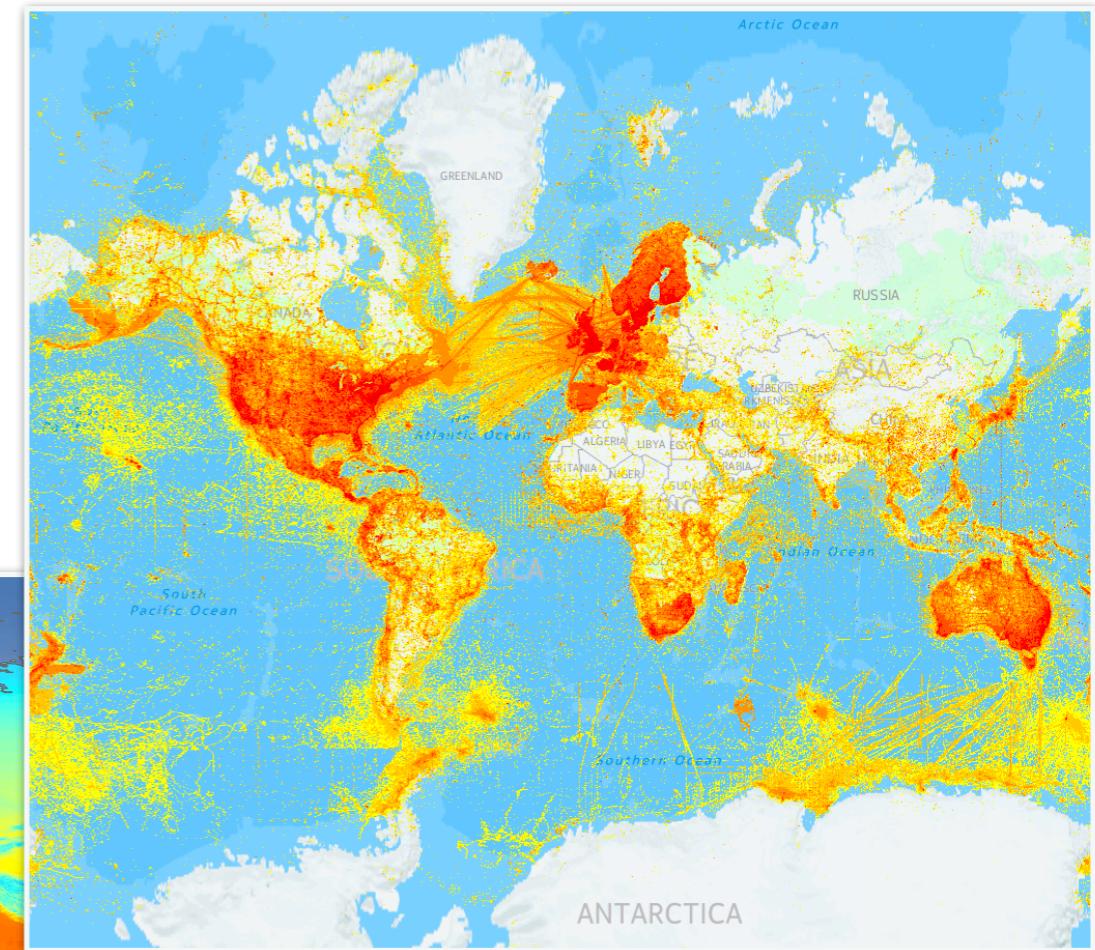
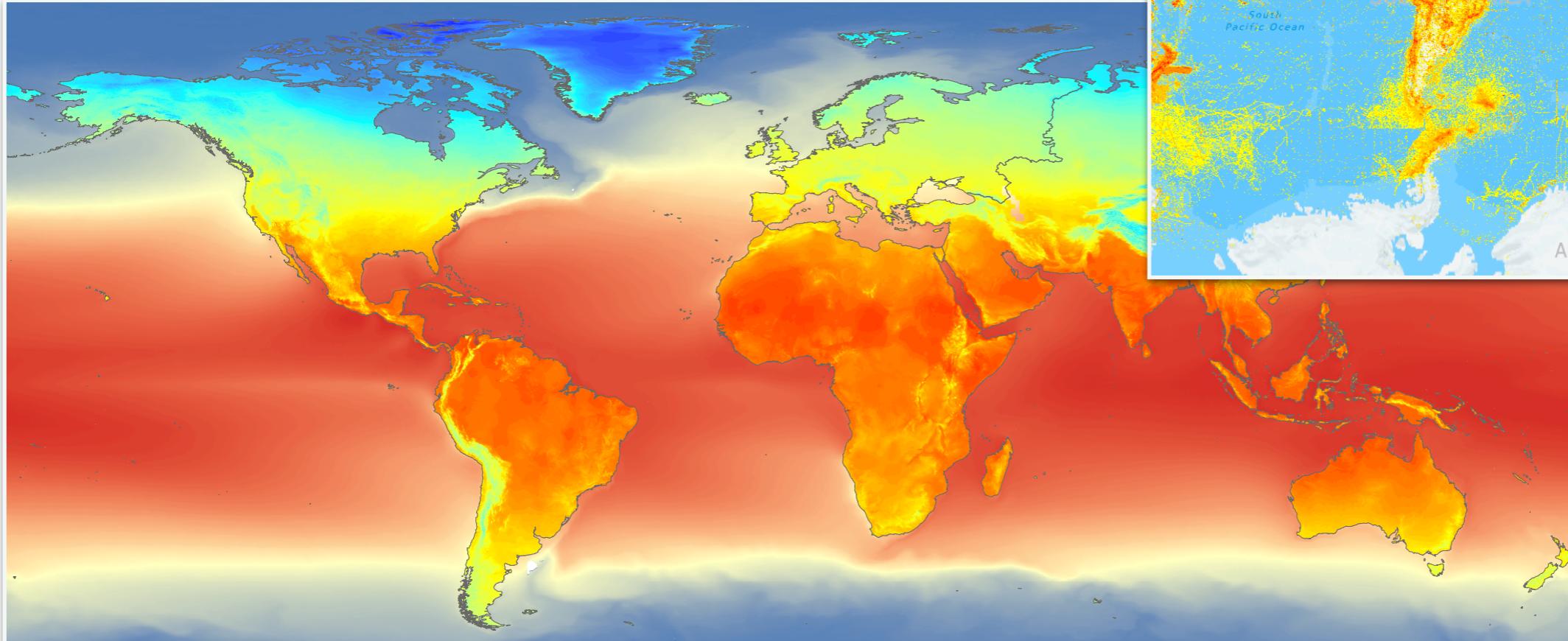


Spatial Data in R



Spatial Data: Two main types

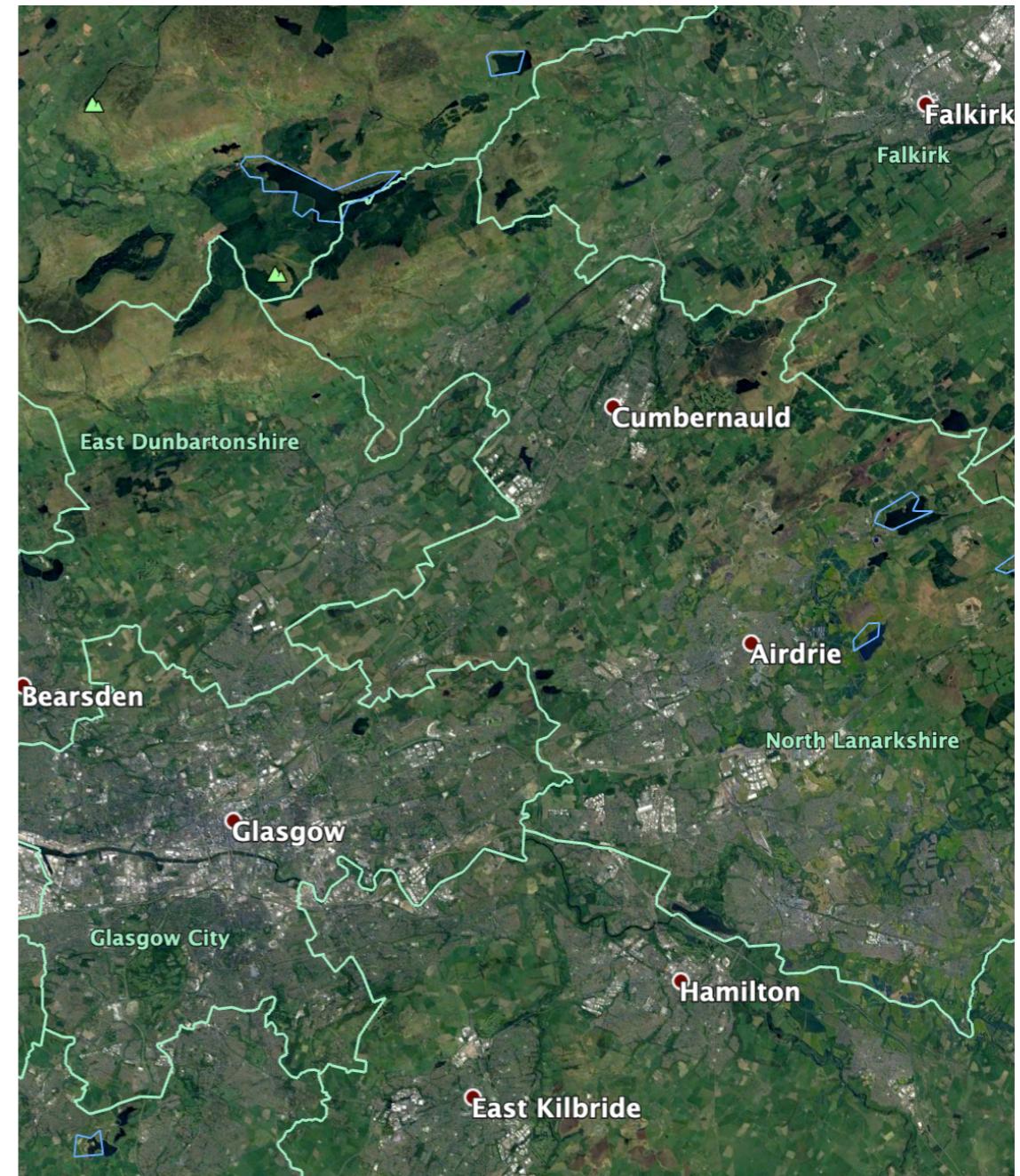
- Two ways to represent spatial phenomena

- **Vector data:** Discrete objects with clear boundaries [\(shapes\)](#)

- Roads, rivers, political boundaries, town centers

- **Raster data:** Continuous objects without clear boundaries [\(images\)](#)

- Land cover, elevation, temperature



Vector data

- Points, lines, polygons
- Spatial & Attribute information
 - Spatial: x-y coordinates define locations or nodes
 - Attributes: Names of countries, population, species observed at a location

point data can include species as well

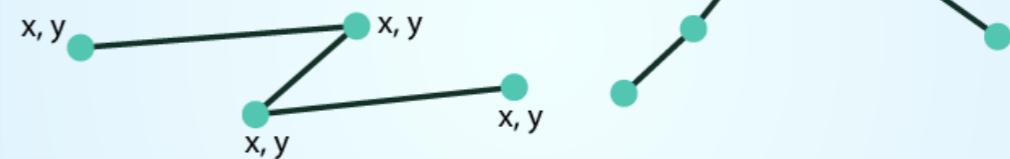
POINTS: Individual x, y locations.

ex: Center point of plot locations, tower locations, sampling locations.



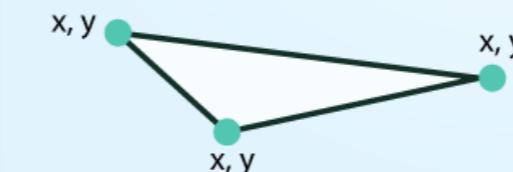
LINES: Composed of many (at least 2) vertices, or points, that are connected.

ex: Roads and streams.



POLYGONS: 3 or more vertices that are connected and closed.

ex: Building boundaries and lakes.



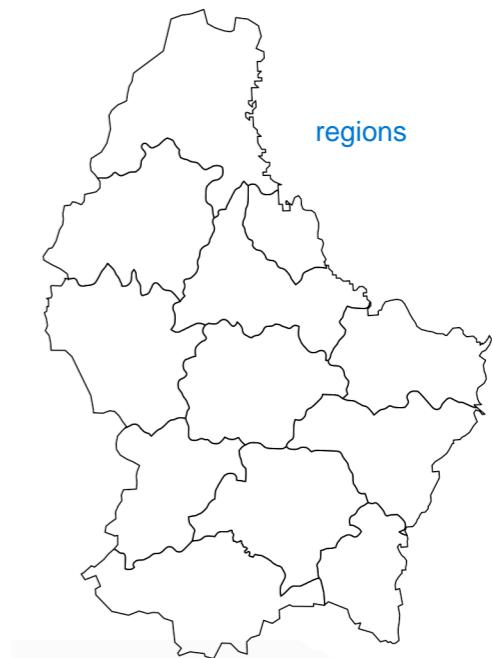
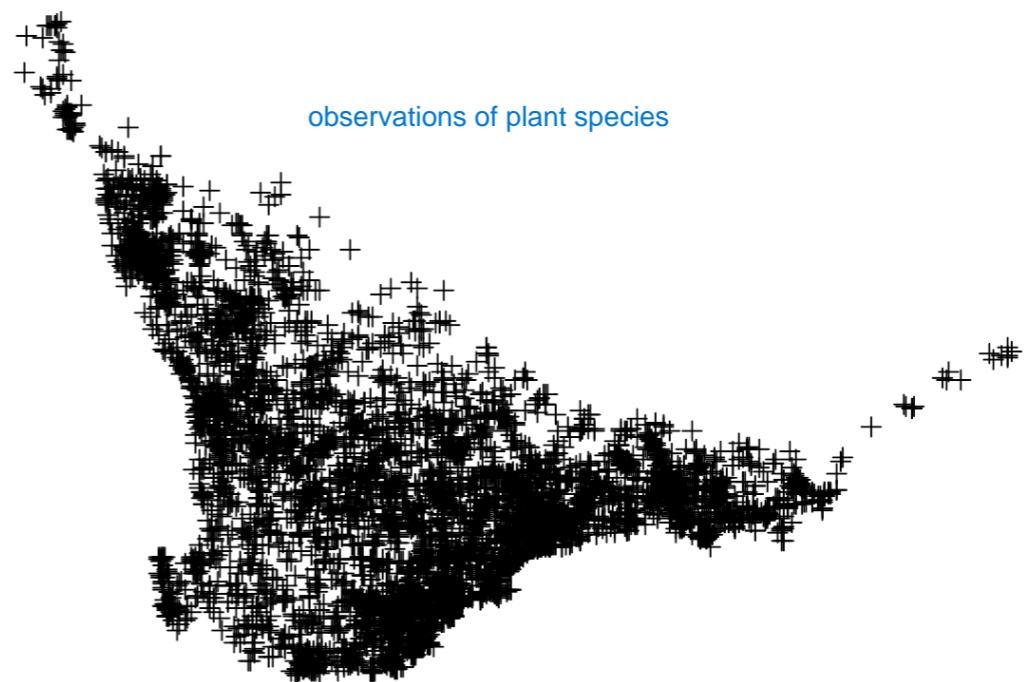
neon

Vector data in R

‘sp’ package (see also ‘sf’)

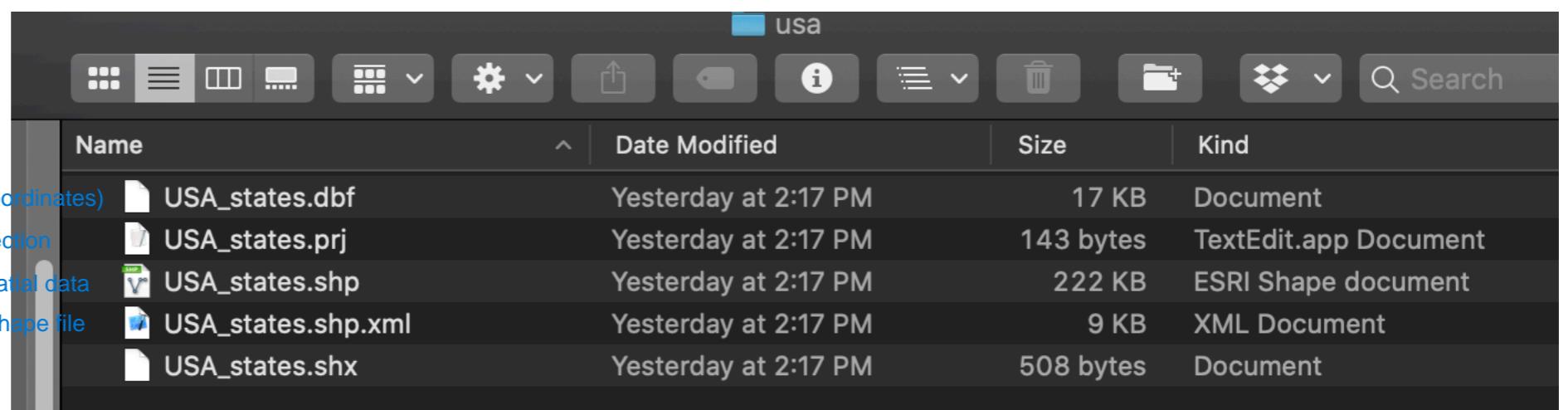
- DEFINES classes of spatial vector data
- sp object types
 - Geometry-only
 - SpatialPoints, SpatialLines, SpatialPolygons
 - Geometry + Attributes
 - SpatialPointsDataFrame, SpatialLinesDataFrame, SpatialPolygonsDataFrame

`sf = simple features`



Vector data in R

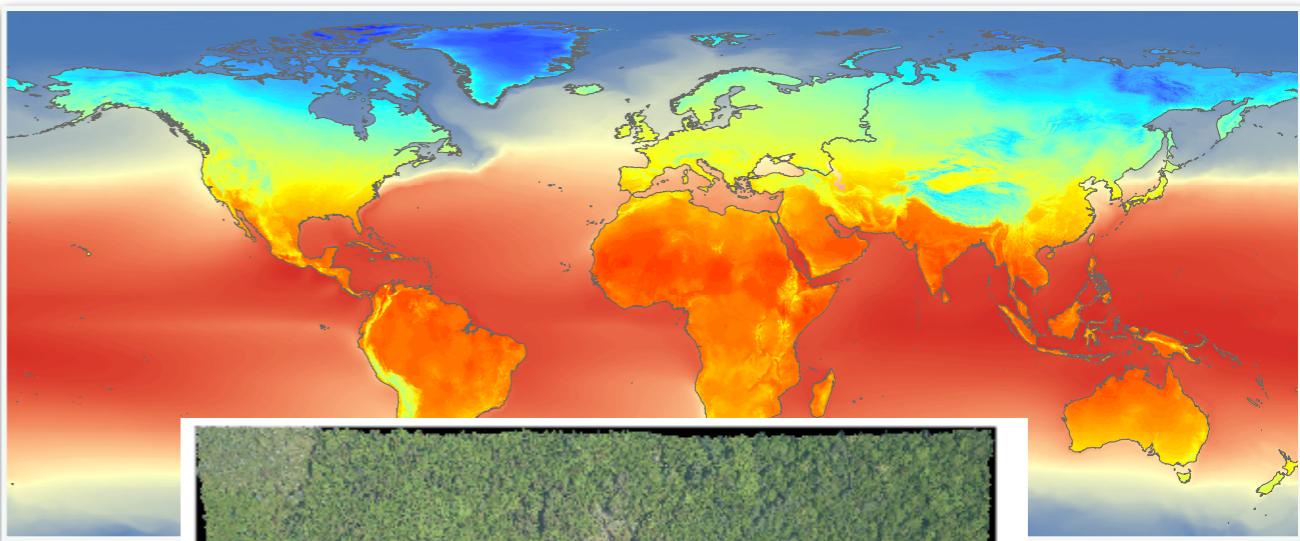
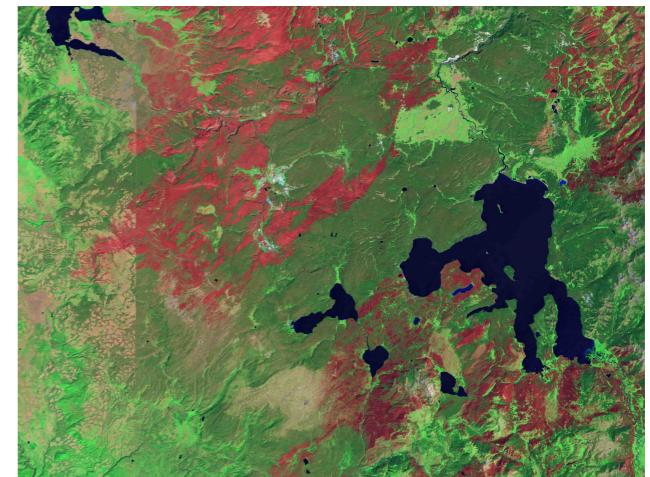
- ‘shapefile’ (.shp) is really the only file type
 - (also could be from GPS unit)
- comprised of multiple associated files so be careful if you move files around!
 - must move all secondary files with it
- Each shapefile can only be of one type of geometry
 - Points, lines, OR, polygons



	Name	Date Modified	Size	Kind
attribute data table (z coordinates)	USA_states.dbf	Yesterday at 2:17 PM	17 KB	Document
projection	USA_states.prj	Yesterday at 2:17 PM	143 bytes	TextEdit.app Document
underlying spatial data	USA_states.shp	Yesterday at 2:17 PM	222 KB	ESRI Shape document
metadata for shape file	USA_states.shp.xml	Yesterday at 2:17 PM	9 KB	XML Document
	USA_states.shx	Yesterday at 2:17 PM	508 bytes	Document

Raster data

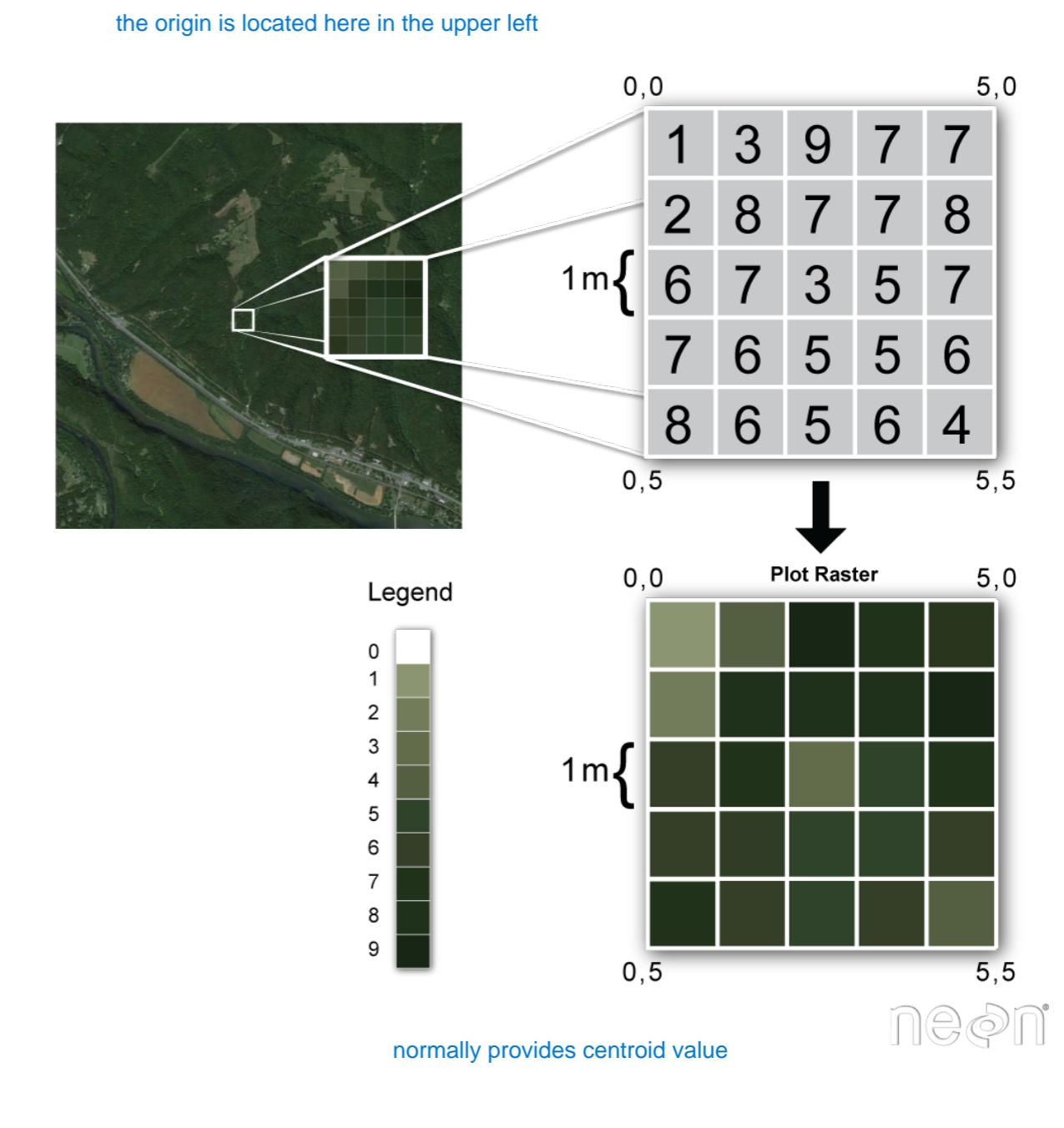
- Grid of equally sized cells (rectangles or squares)
 - ‘Cells’ for non-image data
 - ‘Pixels’ for image data
- EVERY cell has a value (may be NoData)



black pixel areas contain no data in this image

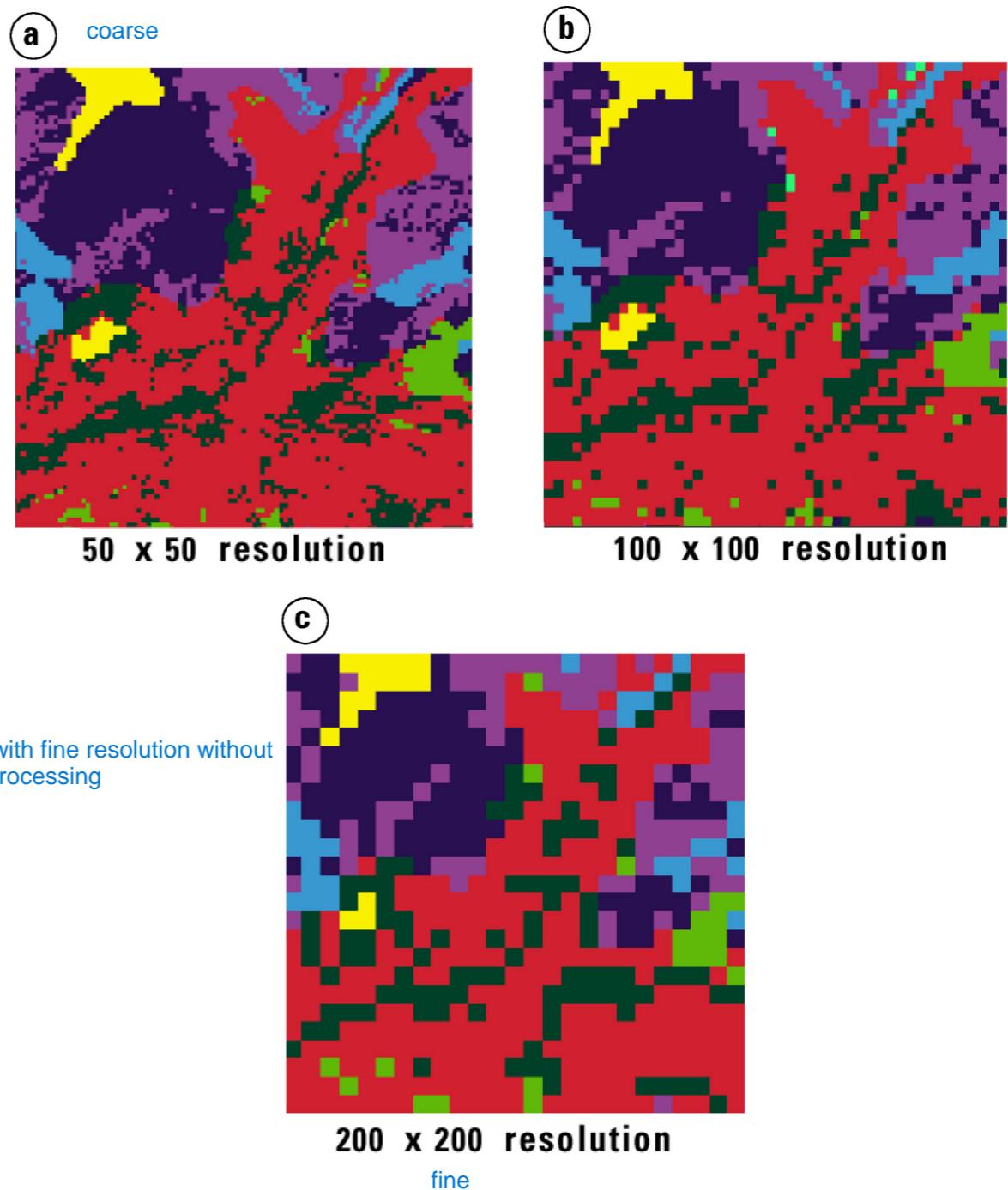
Raster data

- Geometry not explicitly stored as coordinates
- Implicitly defined by extent, # of rows and columns
 - These determine cell size (resolution) and the number of cells
- Origin determines position
- Numerous file formats that differ in data structure, memory efficiency, etc.
 - GeoTiff (.tif), ASCII (.asc), Native Raster Package (.grd), ESRI grid, NetCDF, bil...
(text file)
(native in R)
 - (proprietary)
(array of raster)



Raster data

- Resolution defined by cell size
- Finer resolution (smaller cell size) means more cells per raster
- Resolution & extent trade-off
can't have large extent of area with fine resolution without having very large storage and processing
- More cells = longer computation times



■ Nonforest
■ Lodgepole pine, early succession (burned)

■ Lodgepole pine, mid succession
■ Lodgepole pine, late succession
■ Whitebark pine, early succession (burned)

■ Whitebark pine, nonforest
■ Whitebark pine, late succession

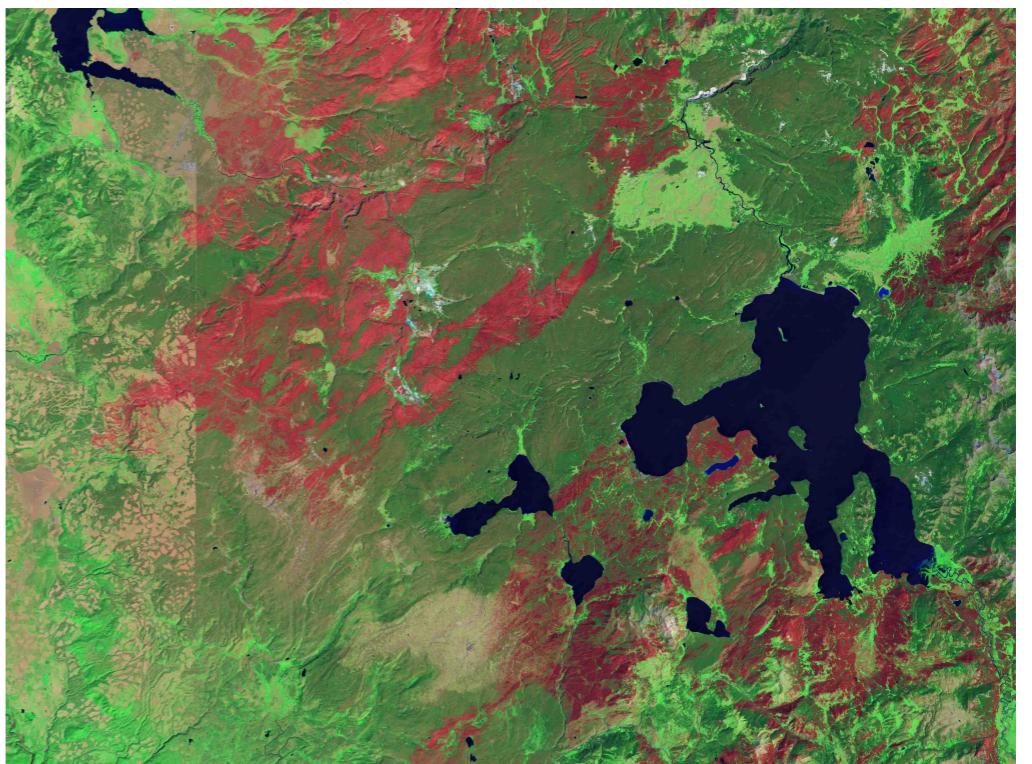
Raster data in R

‘raster’ package (see also
‘terra’)

[terra is new version of raster](#)

[raster package also works with some vector data](#)

- Functions for creating, reading, writing, manipulation, calculations, focal statistics, projections
- Object types [denoted by raster*](#)
 - RasterLayer
 - RasterStack
 - RasterBrick

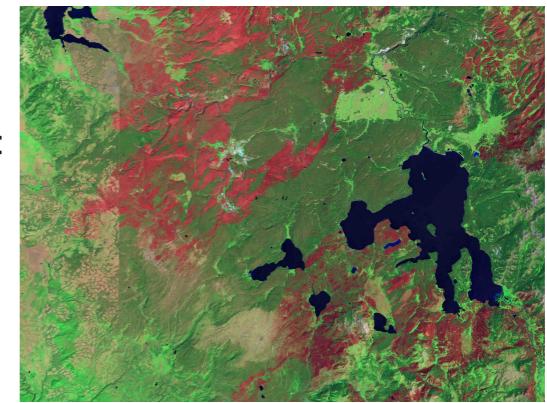


Raster data in R

RasterLayer

- A single raster variable

Raster1.tif

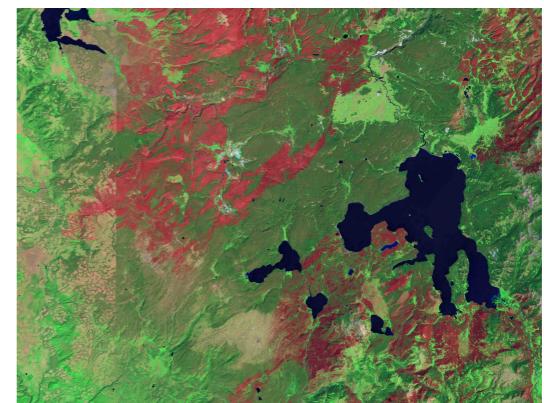


Raster data in R

RasterLayer

- A single raster variable

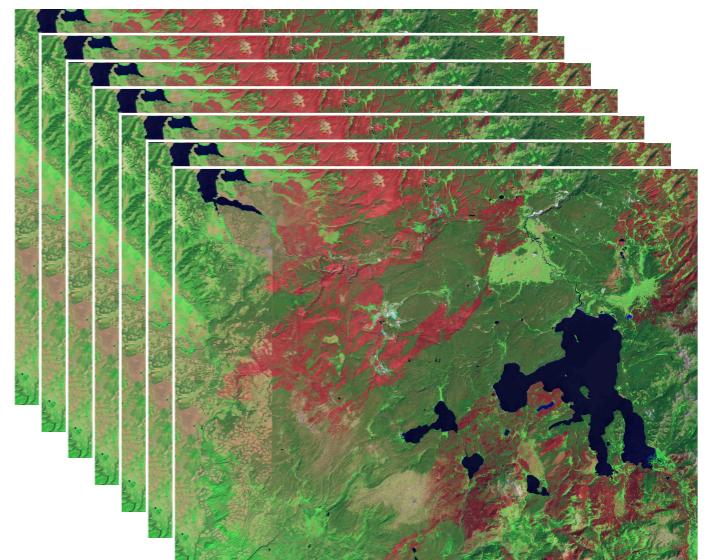
Raster1.tif



RasterStack

- A collection (list) of RasterLayer objects with **identical** spatial attributes
- Can be from a collection of separate raster files, but see point above

Raster1.tif
Raster2.tif
Raster3.tif
Raster4.tif
Raster5.tif
Raster6.tif
Raster7.tif



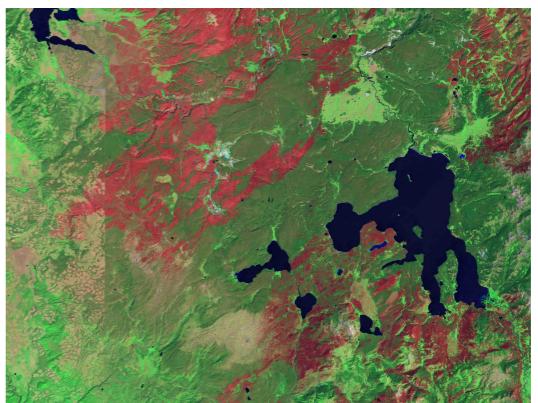
can come from different sources, but must have same attributes

Raster data in R

RasterLayer

- A single raster variable

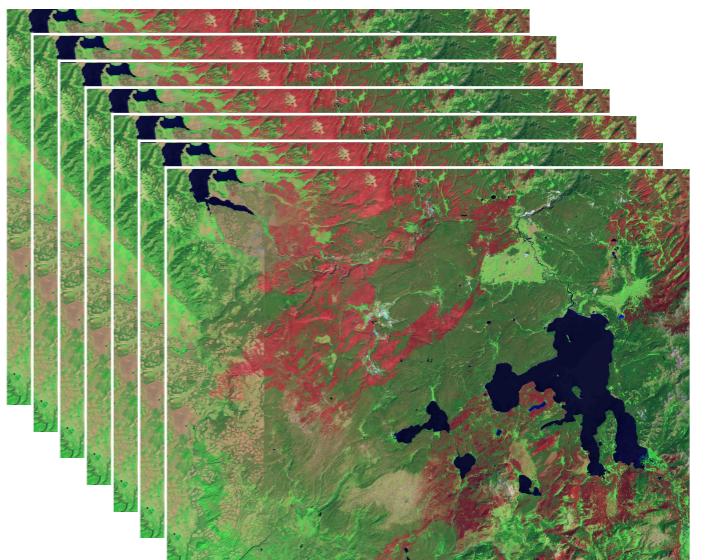
Raster1.tif



RasterStack

- A collection (list) of RasterLayer objects with **identical** spatial attributes
- Can be from a collection of separate raster files, but see point above

Raster1.tif
Raster2.tif
Raster3.tif
Raster4.tif
Raster5.tif
Raster6.tif
Raster7.tif



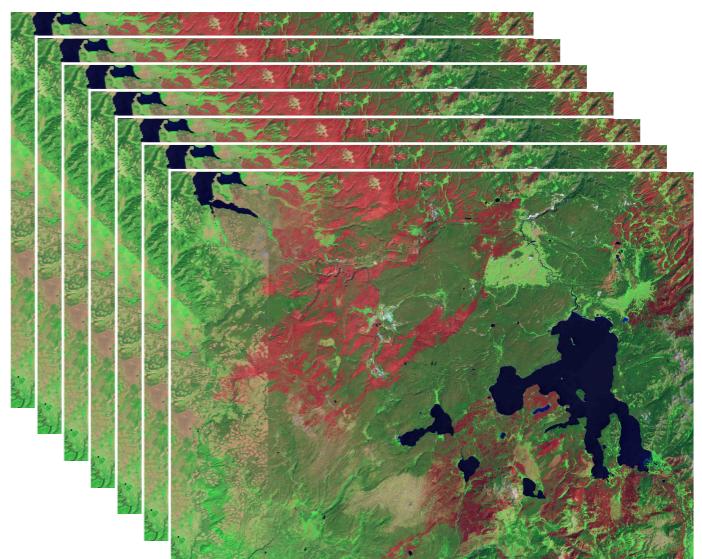
RasterBrick

multiple bands of information often collected simultaneously

example a picture with red, green, blue bands (RGB)

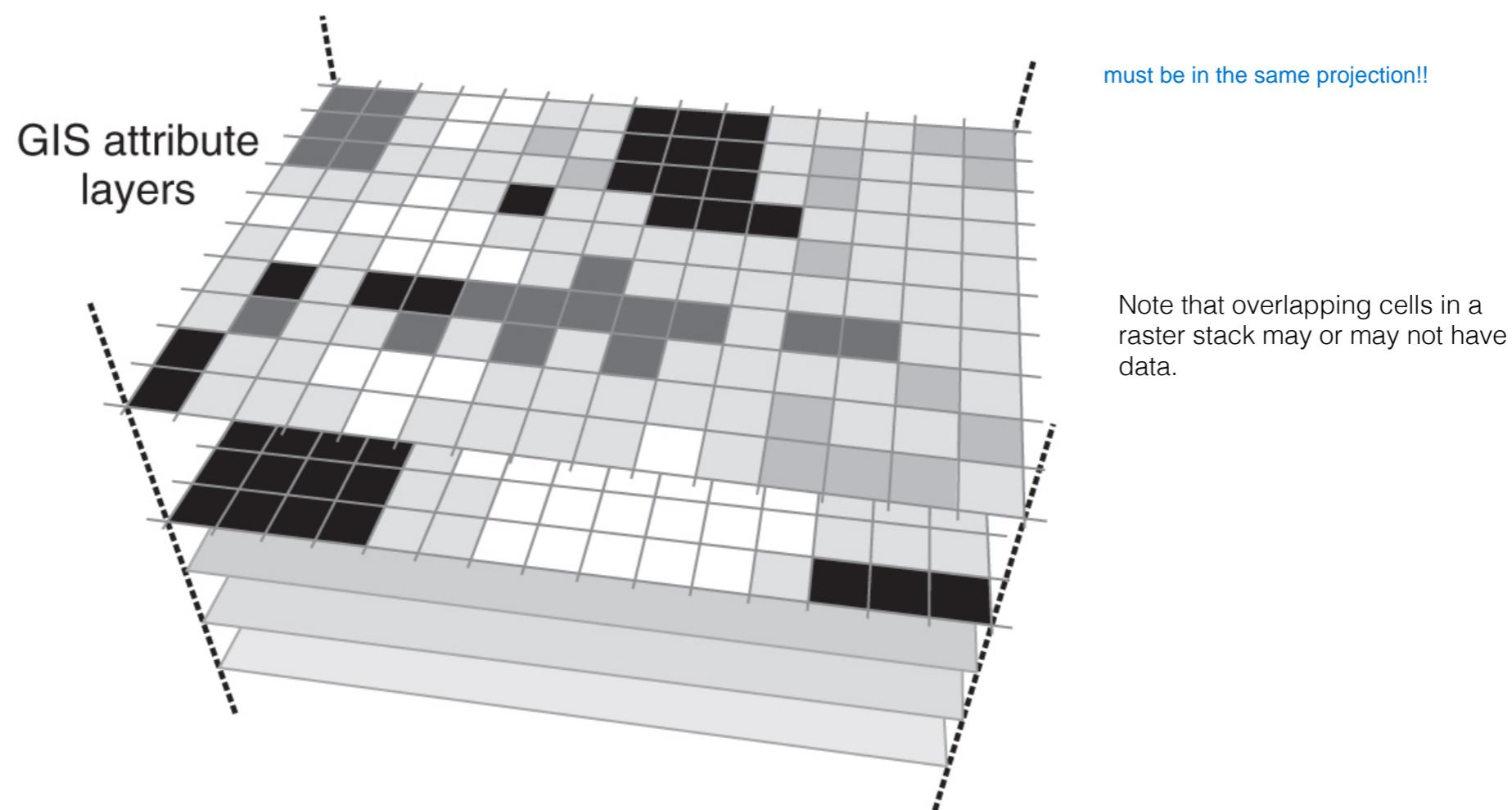
- A multi-layer raster object
- Like a RasterStack, but refers to a single file

Raster.tif



RasterStack

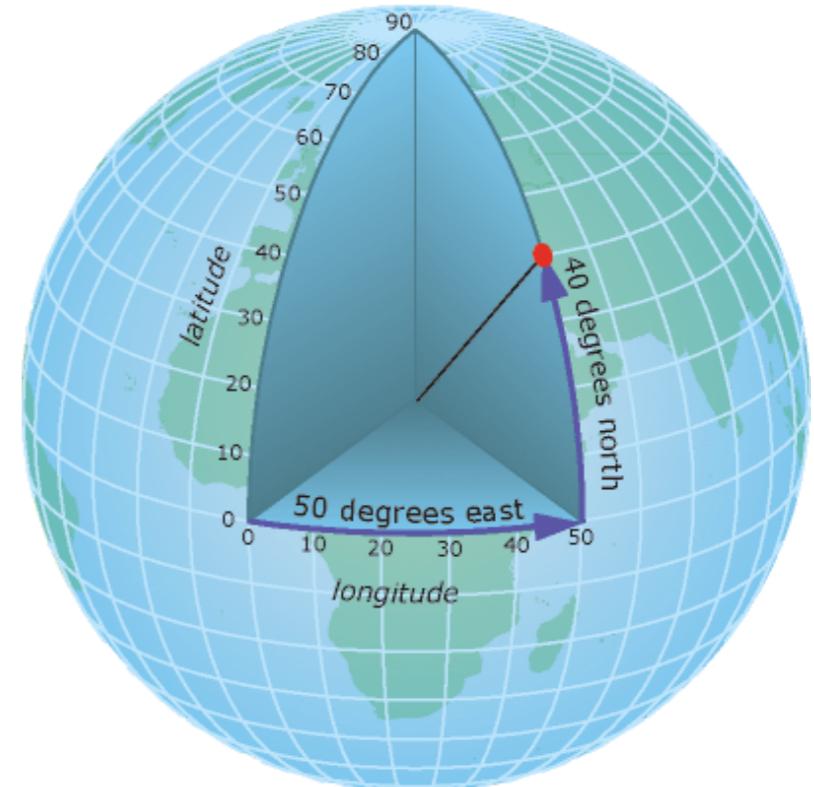
Requires all rasters have
the same **origin, extent
and resolution** (i.e., they
must line up perfectly)



Coordinate reference systems (CRS)

Angular coordinates

- Longitude (x) and latitude (y)
- Datum: model of the shape of the earth used to determine geographic location of the coordinates
 - ‘Spheroid’ - a sphere flattened on top and bottom, bulging in the middle
 - WGS84 most common (global)
 - NAD83 common in North America
 - Other datums for other regions / countries



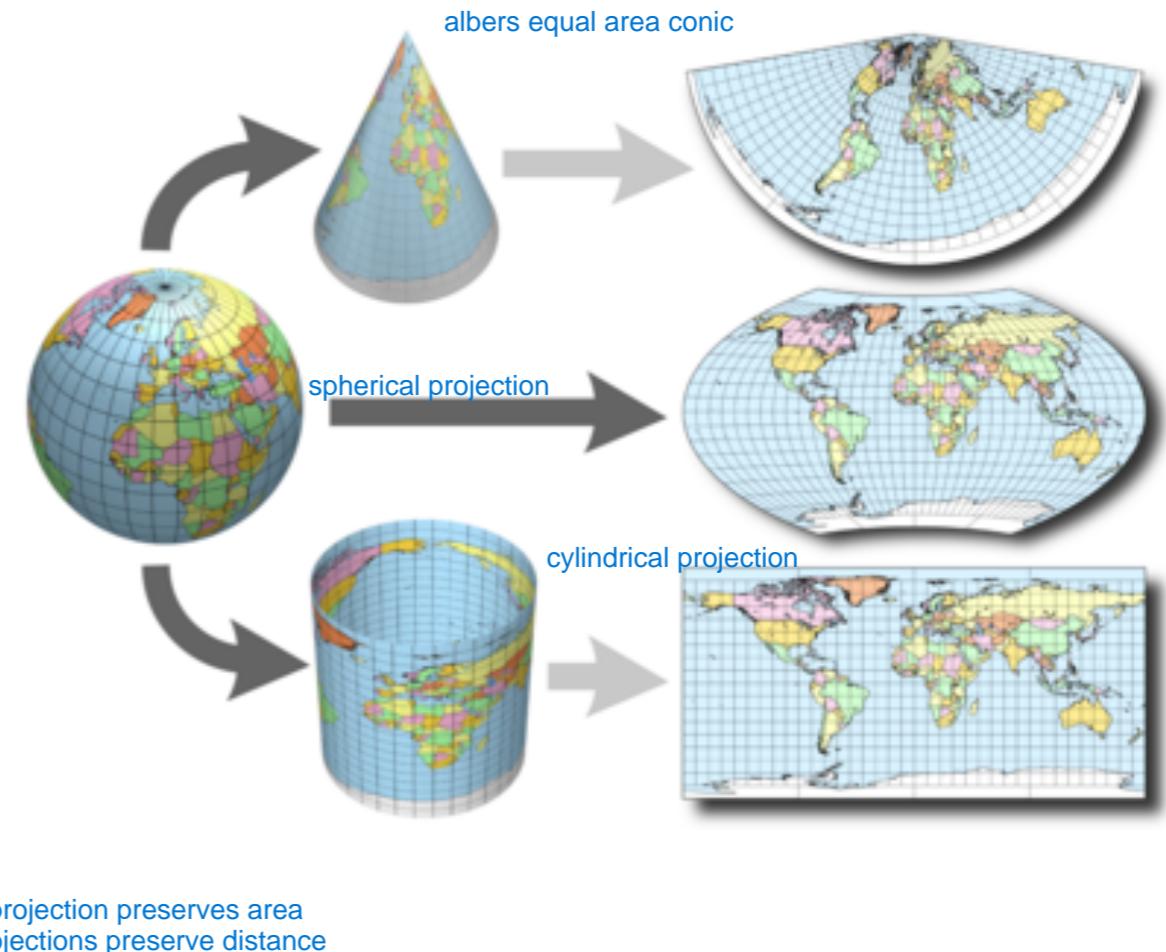
as you zoom in, the spheroid is a worse comparison for local regions. These small deviations are better handled by local datums

Coordinate reference systems (CRS)

projected coordinate systems

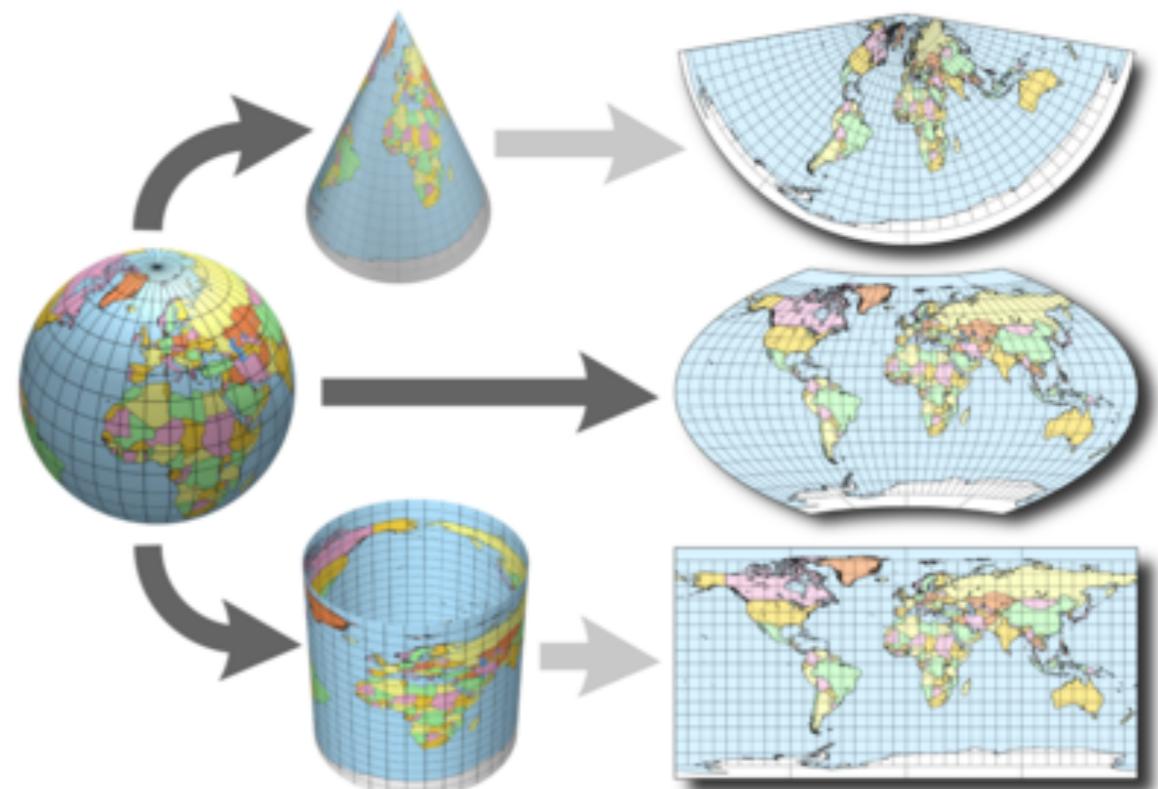
Planar coordinate systems

- Transform from 3D to 2D plane
- Projections
 - Mercator, UTM, Lambert, Albers
 - Best choice depends on extent of data and whether you want to retain area, shape, distance, etc.
- None are perfect, all lead to distortion of area, shape, distance, etc.



CRS in R

- All your data will need to be in the same CRS
- Functions for “projecting” or “transforming” spatial data to change the CRS vary depending on vector or raster data
- Generally want to transform vector data instead of raster (vector attributes do not change, but raster values do when projected)
- EPSG codes or PROJ.4 notation



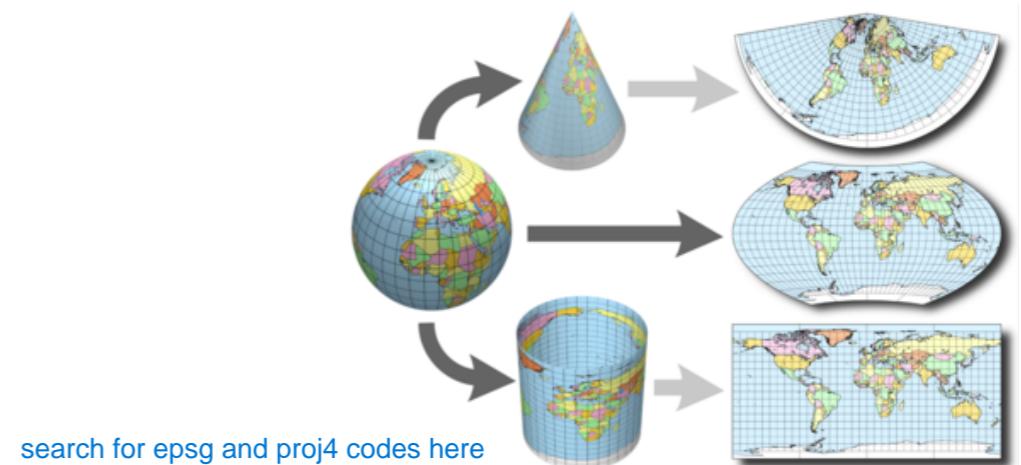
transform vector data to match your raster data

4 number code

vs human readable code

Coordinate reference systems in R

- PROJ.4 notation
- See: <https://spatialreference.org/>



[search for epsg and proj4 codes here](#)

aea = albers equal area

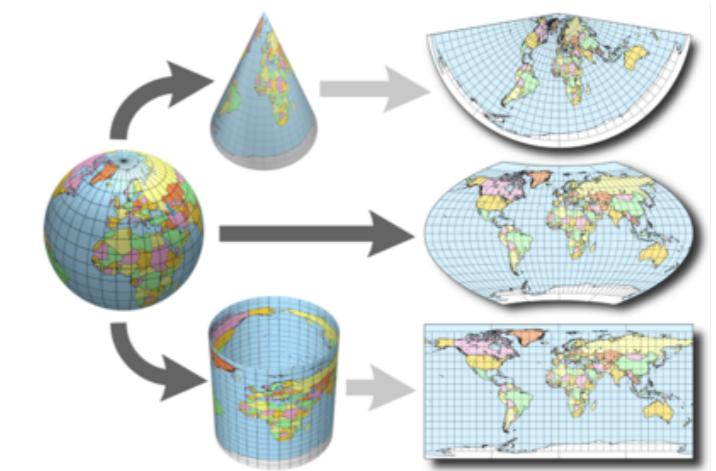
CRS arguments:

```
+proj=aea +lat_1=-21.33333333333333 +lat_2=-29.66666666666666  
+lat_0=-25.5 +lon_0=133.5 +x_0=5000000 +y_0=5000000 +ellps=GRS80  
+units=m +no_defs
```

latitude of origin
longitude of extent

Coordinate reference systems in R

- EPSG codes
 - e.g., 4326
- See: <https://epsg.io/>



[see examples in R for week 1](#)

Questions?