Working with geospatial data

January 15, 2024

```python
[1]: from osgeo import ogr
```

```python
[2]: r = ogr.Geometry(ogr.wkbLinearRing)
     r.AddPoint(1,1)
     r.AddPoint(5,1)
     r.AddPoint(5,5)
     r.AddPoint(1,5)
     r.AddPoint(1,1)
     poly = ogr.Geometry(ogr.wkbPolygon)
     poly.AddGeometry(r)
     print(poly.ExportToWkt())
```

```
POLYGON ((1 1 0,5 1 0,5 5 0,1 5 0,1 1 0))
```

```python
[3]: geojson = """{"type":"Polygon","coordinates":
     →[[[1,1],[5,1],[5,5],[1,5],[1,1]]]}"""
     polygon = ogr.CreateGeometryFromJson(geojson)
     print(polygon)
```

```
POLYGON ((1 1,5 1,5 5,1 5,1 1))
```

```python
[4]: # 1 create area

     print("The area of our polygon is %d" %polygon.Area())
```

```
The area of our polygon is 16
```

```python
[5]: cen = polygon.Centroid()
     print(cen)
```

```
POINT (3 3)
```

```python
[6]: # 4 convex bull does the same in this case as boundary, as our polygon is
     →square:

     ch = polygon.ConvexHull()
     print(ch)
```

```
POLYGON ((1 1,1 5,5 5,5 1,1 1))
```

[7]:
```python
# 5 buffer. A buffer value of 0 (zero) returns the same values as boundary and
  convex hull in this example:

buffer = polygon.Buffer(0)
print(buffer)
```

```
POLYGON ((1 1,1 5,5 5,5 1,1 1))
```

[8]:
```python
#6 check if a point is inside our polygon

point = ogr.Geometry(ogr.wkbPoint)
point.AddPoint(10,10)
polygon.Contains(point)
```

[8]: False

[9]:
```python
import osgeo.ogr, osgeo.osr
```

[10]:
```python
#1 set the spatial reference

spatialReference = osgeo.osr.SpatialReference()
spatialReference.ImportFromProj4('+proj=longlat +ells=WGS84+datum=WGS +no_defs')

#2 create a new shapefile
driver = osgeo.ogr.GetDriverByName('ESRI Shapefile')
shapeData = driver.CreateDataSource('my_polygon.shp')

#3 create the layer
layer = shapeData.CreateLayer('polygon_layer',spatialReference, osgeo.ogr.
  wkbPolygon)
layerDefinition = layer.GetLayerDefn()

#4 geometry is put inside feature
featureIndex = 0
feature = osgeo.ogr.Feature(layerDefinition)
feature.SetGeometry(polygon)
feature.SetFID(featureIndex)

#5 feature is put into layer
layer.CreateFeature(feature)

#6 check if the file has been created correctly
!ogrinfo my_polygon.shp
```

```
INFO: Open of `my_polygon.shp'
      using driver `ESRI Shapefile' successful.
```

```
1: my_polygon (Polygon)
```

```python
[11]: # import modules
      from osgeo import ogr
      import os

      #reference the shapefile and specify driver type
      shapefile = r"Data/10m_cultural/ne_10m_populated_places.shp"
      driver = ogr.GetDriverByName("ESRI Shapefile")

      #open the data source with driver, zero means open in read-only mode
      dataSource = driver.Open(shapefile, 0)

      #use the GetLayer() function for referencing the layer that holds the data
      layer = dataSource.GetLayer()

      #pass in the coordinates for the data frame to the SetSpatialFilterRect()␣
      ↪function. This filter creates a rectangular extent and selects the features␣
      ↪inside the extent

      layer.SetSpatialFilterRect(-102, 26, -94, 36)
      for feature in layer:
          # select only the cities inside of the USA
          # we can do this through a SQL query:
          # we skip the cities inside of the USA,
          # and print the names of the cities that are
          if feature.GetField("ADMONAME") != "United States of America":
                  continue
          else:
                  print(feature.GetField("NAME"))
```

```
Ardmore
McAlester
Bryan
San Marcos
Longview
McAllen
Harlingen
Alice
New Braunfels
Cleburne
Brownwood
Big Spring
Vernon
Childress
Texas City
Pasadena
Baytown
```

```
Arlington
Texarkana
Fort Smith
Lawton
Norman
Muskogee
Shawnee
Conroe
Nacogdoches
Eagle Pass
Edinburg
Kingsville
Huntsville
Killeen
Lufkin
Del Rio
San Angelo
Sherman
Beaumont
Bay City
Port Lavaca
Falfurrias
Beeville
Dumas
Denton
Temple
Galveston
Freeport
Victoria
Wichita Falls
Waco
Lubbock
Abilene
Tyler
Ft.  Worth
Corpus Christi
Austin
Amarillo
Laredo
Oklahoma City
San Antonio
Dallas
Houston
```

[12]:
```python
from shapely.geometry import Polygon
p1 = Polygon(((1, 2), (5, 3), (5, 7), (1, 9), (1, 2)))
p2 = Polygon(((6,6), (7,6), (10,4), (11,8), (6,6)))
```

```
p1
```

[12]:

[13]:
```
# A new command line is required for printing the second polygon:
p2
```

[13]:
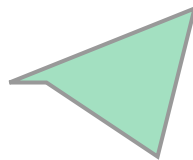
[14]:
```
# Point takes tuples as well as positional coordinate values

from shapely.geometry import Point
point = Point(2.0, 2.0)
q = Point((2.0, 2.0))
q
```

[14]:

[15]:
```
# line geometry

from shapely.geometry import LineString
line = LineString([(0, 0), (10,10)])
line
```

[15]:
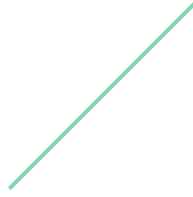
```
[16]: # linear rings

      from shapely.geometry.polygon import LinearRing
      ring = LinearRing([(0,0), (3,3), (3,0)])
      ring
```

[16]:
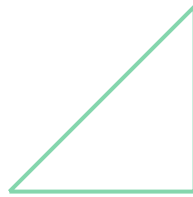

```
[17]: # collection of points

      from shapely.geometry import MultiPoint
      points = MultiPoint([(0.0, 0.0), (3.0, 3.0)])
      points
```

[17]:


```
[18]: # collection of lines

      from shapely.geometry import MultiLineString
      coords = [((0, 0), (1, 1)), ((-1, 0), (1, 0))]
      coords
```

[18]: [((0, 0), (1, 1)), ((-1, 0), (1, 0))]

```python
[19]: # collection of polygons

      from shapely.geometry import MultiPolygon
      polygons = MultiPolygon([p1, p2,])
      polygons
```

[19]:
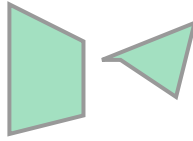
```python
[20]: print(p1.area)
      print(p1.bounds)
      print(p1.length)
      print(p1.geom_type)
```

```
22.0
(1.0, 2.0, 5.0, 9.0)
19.59524158061724
Polygon
```

```python
[21]: import json
      from shapely.geometry import mapping, shape
      p = shape(json.loads('{"type": "Polygon", "coordinates":[[[1,1], [1,3 ],␣
       ↪[3,3]]]}'))
      print(json.dumps(mapping(p)))
      p.area
```

```
{"type": "Polygon", "coordinates": [[[1.0, 1.0], [1.0, 3.0], [3.0, 3.0], [1.0,
1.0]]]}
```

[21]: 2.0

```python
[22]: import fiona
      c = fiona.open(r"Data/110m_cultural/ne_110m_admin_1_states_provinces.shp")
      rec = next(iter(c))
      rec.keys()
```

[22]: dict_keys(['type', 'id', 'properties', 'geometry'])

```python
[23]: import pprint
      pprint.pprint(rec['type'])
      pprint.pprint(rec['id'])
      pprint.pprint(rec['properties'])
```

```
pprint.pprint(rec['geometry'])
```

```
'Feature'
'0'
OrderedDict([('featurecla', 'Admin-1 scale rank'),
             ('scalerank', 2),
             ('adm1_code', 'USA-3514'),
             ('diss_me', 3514),
             ('iso_3166_2', 'US-MN'),
             ('wikipedia', 'http://en.wikipedia.org/wiki/Minnesota'),
             ('iso_a2', 'US'),
             ('adm0_sr', 1),
             ('name', 'Minnesota'),
             ('name_alt', 'MN|Minn.'),
             ('name_local', None),
             ('type', 'State'),
             ('type_en', 'State'),
             ('code_local', 'US27'),
             ('code_hasc', 'US.MN'),
             ('note', None),
             ('hasc_maybe', None),
             ('region', 'Midwest'),
             ('region_cod', None),
             ('provnum_ne', 0),
             ('gadm_level', 1),
             ('check_me', 20),
             ('datarank', 1),
             ('abbrev', 'Minn.'),
             ('postal', 'MN'),
             ('area_sqkm', 0),
             ('sameascity', -99),
             ('labelrank', 0),
             ('name_len', 9),
             ('mapcolor9', 1),
             ('mapcolor13', 1),
             ('fips', 'US27'),
             ('fips_alt', None),
             ('woe_id', 2347582),
             ('woe_label', 'Minnesota, US, United States'),
             ('woe_name', 'Minnesota'),
             ('latitude', 46.0592),
             ('longitude', -93.364),
             ('sov_a3', 'US1'),
             ('adm0_a3', 'USA'),
             ('adm0_label', 2),
             ('admin', 'United States of America'),
             ('geonunit', 'United States of America'),
```

```
('gu_a3', 'USA'),
('gn_id', 5037779),
('gn_name', 'Minnesota'),
('gns_id', -1),
('gns_name', None),
('gn_level', 1),
('gn_region', None),
('gn_a1_code', 'US.MN'),
('region_sub', 'West North Central'),
('sub_code', None),
('gns_level', -1),
('gns_lang', None),
('gns_adm1', None),
('gns_region', None),
('min_label', 3.5),
('max_label', 7.5),
('min_zoom', 2),
('wikidataid', 'Q1527'),
('name_ar', '        '(,
('name_bn', '        '),
('name_de', 'Minnesota'),
('name_en', 'Minnesota'),
('name_es', 'Minnesota'),
('name_fr', 'Minnesota'),
('name_el', 'M      '),
('name_hi', '       '),
('name_hu', 'Minnesota'),
('name_id', 'Minnesota'),
('name_it', 'Minnesota'),
('name_ja', '     '),
('name_ko', '     '),
('name_nl', 'Minnesota'),
('name_pl', 'Minnesota'),
('name_pt', 'Minnesota'),
('name_ru', '        '),
('name_sv', 'Minnesota'),
('name_tr', 'Minnesota'),
('name_vi', 'Minnesota'),
('name_zh', '     '),
('ne_id', 1159315297),
('name_he', '       '(,
('name_uk', '        '),
('name_ur', '       '(,
('name_fa', '       '(,
('name_zht', '     '),
('FCLASS_ISO', None),
('FCLASS_US', None),
('FCLASS_FR', None),
```

                    ('FCLASS_RU', None),
                    ('FCLASS_ES', None),
                    ('FCLASS_CN', None),
                    ('FCLASS_TW', None),
                    ('FCLASS_IN', None),
                    ('FCLASS_NP', None),
                    ('FCLASS_PK', None),
                    ('FCLASS_DE', None),
                    ('FCLASS_GB', None),
                    ('FCLASS_BR', None),
                    ('FCLASS_IL', None),
                    ('FCLASS_PS', None),
                    ('FCLASS_SA', None),
                    ('FCLASS_EG', None),
                    ('FCLASS_MA', None),
                    ('FCLASS_PT', None),
                    ('FCLASS_AR', None),
                    ('FCLASS_JP', None),
                    ('FCLASS_KO', None),
                    ('FCLASS_VN', None),
                    ('FCLASS_TR', None),
                    ('FCLASS_ID', None),
                    ('FCLASS_PL', None),
                    ('FCLASS_GR', None),
                    ('FCLASS_IT', None),
                    ('FCLASS_NL', None),
                    ('FCLASS_SE', None),
                    ('FCLASS_BD', None),
                    ('FCLASS_UA', None),
                    ('FCLASS_TLC', None)])
{'coordinates': [[(-89.95765601272012, 47.286907253603175),
                  (-90.13175391311144, 47.29274669045216),
                  (-90.30585181350276, 47.29801768654593),
                  (-90.47994971389409, 47.30385712339489),
                  (-90.6540476142854, 47.309128119488676),
                  (-90.85778194859611, 47.21282908791278),
                  (-91.06097368036777, 47.117046820659795),
                  (-91.26470801467849, 47.02126455340681),
                  (-91.46844234898919, 46.9249655218309),
                  (-91.59225908076053, 46.876260484395914),
                  (-91.71661841507091, 46.82760712339301),
                  (-91.8409777493813, 46.778385321635),
                  (-91.96479448115262, 46.72970612241605),
                  (-92.01189754918667, 46.71172272397848),
                  (-92.27487891312, 46.65614472104858),
                  (-92.26482784703924, 46.09522288673644),
                  (-92.2965830146826, 46.09628225359842),
                  (-92.54369971390233, 45.98569468849381),

```
(-92.75696834997089, 45.88991242124082),
(-92.89982784704182, 45.705763454768714),
(-92.68922054723626, 45.51843638771068),
(-92.76541744665064, 45.26708222104298),
(-92.76647681351261, 44.9961426865367),
(-92.79665584997105, 44.77602692318949),
(-92.50507158076417, 44.58391978614445),
(-92.38549231644078, 44.57492808692567),
(-92.06215287959051, 44.43258535417769),
(-91.949989183301, 44.364837551443046),
(-91.87960588251947, 44.25742808692439),
(-91.62770911331273, 44.085448920257036),
(-91.28959021682704, 43.93729258887629),
(-91.25729244664458, 43.854739488289965),
(-91.2546569485977, 43.61397899024206),
(-91.22819861526426, 43.5012468531974),
(-92.54000484899348, 43.51977285417405),
(-94.00102678096546, 43.51341665300214),
(-95.35993608272871, 43.50018748633542),
(-96.4526600817565, 43.50178945573647),
(-96.43943091508982, 44.43576345476367),
(-96.56061214881424, 45.39301768653837),
(-96.73576941606754, 45.47081655535372),
(-96.83470394569034, 45.62532908790642),
(-96.78072791216147, 45.76079885515958),
(-96.55689144568922, 45.87244578712617),
(-96.53945064979075, 46.017966620460186),
(-96.53890804725165, 46.199480088885366),
(-96.60135901567638, 46.3513571233911),
(-96.68548824744755, 46.51328522397769),
(-96.73365068234358, 46.71647695574927),
(-96.7458204821483, 46.9445250514533),
(-96.77969438351563, 46.999043687521294),
(-96.82041541216165, 47.29220408791309),
(-96.82465287960957, 47.42661448830425),
(-96.84423824744819, 47.54619375262766),
(-96.89397681352912, 47.74886872007637),
(-97.01515804725355, 47.954205023788134),
(-97.13104244666809, 48.13729462339825),
(-97.14850908078273, 48.31878225360731),
(-97.16122148312654, 48.51458425556122),
(-97.12734758175921, 48.64212169045756),
(-97.1204746162644, 48.75852285419501),
(-97.21413814979343, 48.90244171812793),
(-97.22894344764504, 49.00088532164389),
(-95.15883724646483, 48.9998259547819),
(-95.15620174841791, 49.38401439065592),
(-94.81754024939323, 49.38928538674975),
```

```
                    (-94.64026424841592, 48.84001658791925),
                    (-94.32912044958647, 48.670672919298795),
                    (-93.63061011429733, 48.60928131773602),
                    (-92.60984554723586, 48.45001455341253),
                    (-91.63987891311746, 48.13993012144516),
                    (-90.83026424840062, 48.27010305438836),
                    (-89.59995174839577, 48.01027395282483),
                    (-89.59940914585667, 48.01027395282483),
                    (-89.4900319346622, 48.01340602289096),
                    (-89.52269548211933, 47.96053538674391),
                    (-89.61369767938538, 47.81925202085796),
                    (-89.72800594761503, 47.641976019880644),
                    (-89.84283098016755, 47.464725857119504),
                    (-89.95765601272012, 47.286907253603175)]],
      'type': 'Polygon'}
```

[24]:
```python
print(len(c)) # prints total amount of features
print(c.driver) # prints driver name
print(c.crs) # prints coordinate reference system of data file
```

```
51
ESRI Shapefile
{'init': 'epsg:4326'}
```

[25]:
```python
import pprint, fiona
with fiona.open\
(r"Data/110m_cultural/ne_110m_admin_1_states_provinces.shp") as src:
    pprint.pprint(src[0])
```

```
{'geometry': {'coordinates': [[(-89.95765601272012, 47.286907253603175),
                               (-90.13175391311144, 47.29274669045216),
                               (-90.30585181350276, 47.29801768654593),
                               (-90.47994971389409, 47.30385712339489),
                               (-90.6540476142854, 47.309128119488676),
                               (-90.85778194859611, 47.21282908791278),
                               (-91.06097368036777, 47.117046820659795),
                               (-91.26470801467849, 47.02126455340681),
                               (-91.46844234898919, 46.9249655218309),
                               (-91.59225908076053, 46.876260484395914),
                               (-91.71661841507091, 46.82760712339301),
                               (-91.8409777493813, 46.778385321635),
                               (-91.96479448115262, 46.72970612241605),
                               (-92.01189754918667, 46.71172272397848),
                               (-92.27487891312, 46.65614472104858),
                               (-92.26482784703924, 46.09522288673644),
                               (-92.2965830146826, 46.09628225359842),
                               (-92.54369971390233, 45.98569468849381),
                               (-92.75696834997089, 45.88991242124082),
```

12

(-92.89982784704182, 45.705763454768714),
(-92.68922054723626, 45.51843638771068),
(-92.76541744665064, 45.26708222104298),
(-92.76647681351261, 44.9961426865367),
(-92.79665584997105, 44.77602692318949),
(-92.50507158076417, 44.58391978614445),
(-92.38549231644078, 44.57492808692567),
(-92.06215287959051, 44.43258535417769),
(-91.949989183301, 44.364837551443046),
(-91.87960588251947, 44.25742808692439),
(-91.62770911331273, 44.085448920257036),
(-91.28959021682704, 43.93729258887629),
(-91.25729244664458, 43.854739488289965),
(-91.2546569485977, 43.61397899024206),
(-91.22819861526426, 43.5012468531974),
(-92.54000484899348, 43.51977285417405),
(-94.00102678096546, 43.51341665300214),
(-95.35993608272871, 43.50018748633542),
(-96.4526600817565, 43.50178945573647),
(-96.43943091508982, 44.43576345476367),
(-96.56061214881424, 45.39301768653837),
(-96.73576941606754, 45.47081655535372),
(-96.83470394569034, 45.62532908790642),
(-96.78072791216147, 45.76079885515958),
(-96.55689144568922, 45.87244578712617),
(-96.53945064979075, 46.017966620460186),
(-96.53890804725165, 46.199480088885366),
(-96.60135901567638, 46.3513571233911),
(-96.68548824744755, 46.51328522397769),
(-96.73365068234358, 46.71647695574927),
(-96.7458204821483, 46.9445250514533),
(-96.77969438351563, 46.999043687521294),
(-96.82041541216165, 47.29220408791309),
(-96.82465287960957, 47.42661448830425),
(-96.84423824744819, 47.54619375262766),
(-96.89397681352912, 47.74886872007637),
(-97.01515804725355, 47.954205023788134),
(-97.13104244666809, 48.13729462339825),
(-97.14850908078273, 48.31878225360731),
(-97.16122148312654, 48.51458425556122),
(-97.12734758175921, 48.64212169045756),
(-97.1204746162644, 48.75852285419501),
(-97.21413814979343, 48.90244171812793),
(-97.22894344764504, 49.00088532164389),
(-95.15883724646483, 48.9998259547819),
(-95.15620174841791, 49.38401439065592),
(-94.81754024939323, 49.38928538674975),
(-94.64026424841592, 48.84001658791925),

```
                              (-94.32912044958647, 48.670672919298795),
                              (-93.63061011429733, 48.60928131773602),
                              (-92.60984554723586, 48.45001455341253),
                              (-91.63987891311746, 48.13993012144516),
                              (-90.83026424840062, 48.27010305438836),
                              (-89.59995174839577, 48.01027395282483),
                              (-89.59940914585667, 48.01027395282483),
                              (-89.4900319346622, 48.01340602289096),
                              (-89.52269548211933, 47.96053538674391),
                              (-89.61369767938538, 47.81925202085796),
                              (-89.72800594761503, 47.641976019880644),
                              (-89.84283098016755, 47.464725857119504),
                              (-89.95765601272012, 47.286907253603175)]],
             'type': 'Polygon'},
   'id': '0',
   'properties': OrderedDict([('featurecla', 'Admin-1 scale rank'),
                             ('scalerank', 2),
                             ('adm1_code', 'USA-3514'),
                             ('diss_me', 3514),
                             ('iso_3166_2', 'US-MN'),
                             ('wikipedia',
                              'http://en.wikipedia.org/wiki/Minnesota'),
                             ('iso_a2', 'US'),
                             ('adm0_sr', 1),
                             ('name', 'Minnesota'),
                             ('name_alt', 'MN|Minn.'),
                             ('name_local', None),
                             ('type', 'State'),
                             ('type_en', 'State'),
                             ('code_local', 'US27'),
                             ('code_hasc', 'US.MN'),
                             ('note', None),
                             ('hasc_maybe', None),
                             ('region', 'Midwest'),
                             ('region_cod', None),
                             ('provnum_ne', 0),
                             ('gadm_level', 1),
                             ('check_me', 20),
                             ('datarank', 1),
                             ('abbrev', 'Minn.'),
                             ('postal', 'MN'),
                             ('area_sqkm', 0),
                             ('sameascity', -99),
                             ('labelrank', 0),
                             ('name_len', 9),
                             ('mapcolor9', 1),
                             ('mapcolor13', 1),
                             ('fips', 'US27'),
```

```
('fips_alt', None),
('woe_id', 2347582),
('woe_label', 'Minnesota, US, United States'),
('woe_name', 'Minnesota'),
('latitude', 46.0592),
('longitude', -93.364),
('sov_a3', 'US1'),
('adm0_a3', 'USA'),
('adm0_label', 2),
('admin', 'United States of America'),
('geonunit', 'United States of America'),
('gu_a3', 'USA'),
('gn_id', 5037779),
('gn_name', 'Minnesota'),
('gns_id', -1),
('gns_name', None),
('gn_level', 1),
('gn_region', None),
('gn_a1_code', 'US.MN'),
('region_sub', 'West North Central'),
('sub_code', None),
('gns_level', -1),
('gns_lang', None),
('gns_adm1', None),
('gns_region', None),
('min_label', 3.5),
('max_label', 7.5),
('min_zoom', 2),
('wikidataid', 'Q1527'),
('name_ar', '        '(,
('name_bn', '        '),
('name_de', 'Minnesota'),
('name_en', 'Minnesota'),
('name_es', 'Minnesota'),
('name_fr', 'Minnesota'),
('name_el', 'M      '),
('name_hi', '        '),
('name_hu', 'Minnesota'),
('name_id', 'Minnesota'),
('name_it', 'Minnesota'),
('name_ja', '     '),
('name_ko', '    '),
('name_nl', 'Minnesota'),
('name_pl', 'Minnesota'),
('name_pt', 'Minnesota'),
('name_ru', '        '),
('name_sv', 'Minnesota'),
('name_tr', 'Minnesota'),
```

```
                            ('name_vi', 'Minnesota'),
                            ('name_zh', '    '),
                            ('ne_id', 1159315297),
                            ('name_he', '     '(,
                            ('name_uk', '      '),
                            ('name_ur', '      '(,
                            ('name_fa', '      '(,
                            ('name_zht', '   '),
                            ('FCLASS_ISO', None),
                            ('FCLASS_US', None),
                            ('FCLASS_FR', None),
                            ('FCLASS_RU', None),
                            ('FCLASS_ES', None),
                            ('FCLASS_CN', None),
                            ('FCLASS_TW', None),
                            ('FCLASS_IN', None),
                            ('FCLASS_NP', None),
                            ('FCLASS_PK', None),
                            ('FCLASS_DE', None),
                            ('FCLASS_GB', None),
                            ('FCLASS_BR', None),
                            ('FCLASS_IL', None),
                            ('FCLASS_PS', None),
                            ('FCLASS_SA', None),
                            ('FCLASS_EG', None),
                            ('FCLASS_MA', None),
                            ('FCLASS_PT', None),
                            ('FCLASS_AR', None),
                            ('FCLASS_JP', None),
                            ('FCLASS_KO', None),
                            ('FCLASS_VN', None),
                            ('FCLASS_TR', None),
                            ('FCLASS_ID', None),
                            ('FCLASS_PL', None),
                            ('FCLASS_GR', None),
                            ('FCLASS_IT', None),
                            ('FCLASS_NL', None),
                            ('FCLASS_SE', None),
                            ('FCLASS_BD', None),
                            ('FCLASS_UA', None),
                            ('FCLASS_TLC', None)]),
      'type': 'Feature'}
```

```python
from shapely.geometry import shape
minnesota = {'type': 'Polygon', 'coordinates':
[[(-89.95765601272012, 47.286907253603175),
                        (-90.13175391311144, 47.29274669045216),
```

```
(-90.30585181350276, 47.29801768654593),
(-90.47994971389409, 47.30385712339489),
(-90.6540476142854, 47.309128119488676),
(-90.85778194859611, 47.21282908791278),
(-91.06097368036777, 47.117046820659795),
(-91.26470801467849, 47.02126455340681),
(-91.46844234898919, 46.9249655218309),
(-91.59225908076053, 46.876260484395914),
(-91.71661841507091, 46.82760712339301),
(-91.8409777493813, 46.778385321635),
(-91.96479448115262, 46.72970612241605),
(-92.01189754918667, 46.71172272397848),
(-92.27487891312, 46.65614472104858),
(-92.26482784703924, 46.09522288673644),
(-92.2965830146826, 46.09628225359842),
(-92.54369971390233, 45.98569468849381),
(-92.75696834997089, 45.88991242124082),
(-92.89982784704182, 45.705763454768714),
(-92.68922054723626, 45.51843638771068),
(-92.76541744665064, 45.26708222104298),
(-92.76647681351261, 44.9961426865367),
(-92.79665584997105, 44.77602692318949),
(-92.50507158076417, 44.58391978614445),
(-92.38549231644078, 44.57492808692567),
(-92.06215287959051, 44.43258535417769),
(-91.949989183301, 44.364837551443046),
(-91.87960588251947, 44.25742808692439),
(-91.62770911331273, 44.085448920257036),
(-91.28959021682704, 43.93729258887629),
(-91.25729244664458, 43.854739488289965),
(-91.2546569485977, 43.61397899024206),
(-91.22819861526426, 43.5012468531974),
(-92.54000484899348, 43.51977285417405),
(-94.00102678096546, 43.51341665300214),
(-95.35993608272871, 43.50018748633542),
(-96.4526600817565, 43.50178945573647),
(-96.43943091508982, 44.43576345476367),
(-96.56061214881424, 45.39301768653837),
(-96.73576941606754, 45.47081655535372),
(-96.83470394569034, 45.62532908790642),
(-96.78072791216147, 45.76079885515958),
(-96.55689144568922, 45.87244578712617),
(-96.53945064979075, 46.017966620460186),
(-96.53890804725165, 46.199480088885366),
(-96.60135901567638, 46.3513571233911),
(-96.68548824744755, 46.51328522397769),
(-96.73365068234358, 46.71647695574927),
```

17

```
                                 (-96.7458204821483, 46.9445250514533),
                                 (-96.77969438351563, 46.999043687521294),
                                 (-96.82041541216165, 47.29220408791309),
                                 (-96.82465287960957, 47.42661448830425),
                                 (-96.84423824744819, 47.54619375262766),
                                 (-96.89397681352912, 47.74886872007637),
                                 (-97.01515804725355, 47.954205023788134),
                                 (-97.13104244666809, 48.13729462339825),
                                 (-97.14850908078273, 48.31878225360731),
                                 (-97.16122148312654, 48.51458425556122),
                                 (-97.12734758175921, 48.64212169045756),
                                 (-97.1204746162644, 48.75852285419501),
                                 (-97.21413814979343, 48.90244171812793),
                                 (-97.22894344764504, 49.00088532164389),
                                 (-95.15883724646483, 48.9998259547819),
                                 (-95.15620174841791, 49.38401439065592),
                                 (-94.81754024939323, 49.38928538674975),
                                 (-94.64026424841592, 48.84001658791925),
                                 (-94.32912044958647, 48.670672919298795),
                                 (-93.63061011429733, 48.60928131773602),
                                 (-92.60984554723586, 48.45001455341253),
                                 (-91.63987891311746, 48.13993012144516),
                                 (-90.83026424840062, 48.27010305438836),
                                 (-89.59995174839577, 48.01027395282483),
                                 (-89.59940914585667, 48.01027395282483),
                                 (-89.4900319346622, 48.01340602289096),
                                 (-89.52269548211933, 47.96053538674391),
                                 (-89.61369767938538, 47.81925202085796),
                                 (-89.72800594761503, 47.641976019880644),
                                 (-89.84283098016755, 47.464725857119504),
                                 (-89.95765601272012, 47.286907253603175)]]}
```

[27]:
```
geom = shape(minnesota)
geom
```

[27]:
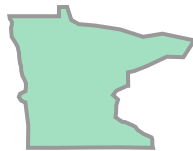
[28]:
```
import geopandas as gpd

%matplotlib inline
```

18

```
df = gpd.read_file\
(r"Data/110m_cultural/ne_110m_admin_1_states_provinces.shp")
df
```

[28]:

	featurecla	scalerank	adm1_code	diss_me	iso_3166_2	\
0	Admin-1 scale rank	2	USA-3514	3514	US-MN	
1	Admin-1 scale rank	2	USA-3515	3515	US-MT	
2	Admin-1 scale rank	2	USA-3516	3516	US-ND	
3	Admin-1 scale rank	2	USA-3517	3517	US-HI	
4	Admin-1 scale rank	2	USA-3518	3518	US-ID	
5	Admin-1 scale rank	2	USA-3519	3519	US-WA	
6	Admin-1 scale rank	2	USA-3520	3520	US-AZ	
7	Admin-1 scale rank	2	USA-3521	3521	US-CA	
8	Admin-1 scale rank	2	USA-3522	3522	US-CO	
9	Admin-1 scale rank	2	USA-3523	3523	US-NV	
10	Admin-1 scale rank	2	USA-3524	3524	US-NM	
11	Admin-1 scale rank	2	USA-3525	3525	US-OR	
12	Admin-1 scale rank	2	USA-3526	3526	US-UT	
13	Admin-1 scale rank	2	USA-3527	3527	US-WY	
14	Admin-1 scale rank	2	USA-3528	3528	US-AR	
15	Admin-1 scale rank	2	USA-3529	3529	US-IA	
16	Admin-1 scale rank	2	USA-3530	3530	US-KS	
17	Admin-1 scale rank	2	USA-3531	3531	US-MO	
18	Admin-1 scale rank	2	USA-3532	3532	US-NE	
19	Admin-1 scale rank	2	USA-3533	3533	US-OK	
20	Admin-1 scale rank	2	USA-3534	3534	US-SD	
21	Admin-1 scale rank	2	USA-3535	3535	US-LA	
22	Admin-1 scale rank	2	USA-3536	3536	US-TX	
23	Admin-1 scale rank	2	USA-3537	3537	US-CT	
24	Admin-1 scale rank	2	USA-3513	3513	US-MA	
25	Admin-1 scale rank	2	USA-3538	3538	US-NH	
26	Admin-1 scale rank	2	USA-3539	3539	US-RI	
27	Admin-1 scale rank	2	USA-3540	3540	US-VT	
28	Admin-1 scale rank	2	USA-3541	3541	US-AL	
29	Admin-1 scale rank	2	USA-3542	3542	US-FL	
30	Admin-1 scale rank	2	USA-3543	3543	US-GA	
31	Admin-1 scale rank	2	USA-3544	3544	US-MS	
32	Admin-1 scale rank	2	USA-3545	3545	US-SC	
33	Admin-1 scale rank	2	USA-3546	3546	US-IL	
34	Admin-1 scale rank	2	USA-3547	3547	US-IN	
35	Admin-1 scale rank	2	USA-3548	3548	US-KY	
36	Admin-1 scale rank	2	USA-3549	3549	US-NC	
37	Admin-1 scale rank	2	USA-3550	3550	US-OH	
38	Admin-1 scale rank	2	USA-3551	3551	US-TN	
39	Admin-1 scale rank	2	USA-3552	3552	US-VA	
40	Admin-1 scale rank	2	USA-3553	3553	US-WI	
41	Admin-1 scale rank	2	USA-3554	3554	US-WV	

```
42  Admin-1 scale rank        2  USA-3555  3555  US-DE
43  Admin-1 scale rank        2  USA-3556  3556  US-DC
44  Admin-1 scale rank        2  USA-3557  3557  US-MD
45  Admin-1 scale rank        2  USA-3558  3558  US-NJ
46  Admin-1 scale rank        2  USA-3559  3559  US-NY
47  Admin-1 scale rank        2  USA-3560  3560  US-PA
48  Admin-1 scale rank        2  USA-3561  3561  US-ME
49  Admin-1 scale rank        2  USA-3562  3562  US-MI
50  Admin-1 scale rank        2  USA-3563  3563  US-AK


                                          wikipedia iso_a2  adm0_sr  \
0            http://en.wikipedia.org/wiki/Minnesota     US        1
1              http://en.wikipedia.org/wiki/Montana     US        1
2         http://en.wikipedia.org/wiki/North_Dakota     US        1
3               http://en.wikipedia.org/wiki/Hawaii     US        8
4                http://en.wikipedia.org/wiki/Idaho     US        1
5    http://en.wikipedia.org/wiki/Washington_(state)     US        6
6              http://en.wikipedia.org/wiki/Arizona     US        1
7           http://en.wikipedia.org/wiki/California     US        8
8            http://en.wikipedia.org/wiki/Colorado     US        1
9              http://en.wikipedia.org/wiki/Nevada     US        1
10         http://en.wikipedia.org/wiki/New_Mexico     US        1
11             http://en.wikipedia.org/wiki/Oregon     US        6
12               http://en.wikipedia.org/wiki/Utah     US        1
13            http://en.wikipedia.org/wiki/Wyoming     US        1
14           http://en.wikipedia.org/wiki/Arkansas     US        1
15               http://en.wikipedia.org/wiki/Iowa     US        1
16             http://en.wikipedia.org/wiki/Kansas     US        1
17           http://en.wikipedia.org/wiki/Missouri     US        1
18           http://en.wikipedia.org/wiki/Nebraska     US        1
19           http://en.wikipedia.org/wiki/Oklahoma     US        1
20        http://en.wikipedia.org/wiki/South_Dakota     US        1
21          http://en.wikipedia.org/wiki/Louisiana     US        5
22              http://en.wikipedia.org/wiki/Texas     US        4
23         http://en.wikipedia.org/wiki/Connecticut     US        1
24       http://en.wikipedia.org/wiki/Massachusetts     US        6
25       http://en.wikipedia.org/wiki/New_Hampshire     US        1
26         http://en.wikipedia.org/wiki/Rhode_Island     US        6
27            http://en.wikipedia.org/wiki/Vermont     US        1
28            http://en.wikipedia.org/wiki/Alabama     US        5
29            http://en.wikipedia.org/wiki/Florida     US        5
30  http://en.wikipedia.org/wiki/Georgia_(U.S._state)     US        6
31        http://en.wikipedia.org/wiki/Mississippi     US        5
32      http://en.wikipedia.org/wiki/South_Carolina     US        1
33           http://en.wikipedia.org/wiki/Illinois     US        1
34            http://en.wikipedia.org/wiki/Indiana     US        1
35           http://en.wikipedia.org/wiki/Kentucky     US        1
```

```
36         http://en.wikipedia.org/wiki/North_Carolina      US     5
37                 http://en.wikipedia.org/wiki/Ohio         US     1
38             http://en.wikipedia.org/wiki/Tennessee        US     1
39              http://en.wikipedia.org/wiki/Virginia        US     6
40             http://en.wikipedia.org/wiki/Wisconsin        US     1
41          http://en.wikipedia.org/wiki/West_Virginia       US     1
42              http://en.wikipedia.org/wiki/Delaware        US     1
43        http://en.wikipedia.org/wiki/Washington,_D.C.      US     1
44              http://en.wikipedia.org/wiki/Maryland        US     1
45            http://en.wikipedia.org/wiki/New_Jersey        US     5
46              http://en.wikipedia.org/wiki/New_York        US     3
47           http://en.wikipedia.org/wiki/Pennsylvania       US     1
48                http://en.wikipedia.org/wiki/Maine         US     6
49              http://en.wikipedia.org/wiki/Michigan        US     1
50                http://en.wikipedia.org/wiki/Alaska        US     6

                 name                                              name_alt  \
0              Minnesota                                            MN|Minn.
1               Montana                                            MT|Mont.
2            North Dakota                                           ND|N.D.
3                Hawaii                                            HI|Hawaii
4                Idaho                                             ID|Idaho
5             Washington                                           WA|Wash.
6               Arizona                                            AZ|Ariz.
7             California                                           CA|Calif.
8              Colorado                                            CO|Colo.
9               Nevada                                             NV|Nev.
10            New Mexico                                           NM|N.M.
11              Oregon                                             OR|Ore.
12               Utah                                               UT
13              Wyoming                                            WY|Wyo.
14             Arkansas                                            AR|Ark.
15                Iowa                                             IA|Iowa
16               Kansas                                            KS|Kans.
17              Missouri                                              MO
18             Nebraska                                            NE|Nebr.
19             Oklahoma                                            OK|Okla.
20           South Dakota                                           SD|S.D.
21             Louisiana                                              LA
22                Texas                                             TX|Tex.
23            Connecticut                                          CT|Conn.
24          Massachusetts        Commonwealth of Massachusetts|MA|Mass.
25           New Hampshire                                          NH|N.H.
26            Rhode Island   State of Rhode Island and Providence Plantatio…
27              Vermont                                               VT
28              Alabama                                             AL|Ala.
29              Florida                                             FL|Fla.
```

```
30            Georgia                                    GA|Ga.
31         Mississippi                                   MS|Miss.
32      South Carolina                                   SC|S.C.
33            Illinois                                    IL|Ill.
34             Indiana                                    IN|Ind.
35            Kentucky          Commonwealth of Kentucky|KY
36      North Carolina                                   NC|N.C.
37                Ohio                                    OH|Ohio
38           Tennessee                                    TN|Tenn.
39            Virginia                                         VA
40           Wisconsin                                    WI|Wis.
41       West Virginia                                    WV|W.Va.
42            Delaware                                    DE|Del.
43 District of Columbia                                   DC|D.C.
44            Maryland                                         MD
45          New Jersey                                    NJ|N.J.
46            New York                                    NY|N.Y.
47        Pennsylvania      Commonwealth of Pennsylvania|PA
48               Maine                                    ME|Maine
49            Michigan                                    MI|Mich.
50              Alaska                                    AK|Alaska
```

```
    … FCLASS_ID FCLASS_PL FCLASS_GR FCLASS_IT FCLASS_NL FCLASS_SE FCLASS_BD  \
0   …      None      None      None      None      None      None      None
1   …      None      None      None      None      None      None      None
2   …      None      None      None      None      None      None      None
3   …      None      None      None      None      None      None      None
4   …      None      None      None      None      None      None      None
5   …      None      None      None      None      None      None      None
6   …      None      None      None      None      None      None      None
7   …      None      None      None      None      None      None      None
8   …      None      None      None      None      None      None      None
9   …      None      None      None      None      None      None      None
10  …      None      None      None      None      None      None      None
11  …      None      None      None      None      None      None      None
12  …      None      None      None      None      None      None      None
13  …      None      None      None      None      None      None      None
14  …      None      None      None      None      None      None      None
15  …      None      None      None      None      None      None      None
16  …      None      None      None      None      None      None      None
17  …      None      None      None      None      None      None      None
18  …      None      None      None      None      None      None      None
19  …      None      None      None      None      None      None      None
20  …      None      None      None      None      None      None      None
21  …      None      None      None      None      None      None      None
22  …      None      None      None      None      None      None      None
23  …      None      None      None      None      None      None      None
```

```
24  …        None    None    None    None    None    None    None
25  …        None    None    None    None    None    None    None
26  …        None    None    None    None    None    None    None
27  …        None    None    None    None    None    None    None
28  …        None    None    None    None    None    None    None
29  …        None    None    None    None    None    None    None
30  …        None    None    None    None    None    None    None
31  …        None    None    None    None    None    None    None
32  …        None    None    None    None    None    None    None
33  …        None    None    None    None    None    None    None
34  …        None    None    None    None    None    None    None
35  …        None    None    None    None    None    None    None
36  …        None    None    None    None    None    None    None
37  …        None    None    None    None    None    None    None
38  …        None    None    None    None    None    None    None
39  …        None    None    None    None    None    None    None
40  …        None    None    None    None    None    None    None
41  …        None    None    None    None    None    None    None
42  …        None    None    None    None    None    None    None
43  …        None    None    None    None    None    None    None
44  …        None    None    None    None    None    None    None
45  …        None    None    None    None    None    None    None
46  …        None    None    None    None    None    None    None
47  …        None    None    None    None    None    None    None
48  …        None    None    None    None    None    None    None
49  …        None    None    None    None    None    None    None
50  …        None    None    None    None    None    None    None

    FCLASS_UA FCLASS_TLC                                      geometry
0       None        None    POLYGON ((-89.95766 47.28691, -90.13175 47.292…
1       None        None    POLYGON ((-116.04823 49.00037, -113.05950 49.0…
2       None        None    POLYGON ((-97.22894 49.00089, -97.21414 48.902…
3       None        None    MULTIPOLYGON ((((-155.93665 19.05939, -155.9080…
4       None        None    POLYGON ((-116.04823 49.00037, -115.96780 47.9…
5       None        None    POLYGON ((-117.03143 48.99931, -117.02665 47.7…
6       None        None    POLYGON ((-109.04522 36.99991, -109.04367 31.3…
7       None        None    POLYGON ((-114.64222 35.05311, -114.62212 34.9…
8       None        None    POLYGON ((-102.05017 40.00081, -102.04012 38.4…
9       None        None    POLYGON ((-117.02825 42.00002, -114.03422 41.9…
10      None        None    POLYGON ((-109.04367 31.34190, -109.04522 36.9…
11      None        None    POLYGON ((-116.91500 45.99998, -116.67900 45.8…
12      None        None    POLYGON ((-114.03422 41.99312, -111.05024 42.0…
13      None        None    POLYGON ((-111.08518 44.50615, -111.06719 44.5…
14      None        None    POLYGON ((-89.66292 36.02307, -89.67351 35.940…
15      None        None    POLYGON ((-96.45266 43.50179, -95.35994 43.500…
16      None        None    POLYGON ((-102.04118 36.99198, -102.04012 38.4…
17      None        None    POLYGON ((-89.66292 36.02307, -90.31539 36.023…
```

```
18      None      None    POLYGON ((-102.05017 40.00081, -102.05017 40.0…
19      None      None    POLYGON ((-103.00322 36.99516, -102.04118 36.9…
20      None      None    POLYGON ((-96.53945 46.01797, -96.55689 45.872…
21      None      None    POLYGON ((-94.05976 33.01212, -93.09403 33.010…
22      None      None    POLYGON ((-106.50734 31.75429, -106.61953 31.9…
23      None      None    POLYGON ((-73.49794 42.05451, -72.73222 42.035…
24      None      None    POLYGON ((-71.80091 42.01325, -72.73222 42.035…
25      None      None    POLYGON ((-70.81505 42.86519, -70.93360 42.884…
26      None      None    POLYGON ((-71.85383 41.32004, -71.79295 41.466…
27      None      None    POLYGON ((-72.45707 42.72708, -73.28203 42.743…
28      None      None    POLYGON ((-88.16696 34.99967, -86.90968 34.999…
29      None      None    POLYGON ((-87.53039 30.27420, -87.45789 30.411…
30      None      None    POLYGON ((-85.00519 30.99069, -85.05442 31.108…
31      None      None    POLYGON ((-91.15624 33.01000, -91.10808 33.206…
32      None      None    POLYGON ((-80.86501 32.03316, -81.03644 32.084…
33      None      None    POLYGON ((-91.43033 40.36860, -91.41023 40.551…
34      None      None    POLYGON ((-88.05108 37.81960, -88.01881 38.021…
35      None      None    POLYGON ((-89.49836 36.50620, -89.27398 36.611…
36      None      None    POLYGON ((-83.07637 34.97903, -84.32097 34.986…
37      None      None    POLYGON ((-84.82368 39.10653, -84.81787 39.799…
38      None      None    POLYGON ((-90.24924 35.02083, -90.13493 35.113…
39      None      None    MULTIPOLYGON (((-83.33059 36.67266, -83.17851 …
40      None      None    POLYGON ((-91.22820 43.50125, -91.25466 43.613…
41      None      None    POLYGON ((-81.97254 37.53595, -82.16728 37.554…
42      None      None    POLYGON ((-75.04839 38.44876, -75.71462 38.449…
43      None      None    POLYGON ((-77.04124 38.78954, -77.04123 38.789…
44      None      None    POLYGON ((-75.37754 38.01538, -75.37754 38.015…
45      None      None    POLYGON ((-75.52781 39.49865, -75.55427 39.691…
46      None      None    POLYGON ((-73.49794 42.05451, -73.55349 41.289…
47      None      None    POLYGON ((-80.51893 40.64111, -80.51627 42.324…
48      None      None    POLYGON ((-70.64573 43.09008, -70.75102 43.080…
49      None      None    POLYGON ((-89.95766 47.28691, -89.84283 47.464…
50      None      None    MULTIPOLYGON (((-153.22873 57.96897, -152.5647…

[51 rows x 122 columns]
```

[29]: `type(df)`

[29]: geopandas.geodataframe.GeoDataFrame

[30]: `df.shape`

[30]: (51, 122)

[31]: `df.columns`

```
[31]: Index(['featurecla', 'scalerank', 'adm1_code', 'diss_me', 'iso_3166_2',
             'wikipedia', 'iso_a2', 'adm0_sr', 'name', 'name_alt',
             ...
             'FCLASS_ID', 'FCLASS_PL', 'FCLASS_GR', 'FCLASS_IT', 'FCLASS_NL',
             'FCLASS_SE', 'FCLASS_BD', 'FCLASS_UA', 'FCLASS_TLC', 'geometry'],
            dtype='object', length=122)
```

```
[32]: df.loc[0]
```

```
[32]: featurecla                                    Admin-1 scale rank
      scalerank                                                      2
      adm1_code                                              USA-3514
      diss_me                                                    3514
      iso_3166_2                                               US-MN
                                           ...
      FCLASS_SE                                                  None
      FCLASS_BD                                                  None
      FCLASS_UA                                                  None
      FCLASS_TLC                                                 None
      geometry       POLYGON ((-89.95765601272012 47.28690725360318...
      Name: 0, Length: 122, dtype: object
```

```
[33]: df['name']
```

```
[33]: 0              Minnesota
      1                Montana
      2           North Dakota
      3                 Hawaii
      4                  Idaho
      5             Washington
      6                Arizona
      7             California
      8               Colorado
      9                 Nevada
      10            New Mexico
      11                Oregon
      12                  Utah
      13               Wyoming
      14              Arkansas
      15                  Iowa
      16                Kansas
      17              Missouri
      18              Nebraska
      19              Oklahoma
      20          South Dakota
      21             Louisiana
      22                 Texas
```

```
23              Connecticut
24             Massachusetts
25             New Hampshire
26              Rhode Island
27                   Vermont
28                   Alabama
29                   Florida
30                   Georgia
31               Mississippi
32            South Carolina
33                  Illinois
34                   Indiana
35                  Kentucky
36            North Carolina
37                      Ohio
38                 Tennessee
39                  Virginia
40                 Wisconsin
41             West Virginia
42                  Delaware
43      District of Columbia
44                  Maryland
45                New Jersey
46                  New York
47              Pennsylvania
48                     Maine
49                  Michigan
50                    Alaska
Name: name, dtype: object
```

[34]:
```
california = df.loc[df['name'] == "California"]
california
```

[34]:
```
          featurecla  scalerank adm1_code  diss_me iso_3166_2  \
7  Admin-1 scale rank          2  USA-3521     3521      US-CA

                              wikipedia iso_a2 adm0_sr        name  \
7  http://en.wikipedia.org/wiki/California     US       8  California

    name_alt  … FCLASS_ID FCLASS_PL FCLASS_GR FCLASS_IT FCLASS_NL FCLASS_SE  \
7  CA|Calif.  …      None      None      None      None      None      None

   FCLASS_BD FCLASS_UA FCLASS_TLC  \
7       None      None       None

                                           geometry
7  POLYGON ((-114.64222 35.05311, -114.62212 34.9…
```

```
[1 rows x 122 columns]
```

[35]: `california.plot(figsize=(7,7))`

[35]: `<matplotlib.axes._subplots.AxesSubplot at 0x7b3114127950>`
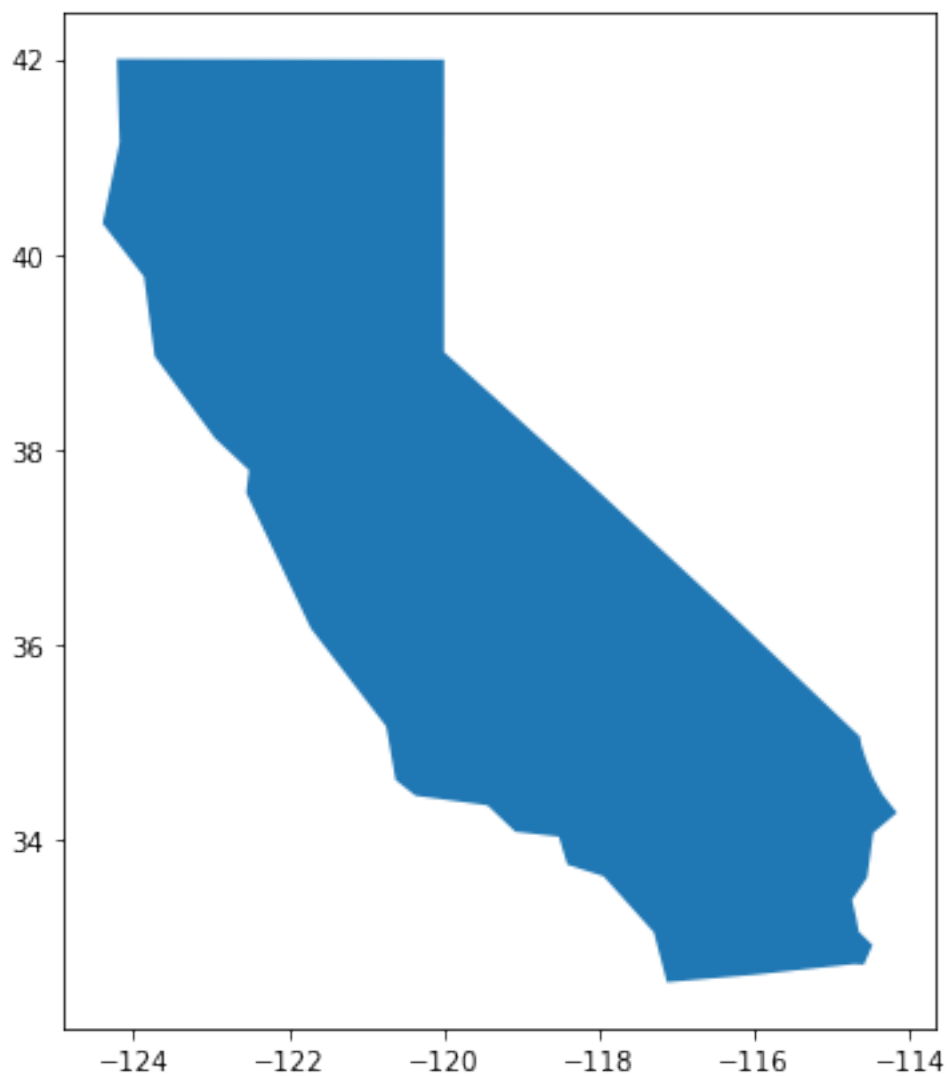
[36]:
```
multipl = df.iloc[[5,7,9,11]]
multipl.plot(cmap="Set1", figsize=(7,7))
```

[36]: `<matplotlib.axes._subplots.AxesSubplot at 0x7b310e1e0a90>`
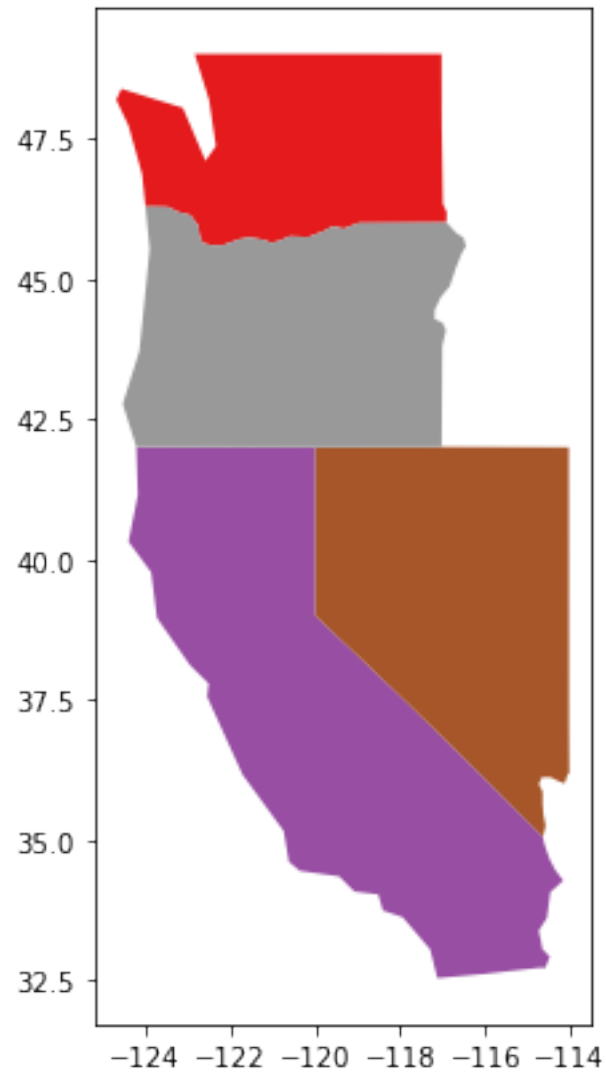
```
[37]: exp = df.cx[-124:-118,30:50]
      exp.plot(cmap="Set1", figsize=(7,7))
```

[37]: <matplotlib.axes._subplots.AxesSubplot at 0x7b310e1eb9d0>
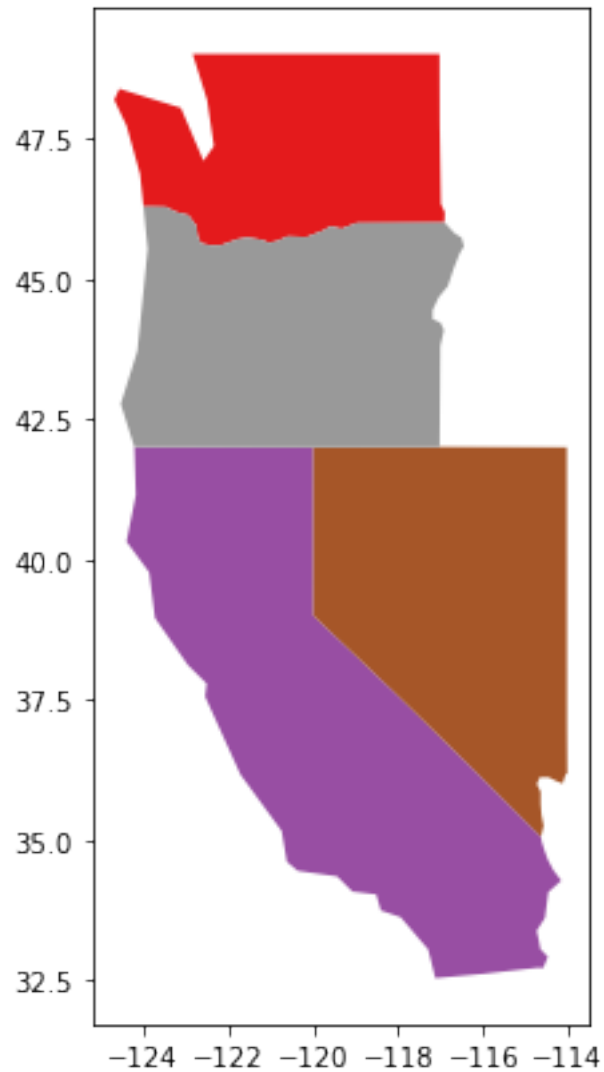
```
[38]: import geopandas
```

```
[39]: states = geopandas.read_file(r"Data/110m_cultural/
      ↪ne_110m_admin_1_states_provinces.shp")
```

```
[40]: states
```

```
[40]:           featurecla  scalerank adm1_code  diss_me iso_3166_2  \
      0   Admin-1 scale rank          2  USA-3514     3514      US-MN
      1   Admin-1 scale rank          2  USA-3515     3515      US-MT
      2   Admin-1 scale rank          2  USA-3516     3516      US-ND
      3   Admin-1 scale rank          2  USA-3517     3517      US-HI
      4   Admin-1 scale rank          2  USA-3518     3518      US-ID
      5   Admin-1 scale rank          2  USA-3519     3519      US-WA
```

```
6   Admin-1 scale rank        2   USA-3520    3520    US-AZ
7   Admin-1 scale rank        2   USA-3521    3521    US-CA
8   Admin-1 scale rank        2   USA-3522    3522    US-CO
9   Admin-1 scale rank        2   USA-3523    3523    US-NV
10  Admin-1 scale rank        2   USA-3524    3524    US-NM
11  Admin-1 scale rank        2   USA-3525    3525    US-OR
12  Admin-1 scale rank        2   USA-3526    3526    US-UT
13  Admin-1 scale rank        2   USA-3527    3527    US-WY
14  Admin-1 scale rank        2   USA-3528    3528    US-AR
15  Admin-1 scale rank        2   USA-3529    3529    US-IA
16  Admin-1 scale rank        2   USA-3530    3530    US-KS
17  Admin-1 scale rank        2   USA-3531    3531    US-MO
18  Admin-1 scale rank        2   USA-3532    3532    US-NE
19  Admin-1 scale rank        2   USA-3533    3533    US-OK
20  Admin-1 scale rank        2   USA-3534    3534    US-SD
21  Admin-1 scale rank        2   USA-3535    3535    US-LA
22  Admin-1 scale rank        2   USA-3536    3536    US-TX
23  Admin-1 scale rank        2   USA-3537    3537    US-CT
24  Admin-1 scale rank        2   USA-3513    3513    US-MA
25  Admin-1 scale rank        2   USA-3538    3538    US-NH
26  Admin-1 scale rank        2   USA-3539    3539    US-RI
27  Admin-1 scale rank        2   USA-3540    3540    US-VT
28  Admin-1 scale rank        2   USA-3541    3541    US-AL
29  Admin-1 scale rank        2   USA-3542    3542    US-FL
30  Admin-1 scale rank        2   USA-3543    3543    US-GA
31  Admin-1 scale rank        2   USA-3544    3544    US-MS
32  Admin-1 scale rank        2   USA-3545    3545    US-SC
33  Admin-1 scale rank        2   USA-3546    3546    US-IL
34  Admin-1 scale rank        2   USA-3547    3547    US-IN
35  Admin-1 scale rank        2   USA-3548    3548    US-KY
36  Admin-1 scale rank        2   USA-3549    3549    US-NC
37  Admin-1 scale rank        2   USA-3550    3550    US-OH
38  Admin-1 scale rank        2   USA-3551    3551    US-TN
39  Admin-1 scale rank        2   USA-3552    3552    US-VA
40  Admin-1 scale rank        2   USA-3553    3553    US-WI
41  Admin-1 scale rank        2   USA-3554    3554    US-WV
42  Admin-1 scale rank        2   USA-3555    3555    US-DE
43  Admin-1 scale rank        2   USA-3556    3556    US-DC
44  Admin-1 scale rank        2   USA-3557    3557    US-MD
45  Admin-1 scale rank        2   USA-3558    3558    US-NJ
46  Admin-1 scale rank        2   USA-3559    3559    US-NY
47  Admin-1 scale rank        2   USA-3560    3560    US-PA
48  Admin-1 scale rank        2   USA-3561    3561    US-ME
49  Admin-1 scale rank        2   USA-3562    3562    US-MI
50  Admin-1 scale rank        2   USA-3563    3563    US-AK

                        wikipedia iso_a2  adm0_sr  \
```

0	http://en.wikipedia.org/wiki/Minnesota	US	1
1	http://en.wikipedia.org/wiki/Montana	US	1
2	http://en.wikipedia.org/wiki/North_Dakota	US	1
3	http://en.wikipedia.org/wiki/Hawaii	US	8
4	http://en.wikipedia.org/wiki/Idaho	US	1
5	http://en.wikipedia.org/wiki/Washington_(state)	US	6
6	http://en.wikipedia.org/wiki/Arizona	US	1
7	http://en.wikipedia.org/wiki/California	US	8
8	http://en.wikipedia.org/wiki/Colorado	US	1
9	http://en.wikipedia.org/wiki/Nevada	US	1
10	http://en.wikipedia.org/wiki/New_Mexico	US	1
11	http://en.wikipedia.org/wiki/Oregon	US	6
12	http://en.wikipedia.org/wiki/Utah	US	1
13	http://en.wikipedia.org/wiki/Wyoming	US	1
14	http://en.wikipedia.org/wiki/Arkansas	US	1
15	http://en.wikipedia.org/wiki/Iowa	US	1
16	http://en.wikipedia.org/wiki/Kansas	US	1
17	http://en.wikipedia.org/wiki/Missouri	US	1
18	http://en.wikipedia.org/wiki/Nebraska	US	1
19	http://en.wikipedia.org/wiki/Oklahoma	US	1
20	http://en.wikipedia.org/wiki/South_Dakota	US	1
21	http://en.wikipedia.org/wiki/Louisiana	US	5
22	http://en.wikipedia.org/wiki/Texas	US	4
23	http://en.wikipedia.org/wiki/Connecticut	US	1
24	http://en.wikipedia.org/wiki/Massachusetts	US	6
25	http://en.wikipedia.org/wiki/New_Hampshire	US	1
26	http://en.wikipedia.org/wiki/Rhode_Island	US	6
27	http://en.wikipedia.org/wiki/Vermont	US	1
28	http://en.wikipedia.org/wiki/Alabama	US	5
29	http://en.wikipedia.org/wiki/Florida	US	5
30	http://en.wikipedia.org/wiki/Georgia_(U.S._state)	US	6
31	http://en.wikipedia.org/wiki/Mississippi	US	5
32	http://en.wikipedia.org/wiki/South_Carolina	US	1
33	http://en.wikipedia.org/wiki/Illinois	US	1
34	http://en.wikipedia.org/wiki/Indiana	US	1
35	http://en.wikipedia.org/wiki/Kentucky	US	1
36	http://en.wikipedia.org/wiki/North_Carolina	US	5
37	http://en.wikipedia.org/wiki/Ohio	US	1
38	http://en.wikipedia.org/wiki/Tennessee	US	1
39	http://en.wikipedia.org/wiki/Virginia	US	6
40	http://en.wikipedia.org/wiki/Wisconsin	US	1
41	http://en.wikipedia.org/wiki/West_Virginia	US	1
42	http://en.wikipedia.org/wiki/Delaware	US	1
43	http://en.wikipedia.org/wiki/Washington,_D.C.	US	1
44	http://en.wikipedia.org/wiki/Maryland	US	1
45	http://en.wikipedia.org/wiki/New_Jersey	US	5
46	http://en.wikipedia.org/wiki/New_York	US	3

```
47        http://en.wikipedia.org/wiki/Pennsylvania    US        1
48              http://en.wikipedia.org/wiki/Maine    US        6
49          http://en.wikipedia.org/wiki/Michigan    US        1
50              http://en.wikipedia.org/wiki/Alaska    US        6


                    name                                      name_alt  \
0                Minnesota                                    MN|Minn.
1                  Montana                                    MT|Mont.
2             North Dakota                                    ND|N.D.
3                   Hawaii                                    HI|Hawaii
4                    Idaho                                    ID|Idaho
5               Washington                                    WA|Wash.
6                  Arizona                                    AZ|Ariz.
7               California                                    CA|Calif.
8                 Colorado                                    CO|Colo.
9                   Nevada                                    NV|Nev.
10              New Mexico                                    NM|N.M.
11                  Oregon                                    OR|Ore.
12                    Utah                                          UT
13                 Wyoming                                    WY|Wyo.
14                Arkansas                                    AR|Ark.
15                    Iowa                                    IA|Iowa
16                  Kansas                                    KS|Kans.
17                Missouri                                          MO
18                Nebraska                                    NE|Nebr.
19                Oklahoma                                    OK|Okla.
20            South Dakota                                    SD|S.D.
21               Louisiana                                          LA
22                   Texas                                    TX|Tex.
23             Connecticut                                    CT|Conn.
24           Massachusetts      Commonwealth of Massachusetts|MA|Mass.
25           New Hampshire                                    NH|N.H.
26            Rhode Island   State of Rhode Island and Providence Plantatio…
27                 Vermont                                          VT
28                 Alabama                                    AL|Ala.
29                 Florida                                    FL|Fla.
30                 Georgia                                    GA|Ga.
31             Mississippi                                    MS|Miss.
32          South Carolina                                    SC|S.C.
33                Illinois                                    IL|Ill.
34                 Indiana                                    IN|Ind.
35                Kentucky                Commonwealth of Kentucky|KY
36          North Carolina                                    NC|N.C.
37                    Ohio                                    OH|Ohio
38               Tennessee                                    TN|Tenn.
39                Virginia                                          VA
40               Wisconsin                                    WI|Wis.
```

```
41            West Virginia                                          WV|W.Va.
42                 Delaware                                          DE|Del.
43       District of Columbia                                        DC|D.C.
44                 Maryland                                                MD
45               New Jersey                                          NJ|N.J.
46                 New York                                          NY|N.Y.
47             Pennsylvania                 Commonwealth of Pennsylvania|PA
48                    Maine                                          ME|Maine
49                 Michigan                                          MI|Mich.
50                   Alaska                                          AK|Alaska
```

		FCLASS_ID	FCLASS_PL	FCLASS_GR	FCLASS_IT	FCLASS_NL	FCLASS_SE	FCLASS_BD	\
0	…	None	None	None	None	None	None	None	
1	…	None	None	None	None	None	None	None	
2	…	None	None	None	None	None	None	None	
3	…	None	None	None	None	None	None	None	
4	…	None	None	None	None	None	None	None	
5	…	None	None	None	None	None	None	None	
6	…	None	None	None	None	None	None	None	
7	…	None	None	None	None	None	None	None	
8	…	None	None	None	None	None	None	None	
9	…	None	None	None	None	None	None	None	
10	…	None	None	None	None	None	None	None	
11	…	None	None	None	None	None	None	None	
12	…	None	None	None	None	None	None	None	
13	…	None	None	None	None	None	None	None	
14	…	None	None	None	None	None	None	None	
15	…	None	None	None	None	None	None	None	
16	…	None	None	None	None	None	None	None	
17	…	None	None	None	None	None	None	None	
18	…	None	None	None	None	None	None	None	
19	…	None	None	None	None	None	None	None	
20	…	None	None	None	None	None	None	None	
21	…	None	None	None	None	None	None	None	
22	…	None	None	None	None	None	None	None	
23	…	None	None	None	None	None	None	None	
24	…	None	None	None	None	None	None	None	
25	…	None	None	None	None	None	None	None	
26	…	None	None	None	None	None	None	None	
27	…	None	None	None	None	None	None	None	
28	…	None	None	None	None	None	None	None	
29	…	None	None	None	None	None	None	None	
30	…	None	None	None	None	None	None	None	
31	…	None	None	None	None	None	None	None	
32	…	None	None	None	None	None	None	None	
33	…	None	None	None	None	None	None	None	
34	…	None	None	None	None	None	None	None	

35	…	None	None	None	None	None	None	None
36	…	None	None	None	None	None	None	None
37	…	None	None	None	None	None	None	None
38	…	None	None	None	None	None	None	None
39	…	None	None	None	None	None	None	None
40	…	None	None	None	None	None	None	None
41	…	None	None	None	None	None	None	None
42	…	None	None	None	None	None	None	None
43	…	None	None	None	None	None	None	None
44	…	None	None	None	None	None	None	None
45	…	None	None	None	None	None	None	None
46	…	None	None	None	None	None	None	None
47	…	None	None	None	None	None	None	None
48	…	None	None	None	None	None	None	None
49	…	None	None	None	None	None	None	None
50	…	None	None	None	None	None	None	None

	FCLASS_UA	FCLASS_TLC	geometry
0	None	None	POLYGON ((-89.95766 47.28691, -90.13175 47.292…
1	None	None	POLYGON ((-116.04823 49.00037, -113.05950 49.0…
2	None	None	POLYGON ((-97.22894 49.00089, -97.21414 48.902…
3	None	None	MULTIPOLYGON ((((-155.93665 19.05939, -155.9080…
4	None	None	POLYGON ((-116.04823 49.00037, -115.96780 47.9…
5	None	None	POLYGON ((-117.03143 48.99931, -117.02665 47.7…
6	None	None	POLYGON ((-109.04522 36.99991, -109.04367 31.3…
7	None	None	POLYGON ((-114.64222 35.05311, -114.62212 34.9…
8	None	None	POLYGON ((-102.05017 40.00081, -102.04012 38.4…
9	None	None	POLYGON ((-117.02825 42.00002, -114.03422 41.9…
10	None	None	POLYGON ((-109.04367 31.34190, -109.04522 36.9…
11	None	None	POLYGON ((-116.91500 45.99998, -116.67900 45.8…
12	None	None	POLYGON ((-114.03422 41.99312, -111.05024 42.0…
13	None	None	POLYGON ((-111.08518 44.50615, -111.06719 44.5…
14	None	None	POLYGON ((-89.66292 36.02307, -89.67351 35.940…
15	None	None	POLYGON ((-96.45266 43.50179, -95.35994 43.500…
16	None	None	POLYGON ((-102.04118 36.99198, -102.04012 38.4…
17	None	None	POLYGON ((-89.66292 36.02307, -90.31539 36.023…
18	None	None	POLYGON ((-102.05017 40.00081, -102.05017 40.0…
19	None	None	POLYGON ((-103.00322 36.99516, -102.04118 36.9…
20	None	None	POLYGON ((-96.53945 46.01797, -96.55689 45.872…
21	None	None	POLYGON ((-94.05976 33.01212, -93.09403 33.010…
22	None	None	POLYGON ((-106.50734 31.75429, -106.61953 31.9…
23	None	None	POLYGON ((-73.49794 42.05451, -72.73222 42.035…
24	None	None	POLYGON ((-71.80091 42.01325, -72.73222 42.035…
25	None	None	POLYGON ((-70.81505 42.86519, -70.93360 42.884…
26	None	None	POLYGON ((-71.85383 41.32004, -71.79295 41.466…
27	None	None	POLYGON ((-72.45707 42.72708, -73.28203 42.743…
28	None	None	POLYGON ((-88.16696 34.99967, -86.90968 34.999…

```
29      None      None   POLYGON ((-87.53039 30.27420, -87.45789 30.411…
30      None      None   POLYGON ((-85.00519 30.99069, -85.05442 31.108…
31      None      None   POLYGON ((-91.15624 33.01000, -91.10808 33.206…
32      None      None   POLYGON ((-80.86501 32.03316, -81.03644 32.084…
33      None      None   POLYGON ((-91.43033 40.36860, -91.41023 40.551…
34      None      None   POLYGON ((-88.05108 37.81960, -88.01881 38.021…
35      None      None   POLYGON ((-89.49836 36.50620, -89.27398 36.611…
36      None      None   POLYGON ((-83.07637 34.97903, -84.32097 34.986…
37      None      None   POLYGON ((-84.82368 39.10653, -84.81787 39.799…
38      None      None   POLYGON ((-90.24924 35.02083, -90.13493 35.113…
39      None      None   MULTIPOLYGON (((-83.33059 36.67266, -83.17851 …
40      None      None   POLYGON ((-91.22820 43.50125, -91.25466 43.613…
41      None      None   POLYGON ((-81.97254 37.53595, -82.16728 37.554…
42      None      None   POLYGON ((-75.04839 38.44876, -75.71462 38.449…
43      None      None   POLYGON ((-77.04124 38.78954, -77.04123 38.789…
44      None      None   POLYGON ((-75.37754 38.01538, -75.37754 38.015…
45      None      None   POLYGON ((-75.52781 39.49865, -75.55427 39.691…
46      None      None   POLYGON ((-73.49794 42.05451, -73.55349 41.289…
47      None      None   POLYGON ((-80.51893 40.64111, -80.51627 42.324…
48      None      None   POLYGON ((-70.64573 43.09008, -70.75102 43.080…
49      None      None   POLYGON ((-89.95766 47.28691, -89.84283 47.464…
50      None      None   MULTIPOLYGON (((-153.22873 57.96897, -152.5647…

[51 rows x 122 columns]
```

[41]:
```python
%matplotlib inline
states.plot(figsize=(10,10))
```

[41]: <matplotlib.axes._subplots.AxesSubplot at 0x7b310e187b90>
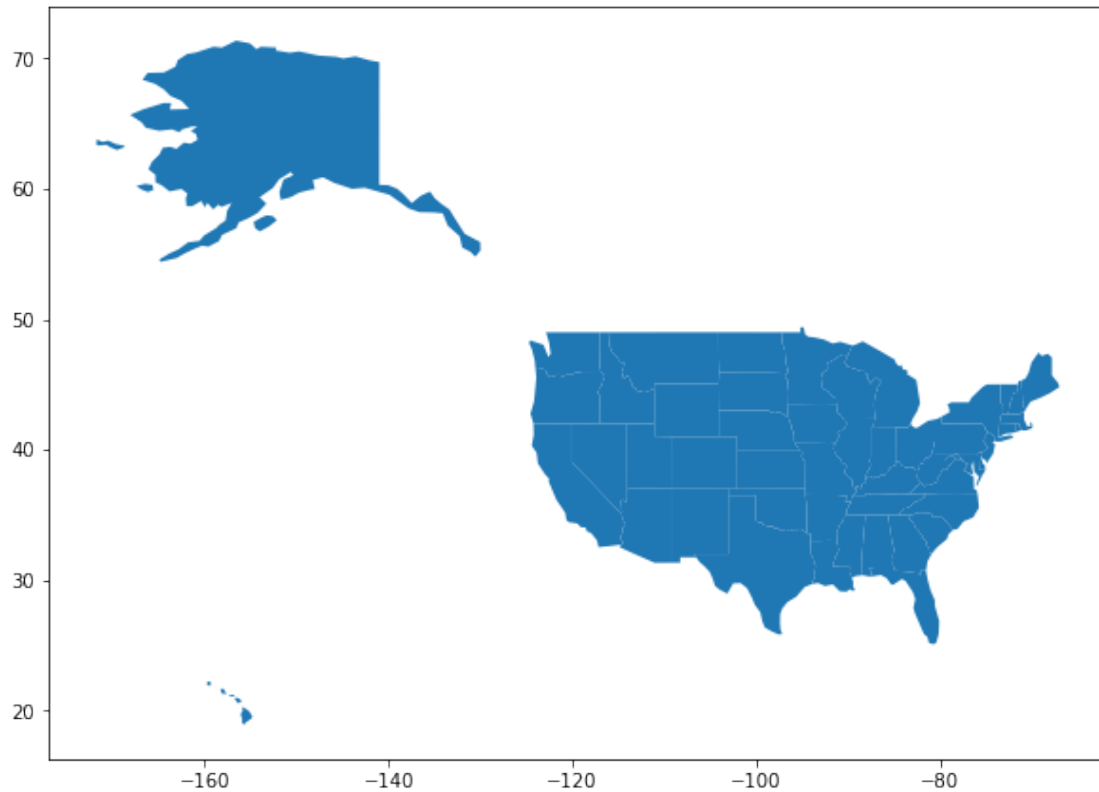
```
[42]: fires = geopandas.read_file(r"Data/mtbs_FODpoints_DD/mtbs_FODpoints_DD.shp")
      fires
```

```
[42]:              Event_ID                              irwinID  \
      0      AK6448214467319840607                         None
      1      SD4308410285019840906                         None
      2      MT4880411345819840819                         None
      3      MT4533610695819840826                         None
      4      MT4561710632319840918                         None
      ...            ...                                    ...
      30413  AL3403308569720210307  4AEFD78F-C2BE-470C-AB5F-1B0918A84A23
      30414  FL2862308067720200715  A7B0E005-54EE-4827-A962-59495C4B0623
      30415  SC3450308143420210307                         None
      30416  AZ3415810972420210707  F1B3DE00-D58E-40FF-AF91-CE3C84389F80
      30417  MT4566510682820210810  996C6346-4C63-4FA8-A193-770E1DE76344


                 Incid_Name    Incid_Type  Map_ID Map_Prog    Asmnt_Type  \
      0       GLACIER CREEK      Wildfire    4534     MTBS   Initial (SS)
      1             SANDOZ      Wildfire    4535     MTBS        Initial
      2          NAPI PEAK      Wildfire    4536     MTBS       Extended
      3              KIRBY      Wildfire    4537     MTBS       Extended
```

```
4            LAKE CREEK         Wildfire      4538    MTBS        Initial
…                …                 …        …     …                …
30413       MT WIESNER           Wildfire  10024251    MTBS      Extended
30414  FMU 5.1 C AND D  Prescribed Fire  10024252    MTBS        Initial
30415          UNNAMED  Prescribed Fire  10024253    MTBS        Initial
30416          FIREBOX           Wildfire  10024338    MTBS      Extended
30417        LAME DEER           Wildfire  10024341    MTBS        Initial

       BurnBndAc BurnBndLat BurnBndLon  … dNBR_offst dNBR_stdDv NoData_T  \
0           1897     64.482   -144.673  …      -9999      -9999     9999
1           2691     43.084   -102.850  …        211      -9999     -970
2           3680     48.804   -113.458  …        -62      -9999     -970
3           1597     45.336   -106.958  …         52      -9999     -970
4           3617     45.617   -106.323  …       -104      -9999     -970
…             …          …          …  …          …          …        …
30413       1905     34.019    -85.687  …         16         16     -970
30414        914     28.641    -80.69   …         18         15     -970
30415        645     34.504    -81.435  …         -5         13     -970
30416       1075     34.157   -109.732  …         11         29     -970
30417       5470     45.644   -106.775  …         50         26     -970

       IncGreen_T  Low_T  Mod_T  High_T  Comment  ORIG_FID  \
0            9999    550    165     -20     None         0
1            -150    220    700    9999     None         1
2            -150    160    308     515     None         2
3            -150    150    309     525     None         3
4            -150    -50    175    9999     None         4
…               …      …      …       …        …         …
30413        -150     20   9999    9999     None     30413
30414        -150     55   9999    9999     None     30414
30415        -150     20   9999    9999     None     30415
30416        -150     50    313     600     None     30416
30417        -150    110    375    9999     None     30417

                          geometry
0        POINT (-144.67325 64.48231)
1        POINT (-102.84988 43.08393)
2        POINT (-113.45772 48.80434)
3        POINT (-106.95829 45.33640)
4        POINT (-106.32284 45.61684)
…                              …
30413    POINT (-85.68731 34.01841)
30414    POINT (-80.68930 28.64502)
30415    POINT (-81.43491 34.50382)
30416   POINT (-109.73103 34.15523)
30417   POINT (-106.77410 45.64768)
```
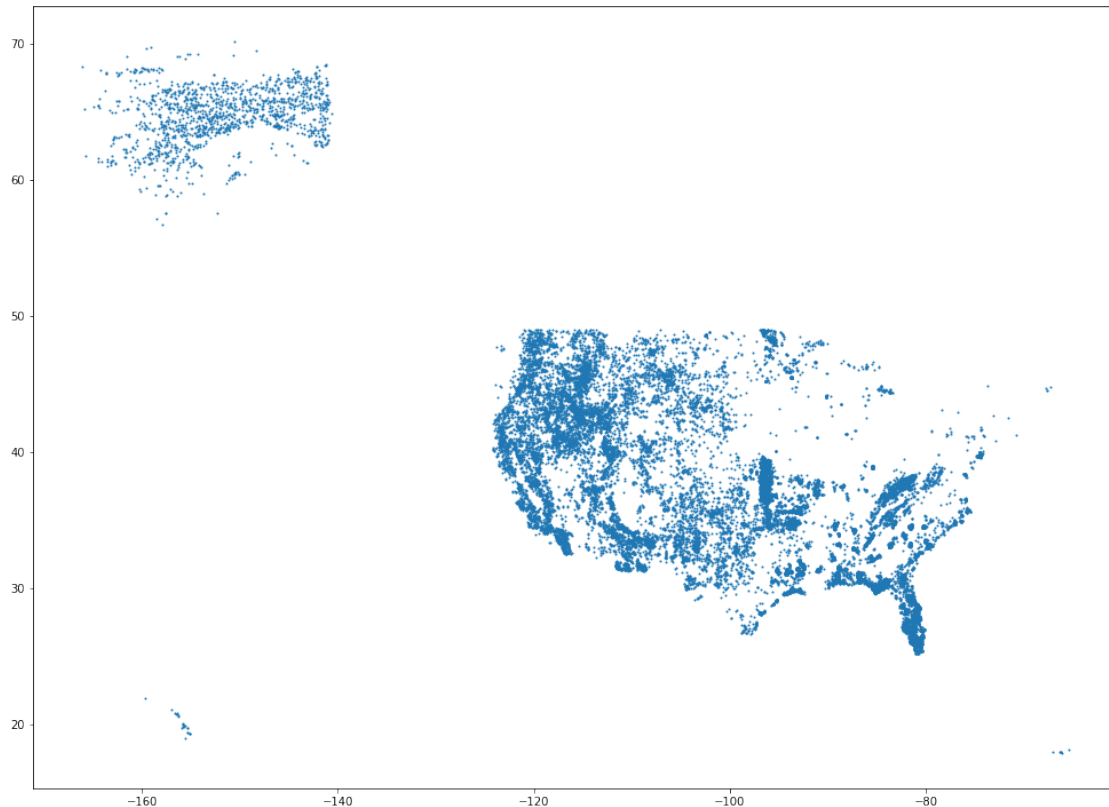
```
[30418 rows x 24 columns]
```

[43]: `fires.plot(markersize=1, figsize=(17,17))`

[43]: `<matplotlib.axes._subplots.AxesSubplot at 0x7b310e18b2d0>`

[44]: `fires.crs`

[44]: <Geographic 2D CRS: EPSG:4269>
Name: NAD83
Axis Info [ellipsoidal]:
- Lat[north]: Geodetic latitude (degree)
- Lon[east]: Geodetic longitude (degree)
Area of Use:
- name: North America - onshore and offshore: Canada - Alberta; British
Columbia; Manitoba; New Brunswick; Newfoundland and Labrador; Northwest
Territories; Nova Scotia; Nunavut; Ontario; Prince Edward Island; Quebec;
Saskatchewan; Yukon. Puerto Rico. United States (USA) - Alabama; Alaska;
Arizona; Arkansas; California; Colorado; Connecticut; Delaware; Florida;
Georgia; Hawaii; Idaho; Illinois; Indiana; Iowa; Kansas; Kentucky; Louisiana;
Maine; Maryland; Massachusetts; Michigan; Minnesota; Mississippi; Missouri;

Montana; Nebraska; Nevada; New Hampshire; New Jersey; New Mexico; New York;
North Carolina; North Dakota; Ohio; Oklahoma; Oregon; Pennsylvania; Rhode
Island; South Carolina; South Dakota; Tennessee; Texas; Utah; Vermont; Virginia;
Washington; West Virginia; Wisconsin; Wyoming. US Virgin Islands. British Virgin
Islands.
- bounds: (167.65, 14.92, -47.74, 86.46)
Datum: North American Datum 1983
- Ellipsoid: GRS 1980
- Prime Meridian: Greenwich

[45]: `states.crs`

[45]: ```
<Geographic 2D CRS: EPSG:4326>
Name: WGS 84
Axis Info [ellipsoidal]:
- Lat[north]: Geodetic latitude (degree)
- Lon[east]: Geodetic longitude (degree)
Area of Use:
- name: World.
- bounds: (-180.0, -90.0, 180.0, 90.0)
Datum: World Geodetic System 1984 ensemble
- Ellipsoid: WGS 84
- Prime Meridian: Greenwich
```

[46]: ```
fires = fires.to_crs("epsg:4326")
```

[47]: ```
state_fires = geopandas.sjoin(fires,states[['name','geometry']].
 ↪copy(),op='within')
state_fires
```

/opt/conda/lib/python3.7/site-packages/IPython/core/interactiveshell.py:3242:
FutureWarning: The `op` parameter is deprecated and will be removed in a future
release. Please use the `predicate` parameter instead.
  if (await self.run_code(code, result,  async_=asy)):

[47]:

| | Event_ID | irwinID | \ |
|---|---|---|---|
| 0 | AK6448214467319840607 | None | |
| 11 | AK6393015752719840606 | None | |
| 12 | AK6375715753719840609 | None | |
| 13 | AK6535415457219840611 | None | |
| 14 | AK6640915520219840617 | None | |
| … | … | … | |
| 16992 | OH3869908322420090424 | None | |
| 28175 | OH3861408255620190322 | DB43038A-5584-4163-B1D1-E7A6F878F79B | |
| 29456 | OH3948808216720210324 | 4BA45C3A-34FE-44E4-976F-B5D1FAF86CAB | |
| 11907 | MA4250107165620050416 | None | |
| 29401 | MA4273407316920210514 | 0DFC1976-D66F-40EA-B769-734EA8E42F99 | |

|       | Incid_Name                  | Incid_Type       | Map_ID   | Map_Prog | \ |
|-------|-----------------------------|------------------|----------|----------|---|
| 0     | GLACIER CREEK               | Wildfire         | 4534     | MTBS     |   |
| 11    | MUD FIRE                    | Wildfire         | 4545     | MTBS     |   |
| 12    | WAPOO FIRE                  | Wildfire         | 4546     | MTBS     |   |
| 13    | 414008                      | Wildfire         | 4547     | MTBS     |   |
| 14    | HUS NW 30                   | Wildfire         | 4548     | MTBS     |   |
| …     | …                           | …                | …        | …        |   |
| 16992 | UNNAMED                     | Wildfire         | 18381    | MTBS     |   |
| 28175 | CY19 BLUEGRASS PRESCRIBED BURN | Prescribed Fire | 10017178 | MTBS    |   |
| 29456 | LONG RIDGE RX UNIT 1-12     | Prescribed Fire  | 10021862 | MTBS     |   |
| 11907 | THE RANGE                   | Wildfire         | 14408    | MTBS     |   |
| 29401 | EAST MOUNTAIN               | Wildfire         | 10021537 | MTBS     |   |

|       | Asmnt_Type     | BurnBndAc | BurnBndLat | BurnBndLon | … | NoData_T | \ |
|-------|----------------|-----------|------------|------------|---|----------|---|
| 0     | Initial (SS)   | 1897      | 64.482     | -144.673   | … | 9999     |   |
| 11    | Extended (SS)  | 10243     | 63.930     | -157.527   | … | 9999     |   |
| 12    | Extended (SS)  | 37083     | 63.757     | -157.537   | … | 9999     |   |
| 13    | Extended (SS)  | 3169      | 65.354     | -154.572   | … | 9999     |   |
| 14    | Extended (SS)  | 1990      | 66.409     | -155.202   | … | 9999     |   |
| …     | …              | …         | …          | …          | … | …        |   |
| 16992 | Initial        | 3259      | 38.699     | -83.224    | … | -970     |   |
| 28175 | Initial        | 1190      | 38.617     | -82.542    | … | -970     |   |
| 29456 | Initial        | 1037      | 39.487     | -82.181    | … | -970     |   |
| 11907 | Initial        | 760       | 42.501     | -71.656    | … | -970     |   |
| 29401 | Initial        | 964       | 42.723     | -73.157    | … | -970     |   |

|       | IncGreen_T | Low_T | Mod_T | High_T | \ |
|-------|------------|-------|-------|--------|---|
| 0     | 9999       | 550   | 165   | -20    |   |
| 11    | 9999       | 475   | 335   | 225    |   |
| 12    | 9999       | 450   | 300   | 200    |   |
| 13    | 9999       | 500   | 260   | -9999  |   |
| 14    | 9999       | 490   | 140   | 325    |   |
| …     | …          | …     | …     | …      |   |
| 16992 | -150       | 70    | 299   | 560    |   |
| 28175 | -150       | 20    | 215   | 9999   |   |
| 29456 | -150       | 75    | 9999  | 9999   |   |
| 11907 | -150       | 150   | 9999  | 9999   |   |
| 29401 | -150       | 25    | 9999  | 9999   |   |

|    | Comment                           | ORIG_FID | \ |
|----|-----------------------------------|----------|---|
| 0  | None                              | 0        |   |
| 11 | Hard to determine fire perimeter  | 11       |   |
| 12 | None                              | 12       |   |
| 13 | Perimeter difficult to delineate. | 13       |   |
| 14 | None                              | 14       |   |
| …  | …                                 | …        |   |

```
16992                                              None     16992
28175    Revised 06/02/2021 - adjusted thresholds, remo…      28175
29456                                              None     29456
11907                                              None     11907
29401                                              None     29401

                           geometry  index_right           name
0       POINT (-144.67325 64.48231)           50         Alaska
11      POINT (-157.52685 63.92986)           50         Alaska
12      POINT (-157.53652 63.75710)           50         Alaska
13      POINT (-154.57250 65.35357)           50         Alaska
14      POINT (-155.20182 66.40871)           50         Alaska
…                               …            …              …
16992    POINT (-83.22436 38.69879)           37           Ohio
28175    POINT (-82.54279 38.61839)           37           Ohio
29456    POINT (-82.17959 39.48788)           37           Ohio
11907    POINT (-71.64979 42.49544)           24  Massachusetts
29401    POINT (-73.15671 42.72522)           24  Massachusetts

[30291 rows x 26 columns]
```

[48]:
```
counts_per_state = state_fires.groupby('name').size()
counts_per_state.sort_values(axis=0, ascending=False)
```

[48]:
```
name
Florida           5507
Kansas            1982
California        1979
Idaho             1587
Texas             1503
Alaska            1377
Arizona           1279
Oklahoma          1112
Oregon            1071
New Mexico        1039
Nevada            1036
Mississippi        909
Montana            878
Alabama            833
South Carolina     815
Louisiana          746
Utah               715
Arkansas           700
Georgia            634
Washington         590
Minnesota          521
Wyoming            449
```

```
Colorado          403
Kentucky          367
Missouri          315
West Virginia     311
North Carolina    303
South Dakota      243
Tennessee         210
Virginia          158
Nebraska          129
New Jersey        114
North Dakota      114
Michigan           82
Indiana            65
Wisconsin          53
Illinois           45
Maryland           40
Hawaii             22
Pennsylvania       18
Iowa               13
New York           11
Maine               4
Ohio                4
Delaware            3
Massachusetts       2
dtype: int64
```

[49]: ```
states = states.merge(counts_per_state.reset_index(name='number_of_fires'))
states.head()
```

[49]:
```
        featurecla  scalerank adm1_code  diss_me iso_3166_2  \
0  Admin-1 scale rank          2  USA-3514     3514      US-MN
1  Admin-1 scale rank          2  USA-3515     3515      US-MT
2  Admin-1 scale rank          2  USA-3516     3516      US-ND
3  Admin-1 scale rank          2  USA-3517     3517      US-HI
4  Admin-1 scale rank          2  USA-3518     3518      US-ID


                              wikipedia iso_a2  adm0_sr          name  \
0      http://en.wikipedia.org/wiki/Minnesota     US        1     Minnesota
1       http://en.wikipedia.org/wiki/Montana     US        1       Montana
2  http://en.wikipedia.org/wiki/North_Dakota     US        1  North Dakota
3        http://en.wikipedia.org/wiki/Hawaii     US        8        Hawaii
4         http://en.wikipedia.org/wiki/Idaho     US        1         Idaho


    name_alt  … FCLASS_PL FCLASS_GR FCLASS_IT FCLASS_NL FCLASS_SE FCLASS_BD  \
0  MN|Minn.  …      None      None      None      None      None      None
1  MT|Mont.  …      None      None      None      None      None      None
2   ND|N.D.  …      None      None      None      None      None      None
```

```
3  HI|Hawaii   …      None      None      None      None      None      None
4  ID|Idaho    …      None      None      None      None      None      None


   FCLASS_UA FCLASS_TLC                                geometry  \
0      None       None  POLYGON ((-89.95766 47.28691, -90.13175 47.292…
1      None       None  POLYGON ((-116.04823 49.00037, -113.05950 49.0…
2      None       None  POLYGON ((-97.22894 49.00089, -97.21414 48.902…
3      None       None  MULTIPOLYGON (((-155.93665 19.05939, -155.9080…
4      None       None  POLYGON ((-116.04823 49.00037, -115.96780 47.9…


   number_of_fires
0              521
1              878
2              114
3               22
4             1587


[5 rows x 123 columns]
```
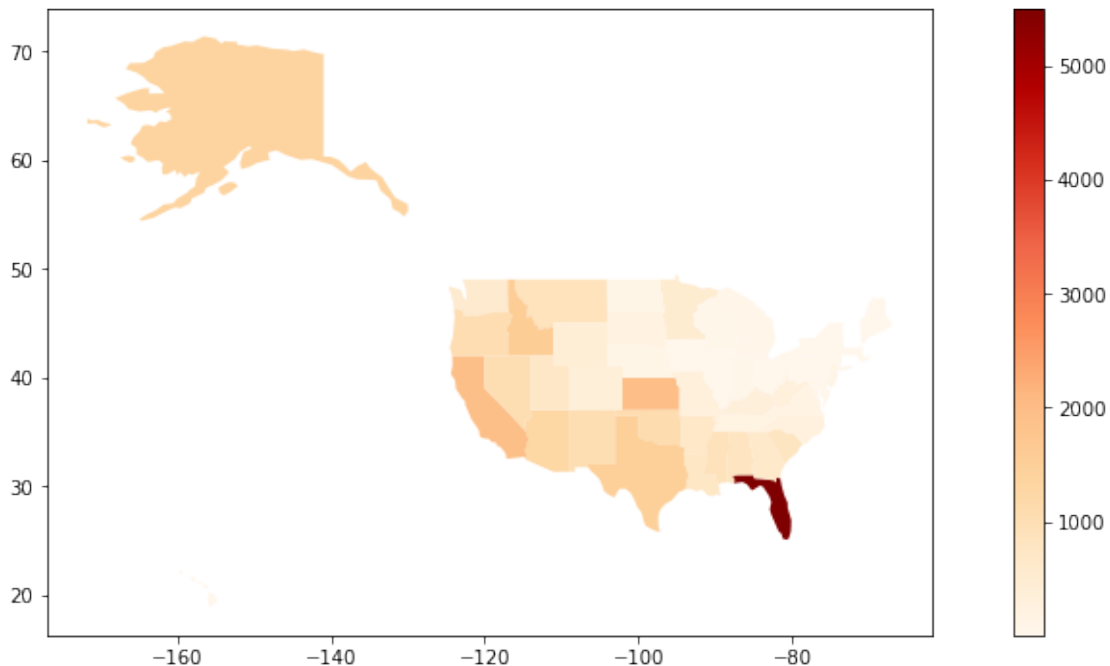
[50]:
```python
ax = states.plot(column='number_of_fires', figsize=(15, 6),
cmap='OrRd', legend=True)
```


[51]:
```python
ax = states.plot(column='number_of_fires', figsize=(15, 6),
cmap='Accent', legend=True)
```
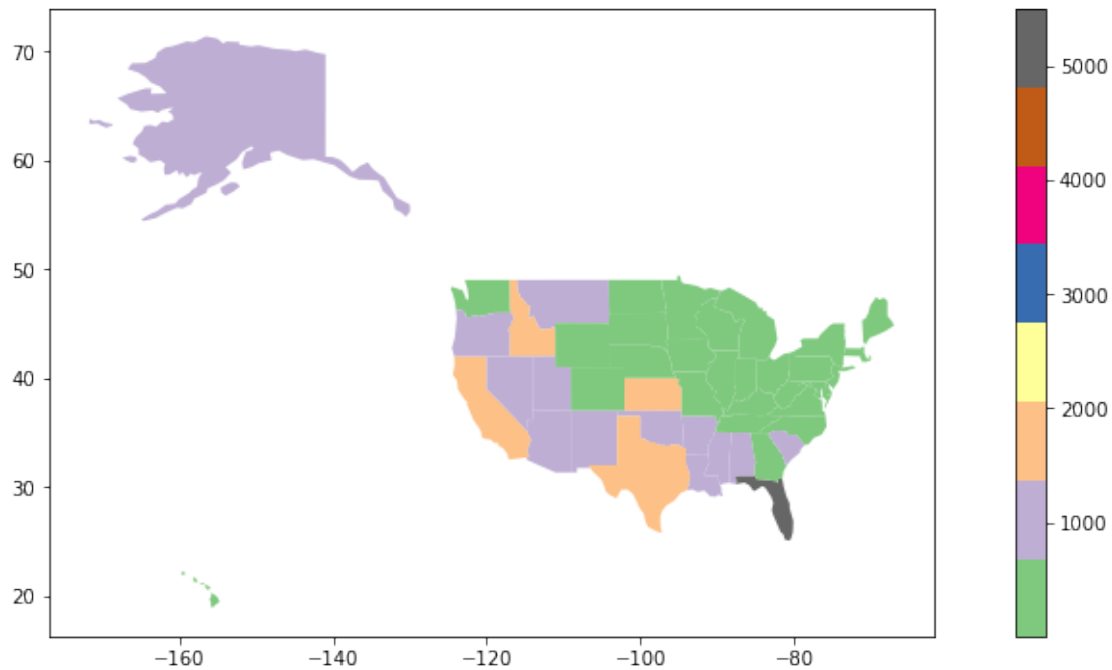
```
[52]: import matplotlib.pyplot as plt
      f, ax = plt.subplots(1, figsize=(18,6))
      ax = states.plot(column='number_of_fires', cmap='OrRd',
      legend=True, ax=ax)
      lims = plt.axis('equal')
      f.suptitle('US Wildfire count per state in 1984-2015')
      ax.set_axis_off()
      plt.show()
```

US Wildfire count per state in 1984-2015
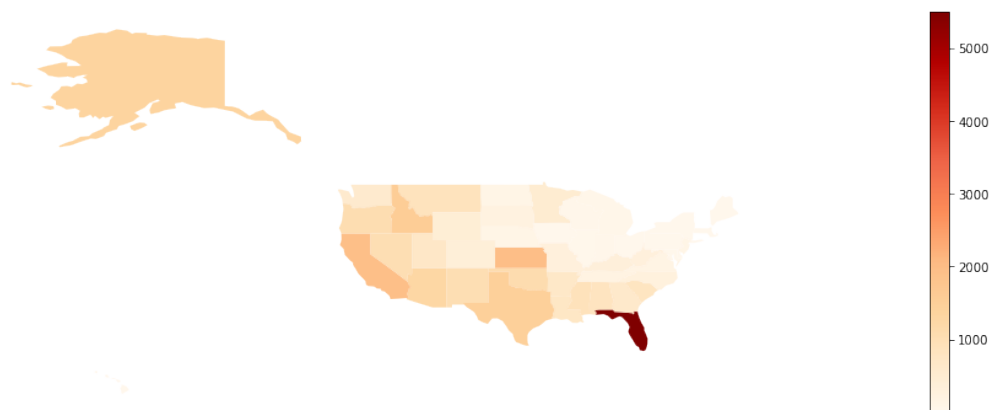
```
[53]: len(fires.index)
```

[53]: 30418

```
[54]: counts_per_state.sum()
```

[54]: 30291

```
[55]: fires.empty #checks if there are empty fields in the dataframe
```

[55]: False

```
[56]: fires['geometry'].empty
```

[56]: False

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

In this lab, I used four key Python libraries – OGR, Shapely, Fiona, and
GeoPandas – to examine geographic data in depth. The investigation began with
the creation of vector geometries like polygons using the OGR package. By
linking together separate points, I illustrated how to define points and form
polygons. In addition, I demonstrated how to read and write vector data as well
as change vector geometries. I also demonstrated how to perform fundamental
geometric operations such as calculating areas, centroids, and borders, as well
as searching for points within a polygon. The tutorial then moved on to using
Shapely and Fiona, both important library, to generate various geometries such
as polygons, points, and lines. Shapely makes it easy to view geometries by
simplifying the plotting process. Fiona is used for reading and interacting
with shapefile. Then, it explains how to explore the data's characteristics
and geometry. Following that, I learned to process more complex geospatial
activities, such as spatial joins, choropleth map construction, and data
inspection, using GeoPandas. These activities necessitated data reading and
cleansing, as well as geographical operations to count and show wildfire
occurrences by state.

Throughout the analysis, data inspection played a pivotal role in ensuring data
quality and identifying missing or erroneous values. The guidance provides
the techniques of how to check for missing values and empty fields in the
dataset, emphasizing the importance of data quality for accurate analysis
and visualization. This data analysis highlighted the versatility of these
Python libraries for geospatial tasks, enabling users to handle geospatial data
effectively from start to finish.