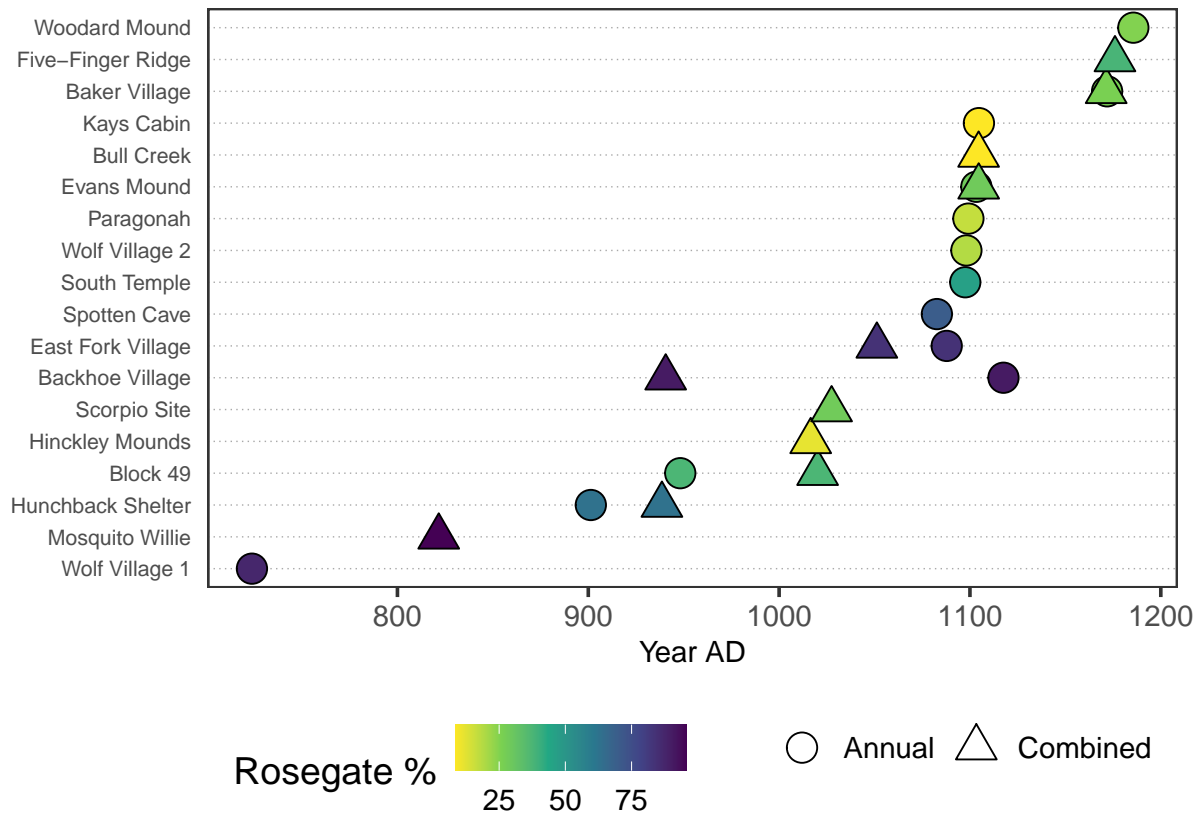
```
theme_gdocs() +
xlab('Year AD') +
ylab('Radiocarbon dates')
```



```
ggsave('Rosegate Figure 4.jpg',
        height = 4.5, width = 6.26, dpi = 600)
```

1.12 Figure 5. Radiocarbon dates by median date.

```
ggplot() +
  geom_point(data = dateEstimatesMedian,
             aes(jitter(ADMedian, factor = 10),
                 reorder(`Site Name`,ADMedian),
                 fill = `Rosegate % of Arrow Points`,
                 shape = Annual), size = 5) +
  theme_dotplot +
  xlab('Year AD') +
  ylab('') +
  scale_fill_viridis_c(direction = -1) +
  scale_shape_manual(values = c(21,24)) +
  guides(fill = guide_colorbar('Rosegate %'), shape = guide_legend('')) +
  theme(legend.position = 'bottom')
```

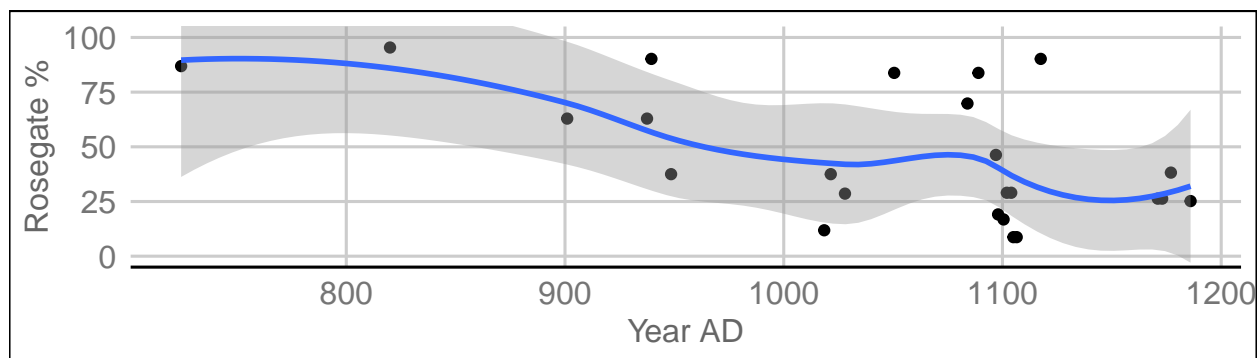


```
ggsave('Rosegate Figure 5.jpg',
        height = 4.5, width = 6.26, dpi = 600)
```

### 1.13 Figure 6. Rosegate percentages and median calibrated radiocarbon date

```
ggplot(dateEstimatesMedian, aes(ADMedian, `Rosegate % of Arrow Points`)) +
  geom_point() + geom_smooth() +
  theme_gdocs() +
  xlab('Year AD') +
  ylab('Rosegate %') +
  coord_fixed(ylim = c(0,100))
```

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

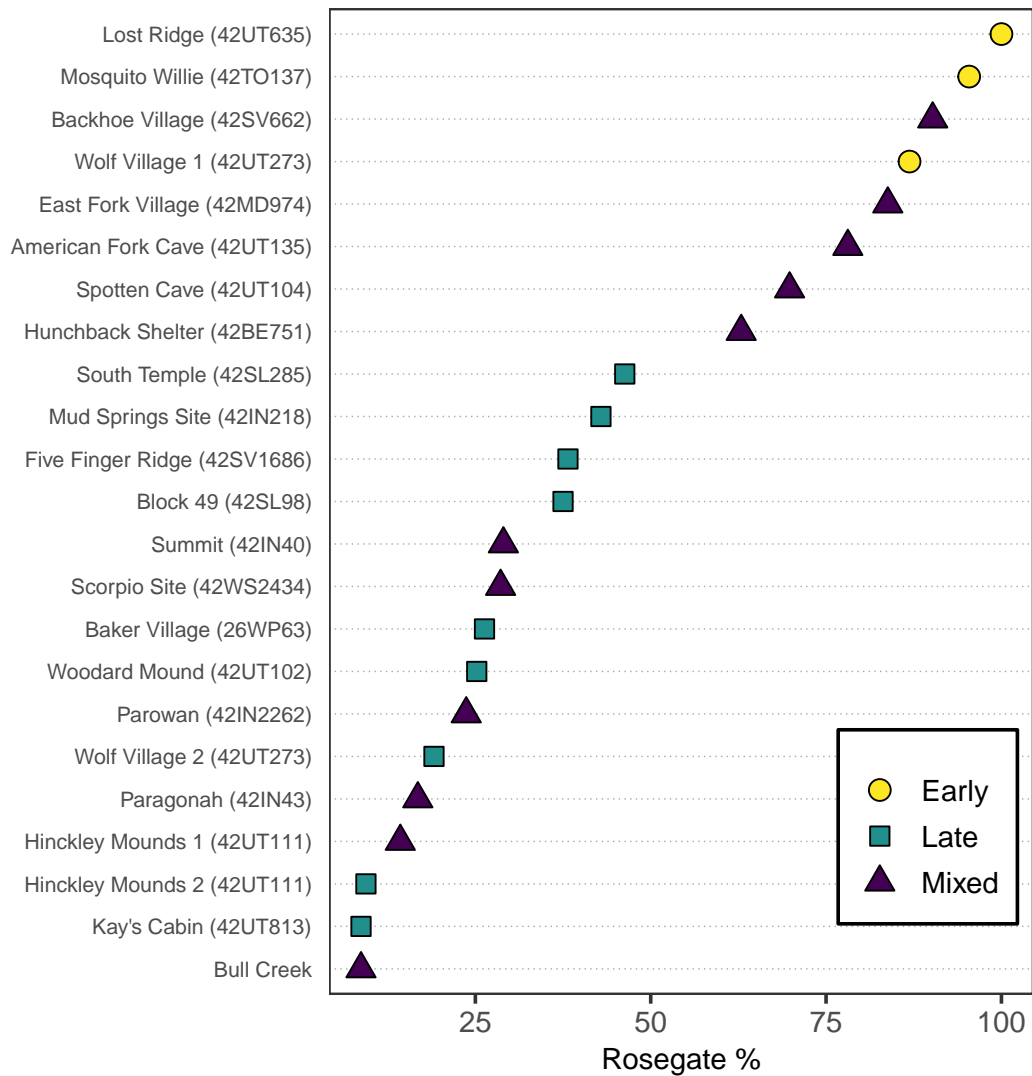


```
ggsave('Rosegate Figure 6.jpg',
        height = 4.5, width = 6.23, dpi = 600)
```

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

1.14 Figure 7. Dot plot showing the percentage of Rosegate points to arrow points.

```
projData %>%
  ggplot() +
  aes(`Rosegate % of Arrow Points`,
      reorder(Site, `Rosegate % of Arrow Points`),
      shape = Period, fill = Period) +
  geom_point(size = 3.5) +
  theme_dotplot +
  xlab("Rosegate %") +
  ylab("") +
  scale_fill_viridis_d(direction = -1) +
  scale_shape_manual(values = c(21, 22, 24)) +
  theme(legend.position = c(.85, .17),
        legend.title = element_blank(),
        legend.background = element_rect(color = "black"))
```



```
ggsave("Rosegate Figure 7.jpg", width = 6.26, height = 5, units = "in",
       dpi = 600)
```

### 1.15 Figure 10. Principal components analysis

```
jpeg('Rosegate Figure 10.jpg',
     width = 6.26, height = 4, units = 'in',
     res = 600)
plot_PCA(outlinesPCA, axes = c(1,2), zoom = 1, ~Type, labelpoints = F,
        palette = viridis::viridis)
dev.off()
```

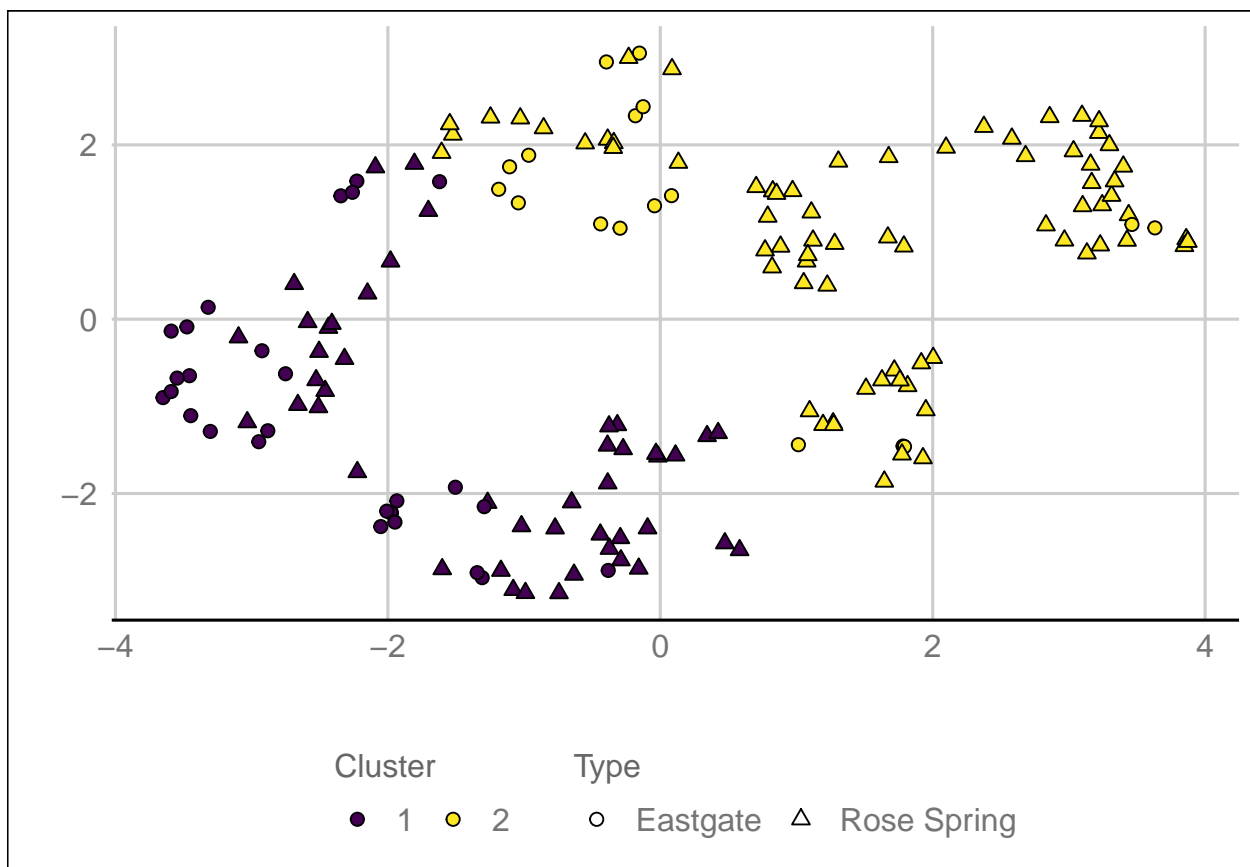
```
## pdf
## 2
```

## 1.16 Figure 11. UMAP

```

outlinesUMAPdf %>%
  ggplot(aes(V1,V2,
             fill = clusterUMAP,
             shape = Type, label = Name)) +
  geom_point(size = 2) +
  scale_shape_manual(values = c(21,24)) +
  guides(fill = guide_legend('Cluster',
                             ncol = 2,
                             byrow = T,
                             override.aes = list(shape = 21)),
         shape = guide_legend(ncol = 2,
                              byrow = T)) +
  scale_fill_viridis_d() +
  xlab('') +
  ylab('') +
  theme(legend.position = 'bottom')

```



```

ggsave('Rosegate Figure 11.jpg', dpi = 600, width = 6.26, units = 'in')

```

```

## Saving 6.26 x 4.5 in image

```