Multidimensional Scaling of the Species in National Parks

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Collecting Data

There are 58 National Parks in the United States, including parks in Alaska, Hawaii, and the US territory of American Samoa.


National Parks and Other Recreational Areas of the United States
National Park
National Historical Park
National Seashore
National Memorial
National Monument
National Recreation Area
National Lakeshore
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Wash.
Oregon
California
Nevada
Idaho
Montana
Wyoming
Utah
Colorado
Arizona
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minn.
Iowa
Missouri
Arkansas
Louisiana
Wis.
Illinois
Michigan
Ind.
Ohio
Ky.
Tennessee
Miss.
Alabama
Georgia
Florida
South Carolina
North Carolina
Va.
W. Va.
Pa.
New York
Md.
Del.
N.J.
Conn.
R.I.
Mass.
VT.
N.H.
Maine
Alaska
Hawaii
San Juan Island
Olympic
North Cascades
Ross Lake
Coulee Dam
Lake Chelan
Klondike Gold Rush
Mount Rainier
Fort Clatsop
Waterton Lakes Park (Canada)
Waterton-Glacier International Peace Park
Glacier
Nez Perce
John Day Fossil Beds
Crater Lake
Oregon Caves
Redwood
Lava Beds
Whiskeytown-Shasta-Trinity
Lassen Volcanic
Point Reyes
Muir Woods
Golden Gate
San Francisco Maritime
Yosemite
Devils Postpile
Pinnacles
Kings Canyon
Sequoia
Death Valley
Santa Monica Mountains
Channel Islands
Mojave
Joshua Tree
Cabrillo
Great Basin
Lake Mead
Craters of the Moon
Hagerman Fossil Beds
Yellowstone
Grand Teton
Little Bighorn Battlefield
Bighorn Canyon
Devils Tower
Fossil Butte
Theodore Roosevelt (North Unit)
Theodore Roosevelt (South Unit)
Mount Rushmore
Jewel Cave
Wind Cave
Badlands
Agate Fossil Beds
Scotts Bluff
Homestead N.M. of America
Timpanogos Cave
Dinosaur
Rocky Mountain
Arches
Canyonlands
Capitol Reef
Cedar Breaks
Bryce Canyon
Zion
Glen Canyon
Natural Bridges
Pipe Spring
Rainbow Bridge
Hovenweep
Yucca House
Mesa Verde
Colorado
Black Canyon of the Gunnison
Curecanti
Florissant Fossil Beds
Great Sand Dunes
Grand Canyon
Navajo
Wupatki
Sunset Crater
Walnut Canyon
Canyon de Chelly
Aztec Ruins
Chaco Culture
Capulin Volcano
Fort Union
Bandelier
Pecos
Zuni-Cibola
El Morro
El Malpais
Petrified Forest
Tuzigoot
Montezuma Castle
Tonto
Salinas Pueblo Missions
Organ Pipe Cactus
Casa Grande
Saguaro
Chiricahua
Tumacacori
Coronado
Gila Cliff Dwellings
White Sands
Carlsbad Caverns
Chamizal
Guadalupe Mountains
Lake Meredith Rec. Area
Alibates Flint Quarries
Chickasaw
Big Bend
Amistad Rec. Area
Lyndon B. Johnson
San Antonio Missions
Padre Island
Voyageurs
Grand Portage
Isle Royale
Apostle Islands
Pictured Rocks
Sleeping Bear Dunes
Mississippi Nat'l River & Rec. Area
Pipestone
Effigy Mounds
Indiana Dunes
Jefferson National Expansion Memorial
George Rogers Clark
George Washington Carver
Hot Springs
Arkansas Post
Poverty Point
Jean Lafitte
Gulf Islands
Perry's Victory and International Peace Memorial
Cuyahoga Valley
Mound City Group
Lincoln Boyhood
Mammoth Cave
Cumberland Gap
Big South Fork
Great Smoky Mountains
Russell Cave
Chattahoochee River
Ocmulgee
Fort Frederica
Cumberland Island
Fort Caroline
Castillo de San Marcos
Fort Matanzas
Canaveral
De Soto
Everglades
Biscayne
Dry Tortugas
Congaree Swamp
Fort Sumter
Fort Pulaski
Cape Lookout
Cape Hatteras
Wright Brothers
Booker T. Washington
Appomattox Court House
Shenandoah
Colonial
George Washington Birthplace
Assateague Island
Harper's Ferry
Fort McHenry
Chesapeake and Ohio
Valley Forge
Independence
Thaddeus Kosciuszko
Delaware Water Gap
Statue of Liberty
Morristown
Fire Island
Women's Rights
Fort Stanwix
Saratoga
Lowell
Boston
Cape Cod
Minute Man
Roger Williams
Acadia
St. Croix Island International Historic Site
New York City
Castle Clinton
Federal Hall
Gateway
General Grant
Hamilton Grange
Kobuk Valley
Gates of Arctic
Cape Krusenstern
Denali
Wrangell-St.Elias
Lake Clark
Klondike Gold Rush
Katmai
Kenai Fjords
Glacier Bay
Aniakchak
Sitka
Kauai
Niihau
Oahu
USS Arizona
Molokai
Kalaupapa
Maui
Haleakala
Lanai
Kahoolawe
Kaloko-Honokohau
Pu'uhonua o Honaunau
Hawaii Volcanoes
Virgin Islands
Buck Island Reef
Puerto Rico

Collecting Data

We were able to collect data for the animal species from 56 parks from the United States National Park Service website

The data we collected was a list of taxonomy codes for each park, where every taxonomy code represents a unique species

Collecting Data

To calculate the distance between two parks, we consider the number of taxonomy codes in common.

The distance between parks is greater for two parks that have fewer species in common, and less for two parks that have more species in common.

Creating the Distance Matrix

We make the following definitions of variables.

$$
\begin{aligned}
P &= \text{The set of all national parks } \{1, 2, 3, \ldots, 56\}. \\
n_i &= \text{The number of species that exist in park } i.\ (i \in P) \\
c_{i,j} &= \text{The number of common species between park } i \text{ and park } j.\ (i, j \in P) \\
d_{i,j} &= \text{The ecological distance between park } i \text{ and park } j.\ (i, j \in P)
\end{aligned}
$$

Then, we define the ecological distance between park i and park j as the following.

$$
d_{i,j} = \left(1 - \frac{2c_{i,j}}{n_i + n_j}\right)^4 , \forall i, j \in P \tag{1}
$$

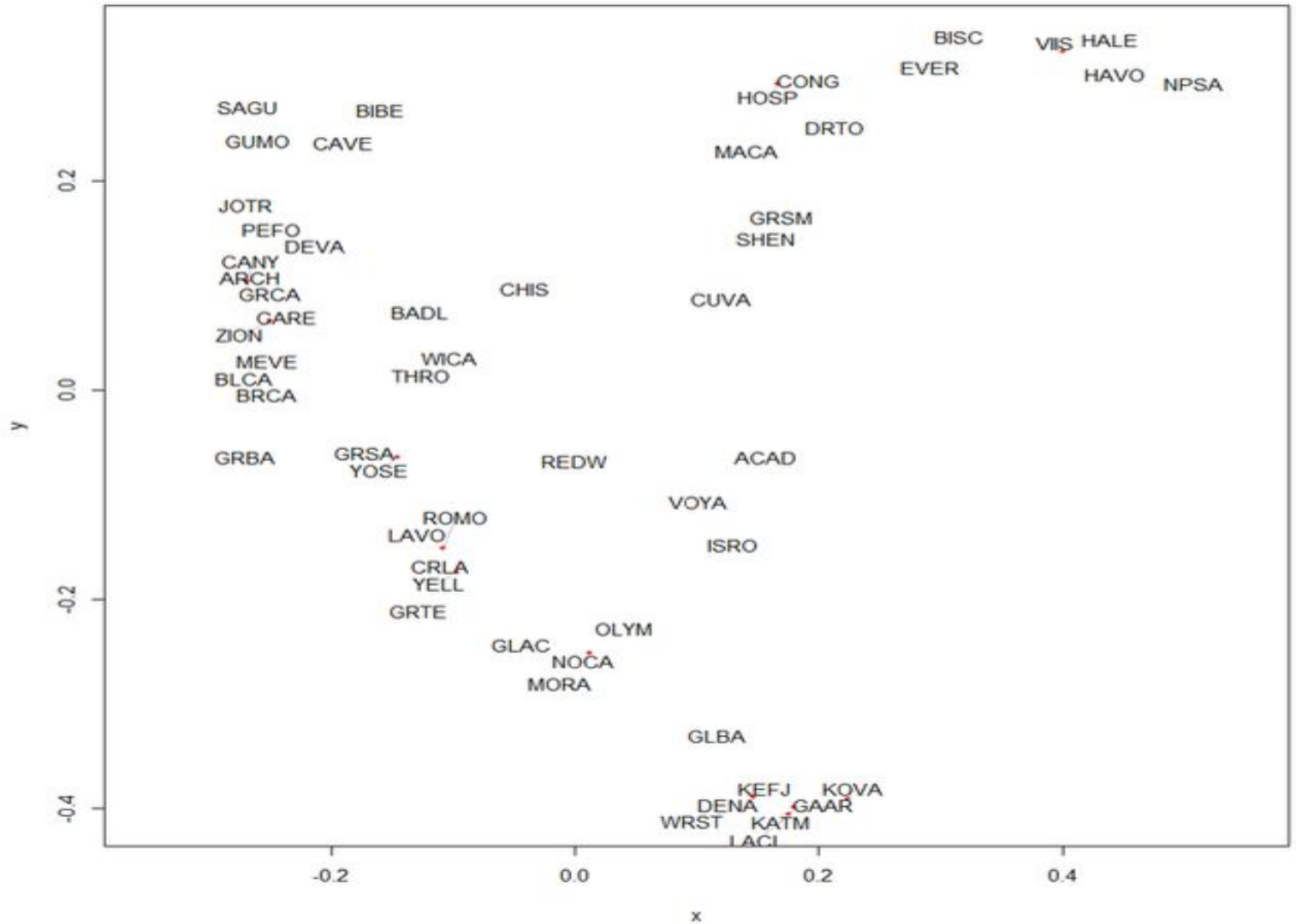
Creating the Distance Matrix

There is no dimensionality to species in National Parks. There was no guarantee that there would be anything meaningful about the map created.

We had to modify our distance formula until the GOF indicated that it was actually meaningful to have our data condensed to two dimensions

Creating a Visual

We can put our distance matrix into R and run MDS to produce a visual, two dimensional representation of the distances between every two parks


BISC
VIIS
HALE
EVER
HAVO
NPSA
CONG
HOSP
SAGU
BIBE
DRTO
GUMO
CAVE
MACA
JOTR
GRSM
PEFO
SHEN
DEVA
CANY
ARCH
CHIS
GRCA
CUVA
BADL
GARE
ZION
MEVE
WICA
BLCA
THRO
BRCA
GRBA
GRSA
REDW
ACAD
YOSE
VOYA
ROMO
LAVO
ISRO
CRLA
YELL
GRTE
OLYM
GLAC
NOCA
MORA
GLBA
KEFJ
KOVA
DENA
GAAR
WRST
KATM
LACI
0.2
0.0
-0.2
-0.4
y
-0.2
0.0
0.2
0.4
x

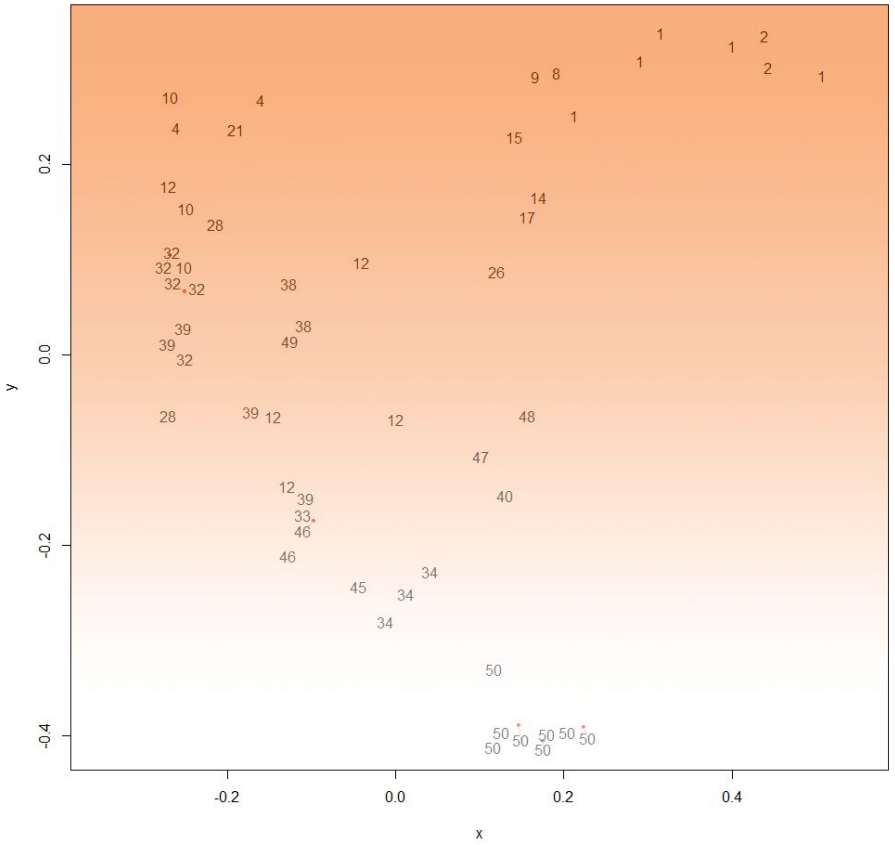
Creating a Model

We have a map, but not yet a model.

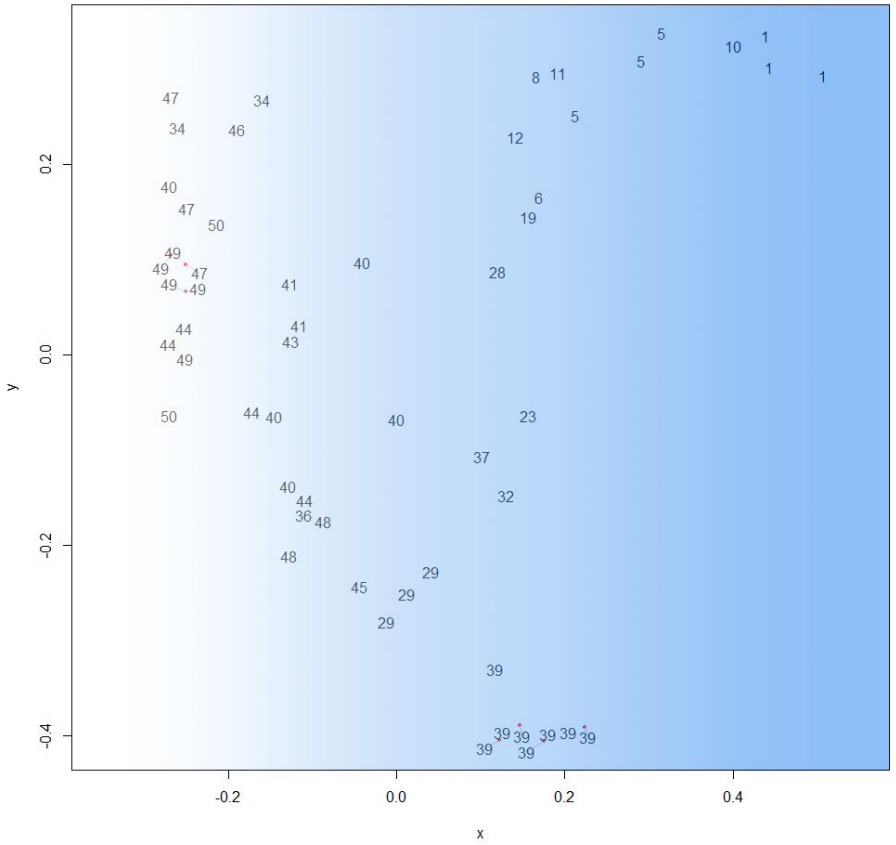
To have a mathematical model we have to be able to say something about what it means: what can we predict based upon it?

In other words, what do the x and y axes represent?

Temperature Ranking



Precipitation Ranking

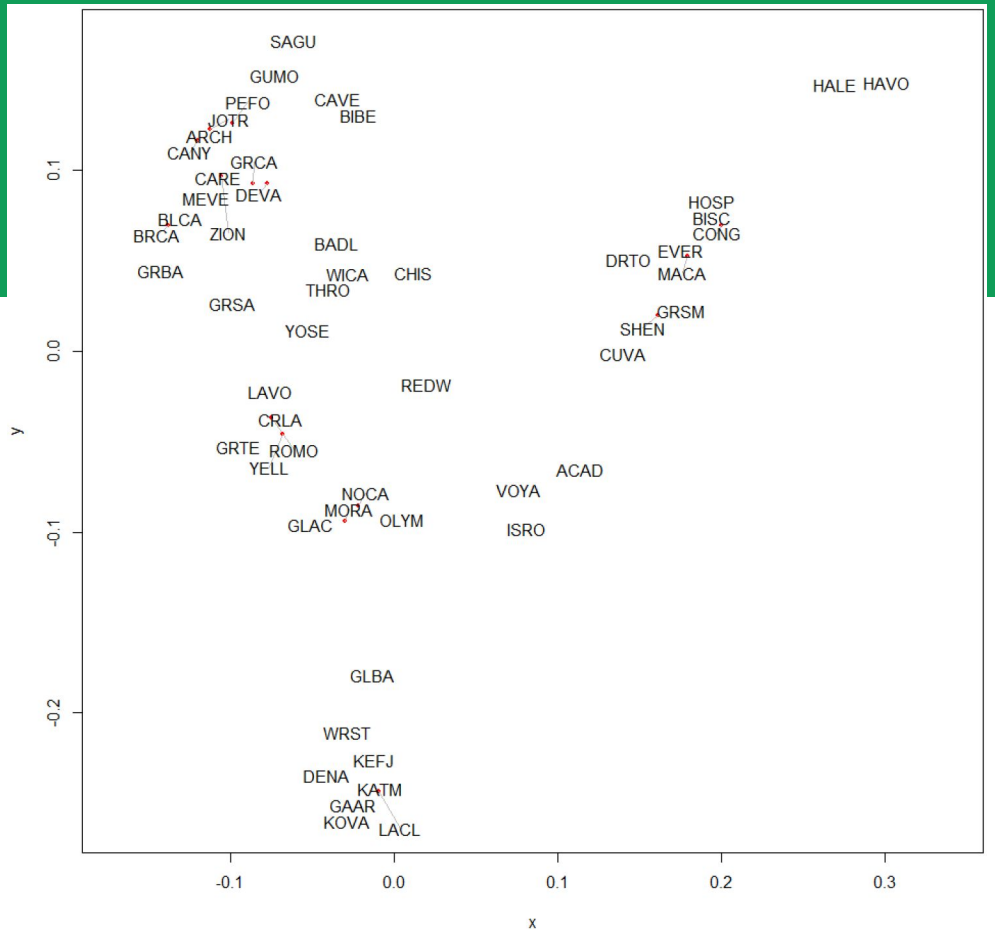


Adjustment 1

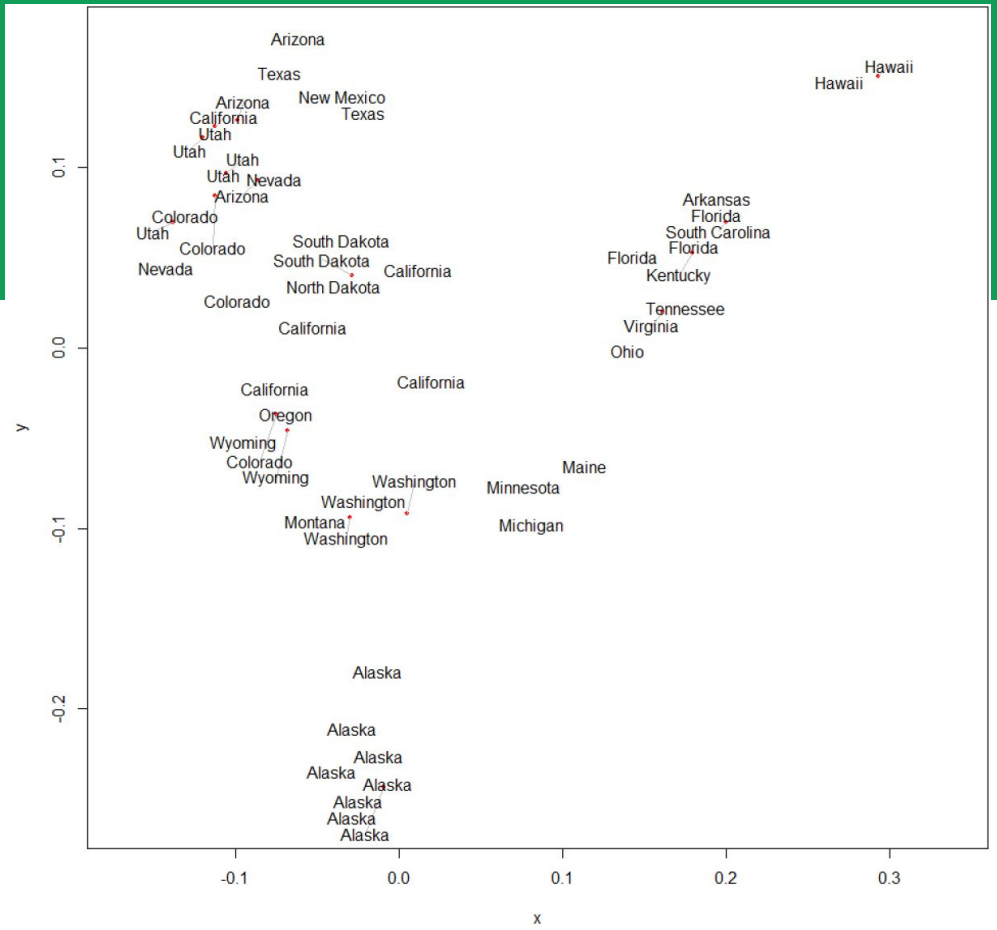
The new distance formula.

$$d_{i,j} = \begin{cases} \dfrac{1}{(1 + c_{i,j})^{\frac{1}{32}}} & \text{if } i \neq j,\ \forall i, j \in P \\ 0 & \text{if } i = j,\ \forall i, j \in P \end{cases}$$

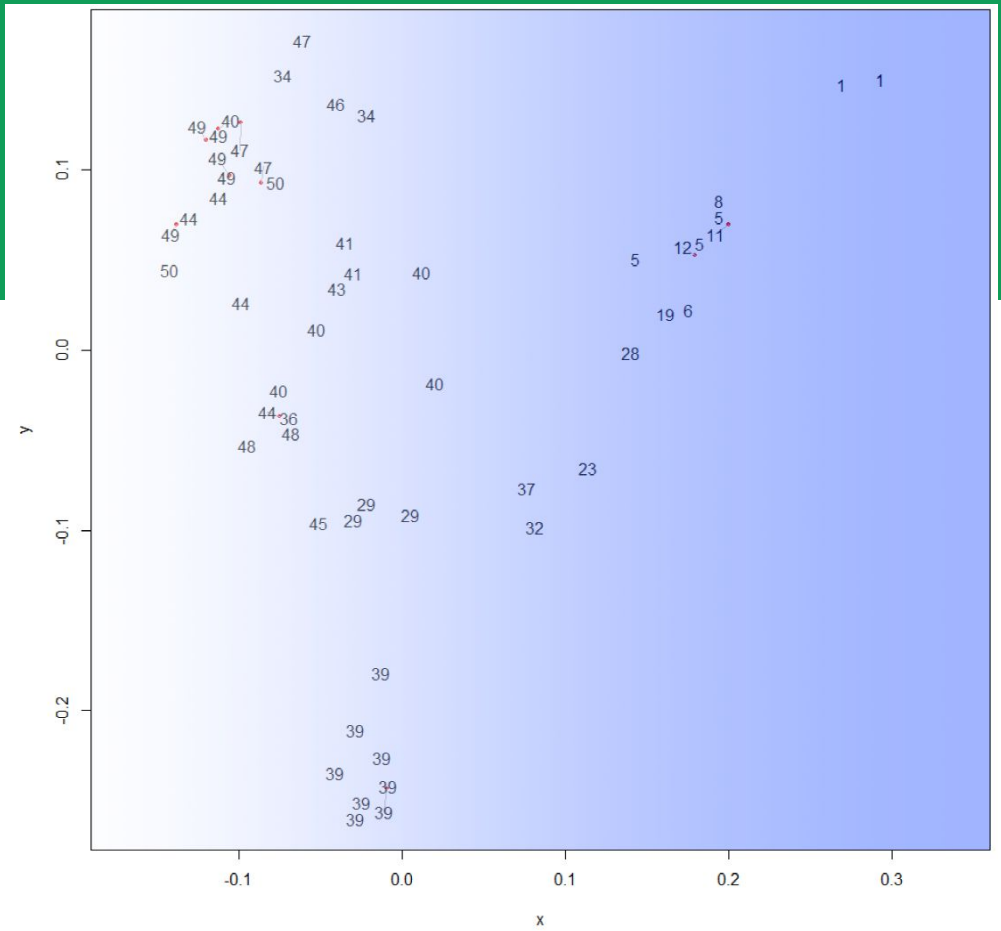
Abbreviations



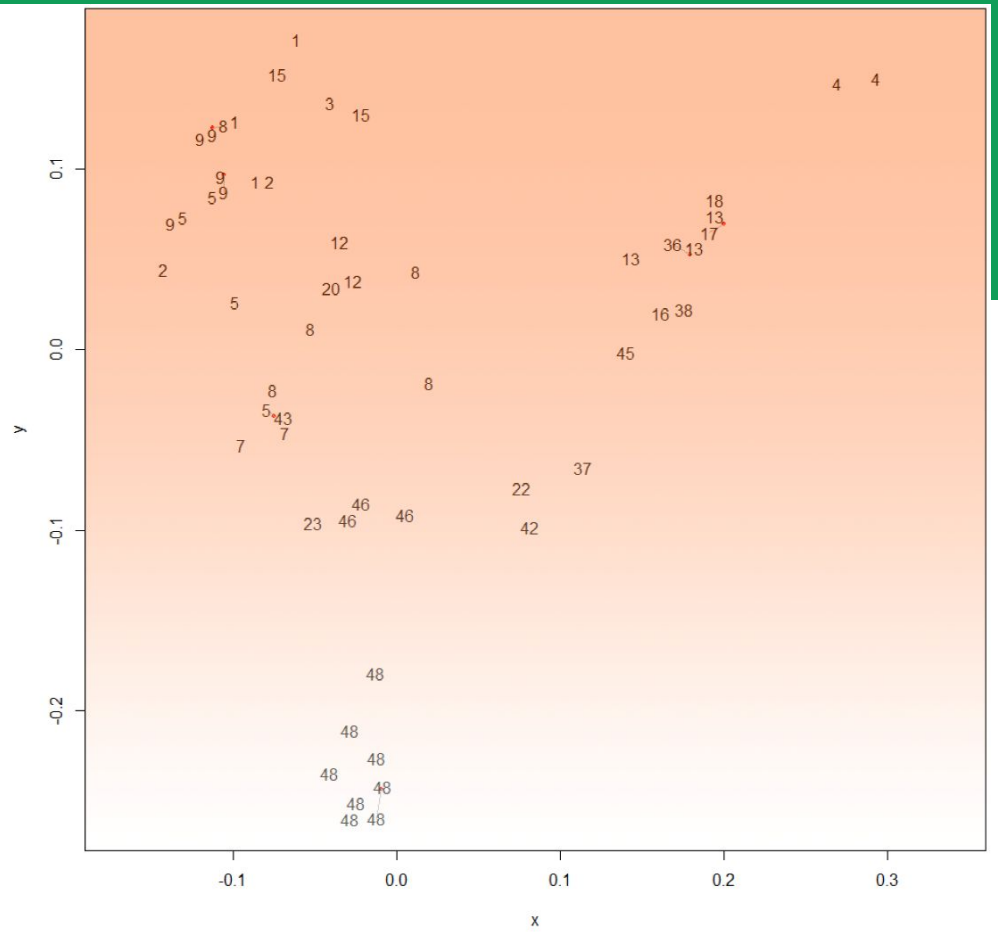
States


Arizona
Texas
Arizona
New Mexico
Texas
California
Utah
Utah
Utah
Nevada
Arizona
Colorado
Utah
Colorado
South Dakota
Nevada
South Dakota
California
North Dakota
Colorado
California
California
Oregon
Wyoming
Colorado
Wyoming
Washington
Washington
Montana
Washington
Alaska
Alaska
Alaska
Alaska
Alaska
Alaska
Alaska
Hawaii
Hawaii
Arkansas
Florida
South Carolina
Florida
Florida
Kentucky
Tennessee
Virginia
Ohio
Maine
Minnesota
Michigan
0.1
0.0
-0.1
-0.2
y
-0.1
0.0
0.1
0.2
0.3
x

Precipitation



Sunshine Hours



Adjustment 2

National Parks in the Northwest:

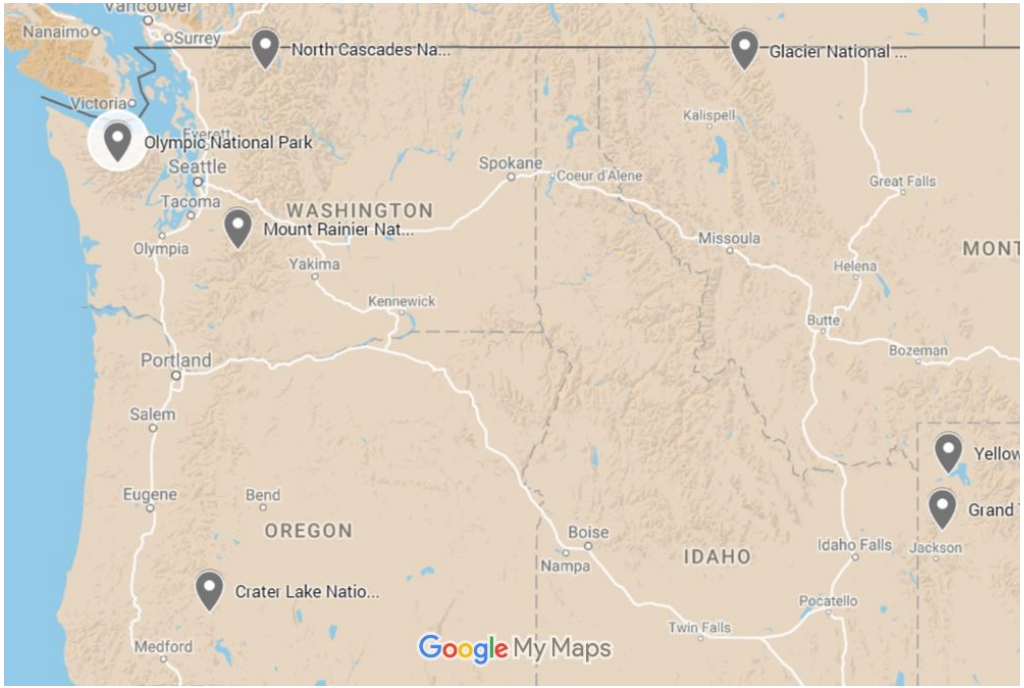
Washington - Mount Rainier, North Cascades, and Olympic National Parks

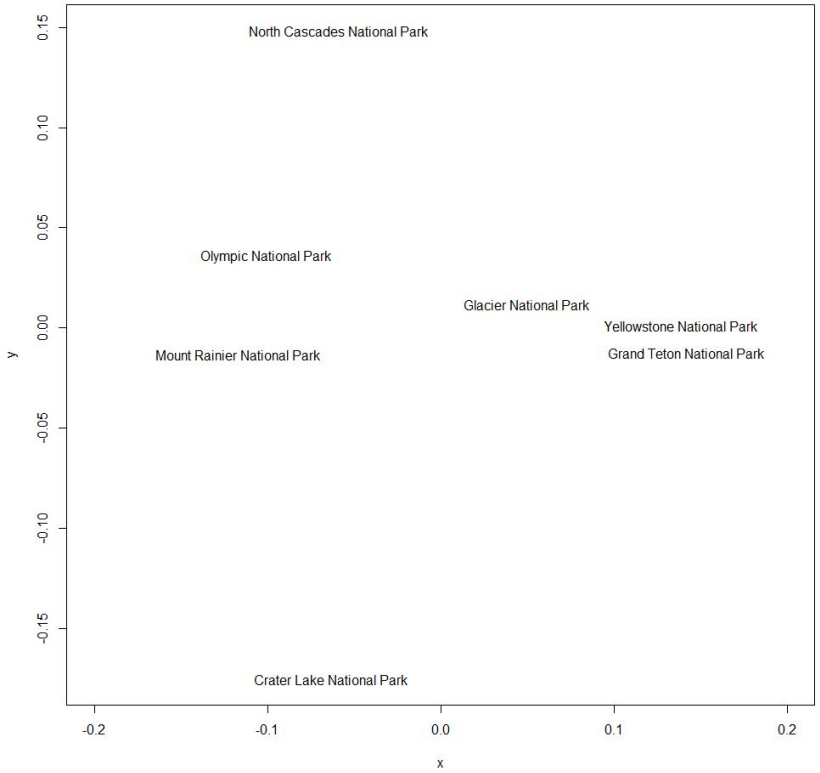
Oregon - Crater Lake National Park

Montana - Glacier National Park

Wyoming - Grand Teton and Yellowstone National Parks

MDS output of Northwest





Questions?