In [1]:
```
# Import modules
import pandas as pd
import geopandas as gpd
import matplotlib.pyplot as plt
```

In [2]:
```
# Define data filepath
pathname = '/Users/jack/Documents/GitHub/geospatial-data-science/labs/

# Read data
df = gpd.read_file(pathname + 'or_1992-2018.shp') # 'df' stands for Da
```

In [3]:
```
# Find column labels
df.columns
```

Out[3]:
```
Index(['OBJECTID', 'FOD_ID', 'FPA_ID', 'SOURCE_SYS', 'SOURCE_S_1',
       'NWCG_REPOR', 'NWCG_REP_1', 'NWCG_REP_2', 'SOURCE_REP', 'SOURC
E_R_1',
       'LOCAL_FIRE', 'LOCAL_INCI', 'FIRE_CODE', 'FIRE_NAME', 'ICS_209
_PL',
       'ICS_209__1', 'MTBS_ID', 'MTBS_FIRE_', 'COMPLEX_NA', 'FIRE_YEA
R',
       'DISCOVERY_', 'DISCOVER_1', 'DISCOVER_2', 'NWCG_CAUSE', 'NWCG_
GENER',
       'NWCG_CAU_1', 'CONT_DATE', 'CONT_DOY', 'CONT_TIME', 'FIRE_SIZE
',
       'FIRE_SIZE_', 'LATITUDE', 'LONGITUDE', 'OWNER_DESC', 'STATE',
'COUNTY',
       'FIPS_CODE', 'FIPS_NAME', 'geometry'],
      dtype='object')
```

In [4]:
```
# Find columns datatypes
df.dtypes
```

Out[4]:
```
OBJECTID       float64
FOD_ID           int64
FPA_ID          object
SOURCE_SYS      object
SOURCE_S_1      object
NWCG_REPOR      object
NWCG_REP_1      object
NWCG_REP_2      object
SOURCE_REP      object
SOURCE_R_1      object
LOCAL_FIRE      object
LOCAL_INCI      object
FIRE_CODE       object
FIRE_NAME       object
ICS_209_PL      object
ICS_209__1      object
MTBS_ID         object
MTBS_FIRE_      object
COMPLEX_NA      object
FIRE_YEAR        int64
DISCOVERY_      object
DISCOVER_1       int64
DISCOVER_2      object
NWCG_CAUSE      object
NWCG_GENER      object
NWCG_CAU_1      object
CONT_DATE       object
CONT_DOY       float64
CONT_TIME       object
FIRE_SIZE      float64
FIRE_SIZE_      object
LATITUDE       float64
LONGITUDE      float64
OWNER_DESC      object
STATE           object
COUNTY          object
FIPS_CODE       object
FIPS_NAME       object
geometry      geometry
dtype: object
```

In [5]:
```
# Get some stats for numeric columns
df['FIRE_SIZE'].describe()
```

Out[5]:
```
count     67042.000000
mean        144.878795
std        3815.600420
min           0.010000
25%           0.100000
50%           0.100000
75%           0.330000
max      558198.300000
Name: FIRE_SIZE, dtype: float64
```

In [6]:
```
# Filter fires larger than 100 acres
df_large = df[df['FIRE_SIZE'] > 100]
```

In [7]:
```
# Find mean size of wildfires larger than 100 acres
df_large['FIRE_SIZE'].mean()
```

Out[7]:
```
5077.047927022739
```

In [8]:
```
# Find the different cause of large wildfires
df_large['NWCG_CAUSE'].unique()
```

Out[8]:
```
array(['Human', 'Natural', 'Missing data/not specified/undetermined']
,
      dtype=object)
```

In [9]:
```
# Filter fires that were caused by natural causes
df_large_natural = df_large[df_large['NWCG_CAUSE'] == 'Natural']
```

In [10]:
```
# Find date of discovery
df_large_natural['DISCOVERY_']
```

Out[10]:
```
56       2008/07/02 00:00:00.000
89       2000/07/22 00:00:00.000
95       2007/08/31 00:00:00.000
96       2003/06/29 00:00:00.000
109      2007/07/13 00:00:00.000
                   ...
67007    2017/08/29 00:00:00.000
67008    2011/09/15 00:00:00.000
67014    2014/09/16 00:00:00.000
67017    2013/08/07 00:00:00.000
67022    2016/08/17 00:00:00.000
Name: DISCOVERY_, Length: 1164, dtype: object
```

In [11]:
```
datetime = pd.to_datetime(df_large_natural['DISCOVERY_'], format='%Y/%
datetime
```

Out[11]:
```
56      2008-07-02
89      2000-07-22
95      2007-08-31
96      2003-06-29
109     2007-07-13
           ...
67007   2017-08-29
67008   2011-09-15
67014   2014-09-16
67017   2013-08-07
67022   2016-08-17
Name: DISCOVERY_, Length: 1164, dtype: datetime64[ns]
```

In [12]:
```
df_large_natural['datetime'] = datetime # Sorry about the warning, ext
```

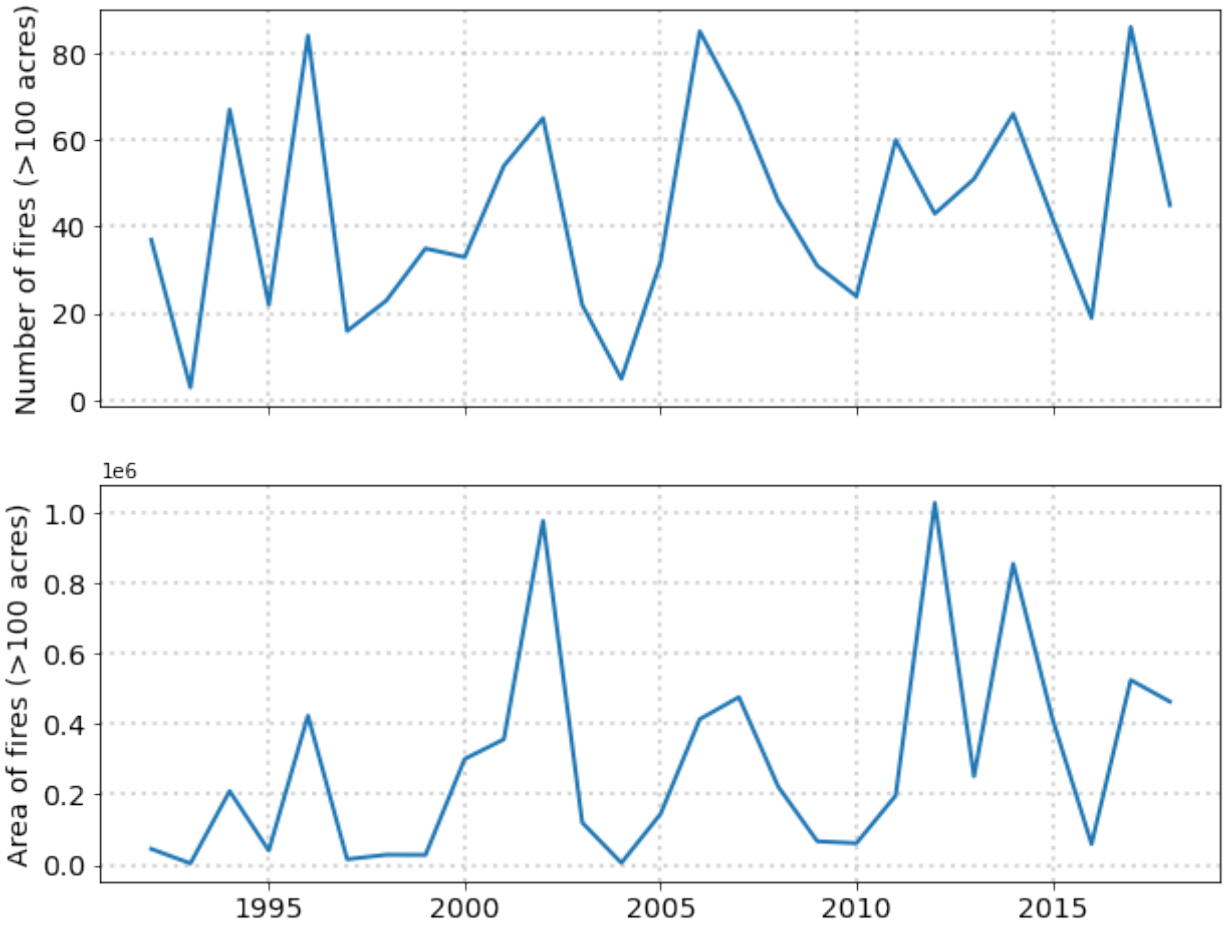
```
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/sit
e-packages/geopandas/geodataframe.py:1351: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/panda
s-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
(https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.htm
l#returning-a-view-versus-a-copy)
  super().__setitem__(key, value)
```

In [13]:
```
# Filter large, natural wildfires in 2016
df_large_natural_2016 = df_large_natural[df_large_natural['datetime'].
```

In [14]:
```
# Find number of large fires in each year (i.e. number of rows in each
large_fire_count = df_large.iloc[:,0].groupby(df_large_natural['dateti
```

In [15]:
```
# Find acres of wildfire for each year
large_fire_area = df_large['FIRE_SIZE'].groupby(df_large_natural['date
```

In [16]:
```
# Plot number and acres of wildfire for each year
fig, (ax1, ax2) = plt.subplots(nrows=2, ncols=1, figsize=(10,8), share
ax1.plot(large_fire_count, lw=2)
ax1.set_ylabel('Number of fires (>100 acres)', fontsize=14)
ax1.tick_params(axis='x', labelsize=14)
ax1.tick_params(axis='y', labelsize=14)
ax1.grid(ls='dotted', lw=2, alpha=0.5)

ax2.plot(large_fire_area, lw=2)
ax2.set_ylabel('Area of fires (>100 acres)', fontsize=14)
ax2.tick_params(axis='x', labelsize=14)
ax2.tick_params(axis='y', labelsize=14)
ax2.grid(ls='dotted', lw=2, alpha=0.5)
```



Question 1a

In [17]:
```
#df_large['FIRE_SIZE'].groupby(df_large_natural)
df_large = df[df['FIRE_SIZE'] > 50]
```

In [18]:
```
# Find the fire area in acres
#large_fire_area = df_large['FIRE_SIZE'].groupby(df_large_natural['dat
```

In [19]:
```
# Filter fires that were caused by human causes
df_large = df_large[df_large['NWCG_CAUSE'] == 'Human']
```

In [20]:
```
most_count = df_large.groupby('FIPS_NAME').count()
```

In [21]:
```
most_count.sort_values(by='OBJECTID')
```

Out[21]:

FIPS_NAME	OBJECTID	FOD_ID	FPA_ID	SOURCE_SYS	SOURCE_S_1	NWCG_REPOR	NWCG
Adams County	1	1	1	1	1	1	
Tillamook County	1	1	1	1	1	1	
Columbia County	1	1	1	1	1	1	
Yamhill County	1	1	1	1	1	1	
Klickitat County	2	2	2	2	2	2	
Washington County	2	2	2	2	2	2	
Clatsop County	3	3	3	3	3	3	
Multnomah County	3	3	3	3	3	3	
Polk County	4	4	4	4	4	4	
Clackamas County	4	4	4	4	4	4	
Benton County	5	5	5	5	5	5	
Hood River County	5	5	5	5	5	5	
Linn County	5	5	5	5	5	5	
Lincoln County	6	6	6	6	6	6	

Marion County	7	7	7	7	7	7
Coos County	8	8	8	8	8	8
Curry County	9	9	9	9	9	9
Crook County	10	10	10	10	10	10
Wallowa County	10	10	10	10	10	10
Morrow County	11	11	11	11	11	11
Union County	14	14	14	14	14	14
Lake County	18	18	18	18	18	18
Lane County	18	18	18	18	18	18
Gilliam County	19	19	19	19	19	19
Josephine County	20	20	20	20	20	20
Sherman County	20	20	20	20	20	20
Baker County	22	22	22	22	22	22
Deschutes County	22	22	22	22	22	22
Jackson County	25	25	25	25	25	25
Wheeler County	28	28	28	28	28	28
Grant County	28	28	28	28	28	28
Jefferson County	30	30	30	30	30	30
Harney County	31	31	31	31	31	31
Klamath County	34	34	34	34	34	34

Umatilla County	40	40	40	40	40	40
Douglas County	40	40	40	40	40	40
Malheur County	49	49	49	49	49	49
Wasco County	71	71	71	71	71	71

38 rows × 38 columns

Question 1b

In [22]:
```
df_large_natural['FIRE_SIZE'].groupby(df_large_natural['FIPS_NAME']).c
```

Out[22]:
```
FIPS_NAME
Baker County          29
Clackamas County       2
Crook County          24
Curry County           4
Deschutes County      12
Douglas County        45
Gilliam County        21
Grant County          63
Harney County        119
Hood River County      3
Jackson County        30
Jefferson County      26
Josephine County      15
Klamath County        15
Lake County           34
Lane County           15
Linn County            3
Malheur County       183
Marion County          5
```

In [23]:
```
#Question 1b
df_large = df[df['FIRE_SIZE'] > 100]
```

In [24]:
```
df_natural = df_large[df_large['NWCG_CAUSE']=='Natural']
```

In [25]:
```
#df_natural['month'].describe()
```

In [26]:
```
df_large_natural = df_natural[df_natural['FIRE_SIZE']>100]
```

In [27]:
```
datetime = pd.to_datetime(df_large_natural['DISCOVERY_'],format='%Y/%m
df_large_natural.month = datetime

#monthcount = df_large_natural.groupby('month').count()
#monthcount
```

```
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/site-packages/geopandas/geodataframe.py:199: UserWarning: Pandas doesn't allow columns to be created via a new attribute name - see https://pandas.pydata.org/pandas-docs/stable/indexing.html#attribute-access (https://pandas.pydata.org/pandas-docs/stable/indexing.html#attribute-access)
  super().__setattr__(attr, val)
```

In [28]:
```
datetime = pd.to_datetime(df_large_natural['DISCOVERY_'],format='%Y/%m
df_large_natural["month"] = datetime.dt.month
```

In [29]:
```
df_large_natural["month"]
```

Out[29]:
```
56       7
89       7
95       8
96       6
109      7
        ..
67007    8
67008    9
67014    9
67017    8
67022    8
Name: month, Length: 1164, dtype: int64
```

In [30]:
```
df_large_natural['FIRE_SIZE'].groupby(df_large_natural['month']).count
```

Out[30]:
```
month
4       2
5       6
6      98
7     410
8     549
9      93
10      6
Name: FIRE_SIZE, dtype: int64
```

Question 1c

In [31]:
```
# Filter fires larger than 200 acres
df_large = df[df['FIRE_SIZE'] > 200]
```

In [32]:
```
# Find the different cause of large wildfires
df_large['NWCG_CAUSE'].unique()
```

Out[32]:
```
array(['Natural', 'Human', 'Missing data/not specified/undetermined']
,
      dtype=object)
```

In [33]:
```
# Filter fires that were caused by specified/undetermined causes
df_large = df_large[df_large['NWCG_CAUSE'] == 'Missing data/not specif
```

Question 1d

In [34]:
```
# Get some stats for numeric columns
df['FIRE_SIZE'].describe()
```

Out[34]:
```
count     67042.000000
mean        144.878795
std        3815.600420
min           0.010000
25%           0.100000
50%           0.100000
75%           0.330000
max      558198.300000
Name: FIRE_SIZE, dtype: float64
```

In [35]:
```
df_large['FIRE_SIZE'].max()
```

Out[35]:
```
23600.0
```

In [36]:
```
largest_fire = df_large['FIRE_SIZE'].max()
```

In [37]:
```
df[df['FIRE_SIZE']== df['FIRE_SIZE'].max()][['DISCOVERY_','FIRE_NAME',
```

Out[37]:

	DISCOVERY_	FIRE_NAME	FIPS_NAME	FIRE_SIZE
66964	2012/07/08 00:00:00.000	LONG DRAW	Malheur County	558198.3

Question 1e

In [38]:
```
# Filter fires larger than 50 acres
df_large = df[df['FIRE_SIZE'] > 50]
```

In [39]:
```
df_large[df_large["FIPS_NAME"]=="Lane County"]['FIRE_SIZE'].groupby(df
```

Out[39]:
```
FIPS_NAME
Lane County    33
Name: FIRE_SIZE, dtype: int64
```

Lab 2b: Where are wildfires occurring in Oregon?

In [40]:
```
# Import modules
from cenpy import products
import matplotlib.pyplot as plt

# Define product
acs = products.ACS(2019)
```

In [41]:
```
# Print list of tables
acs.filter_tables('POPULATION', by='description')
```

Out[41]:

table_name	description	columns
B01003	TOTAL POPULATION	[B01003_001E]
B05006	PLACE OF BIRTH FOR THE FOREIGN-BORN POPULATION...	[B05006_001E, B05006_002E, B05006_003E, B05006...
B05007	PLACE OF BIRTH BY YEAR OF ENTRY BY CITIZENSHIP...	[B05007_001E, B05007_002E, B05007_003E, B05007...
B05008	SEX BY PLACE OF BIRTH BY YEAR OF ENTRY FOR THE...	[B05008_001E, B05008_002E, B05008_003E, B05008...
B05013	SEX BY AGE FOR THE FOREIGN-BORN POPULATION	[B05013_001E, B05013_002E, B05013_003E, B05013...
...	...	...
C24030	SEX BY INDUSTRY FOR THE CIVILIAN EMPLOYED POPU...	[C24030_001E, C24030_002E, C24030_003E, C24030...
C24040	SEX BY INDUSTRY FOR THE FULL-TIME, YEAR-ROUND ...	[C24040_001E, C24040_002E, C24040_003E, C24040...
C24050	INDUSTRY BY OCCUPATION FOR THE CIVILIAN EMPLO...	[C24050_001E, C24050_002E, C24050_003E, C24050...
C24060	OCCUPATION BY CLASS OF WORKER FOR THE CIVILIAN...	[C24060_001E, C24060_002E, C24060_003E, C24060...
C24070	INDUSTRY BY CLASS OF WORKER FOR THE CIVILIAN E...	[C24070_001E, C24070_002E, C24070_003E, C24070...

143 rows × 2 columns

In [42]:
```
# Print list of variables
acs.filter_variables('B01003')
```

Out[42]:

	label	concept	predicateType	group	limit	predicateOnly	hasGeo
B01003_001E	Estimate!!Total	TOTAL POPULATION	int	B01003	0	NaN	

In [43]:
```
# Download data
malheur_pop = products.ACS(2019).from_county('Malheur County', level='
                                             variables=['B01003_001E']) # d
```

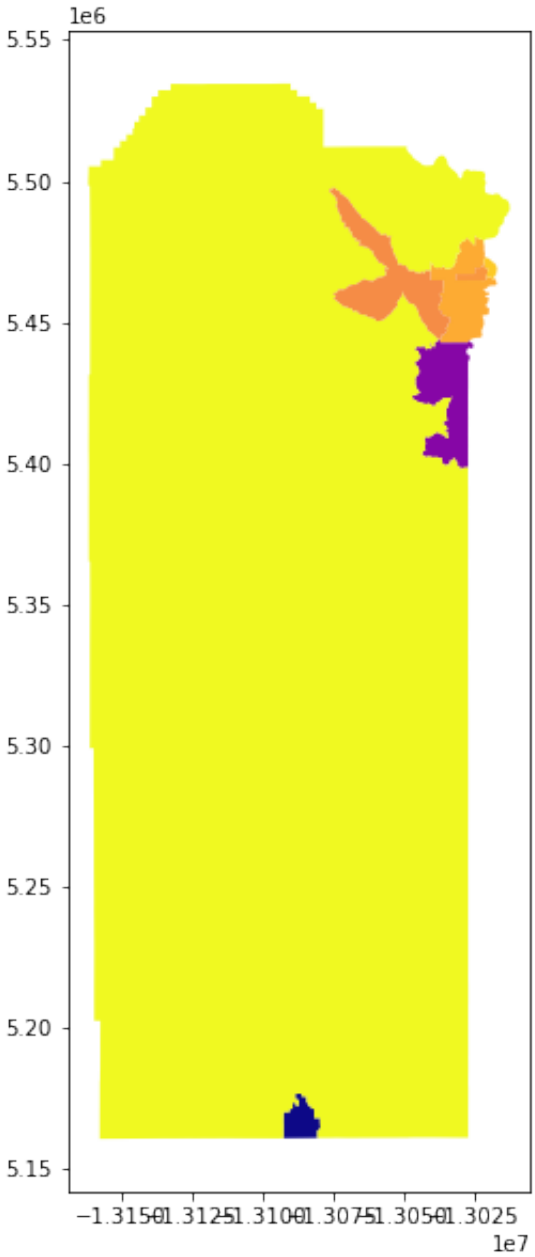
```
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/sit
e-packages/pyproj/crs/crs.py:131: FutureWarning: '+init=<authority>:<
code>' syntax is deprecated. '<authority>:<code>' is the preferred in
itialization method. When making the change, be mindful of axis order
changes: https://pyproj4.github.io/pyproj/stable/gotchas.html#axis-or
der-changes-in-proj-6
(https://pyproj4.github.io/pyproj/stable/gotchas.html#axis-order-chan
ges-in-proj-6)
  in_crs_string = _prepare_from_proj_string(in_crs_string)
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/sit
e-packages/pyproj/crs/crs.py:131: FutureWarning: '+init=<authority>:<
code>' syntax is deprecated. '<authority>:<code>' is the preferred in
itialization method. When making the change, be mindful of axis order
changes: https://pyproj4.github.io/pyproj/stable/gotchas.html#axis-or
der-changes-in-proj-6
(https://pyproj4.github.io/pyproj/stable/gotchas.html#axis-order-chan
ges-in-proj-6)
  in_crs_string = _prepare_from_proj_string(in_crs_string)
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/sit
e-packages/cenpy/products.py:762: FutureWarning: The `op` parameter i
s deprecated and will be removed in a future release. Please use the
`predicate` parameter instead.
  return self._from_name(county, variables, level, "Counties", **kwar
gs)
```

In [44]:
```
# Calculate some stats
malheur_pop['B01003_001E'].describe()
```

Out[44]:
```
count       8.000000
mean     3801.500000
std      1968.306088
min         0.000000
25%      3540.750000
50%      4518.500000
75%      4802.250000
max      5781.000000
Name: B01003_001E, dtype: float64
```

In [45]:
```
# Plot map
f, ax = plt.subplots(1, 1, figsize=(10,10))
malheur_pop.plot('B01003_001E', ax=ax, cmap='plasma')
```

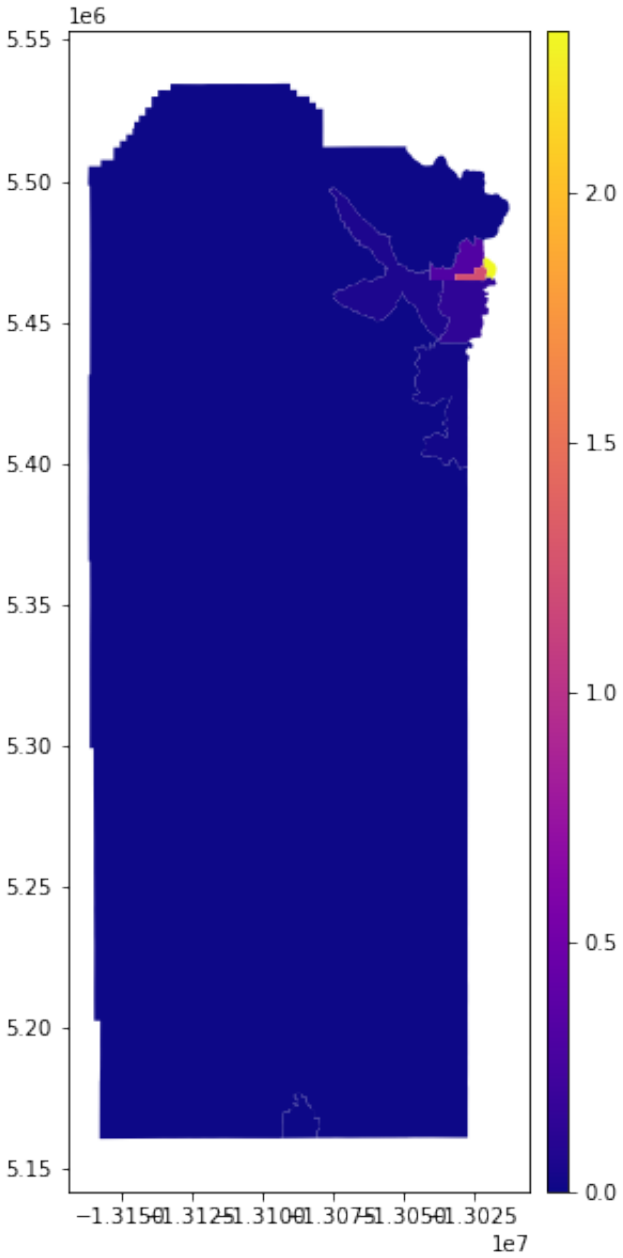
Out[45]: <AxesSubplot:>



In [46]:
```
malheur_pop['pop_density'] = 1e4 * malheur_pop['B01003_001E'] / malheu

from mpl_toolkits.axes_grid1 import make_axes_locatable

# Plot map
f, ax = plt.subplots(1, 1, figsize=(10,10))

# These two lines make the colorbar the same size as the axes
```

```
# These two lines make the colorbar the same size as the axes.
divider = make_axes_locatable(ax)
cax = divider.append_axes("right", size="5%", pad=0.1)

malheur_pop.plot('pop_density', ax=ax, cmap='plasma', legend=True, cax
```

Out[46]: <AxesSubplot:>



In [47]:
```
malheur_pop.crs
```

Out[47]:
```
<Derived Projected CRS: EPSG:3857>
Name: WGS 84 / Pseudo-Mercator
Axis Info [cartesian]:
- E[east]: Easting (metre)
- N[north]: Northing (metre)
Area of Use:
- name: World between 85.06°S and 85.06°N.
- bounds: (-180.0, -85.06, 180.0, 85.06)
Coordinate Operation:
- name: Popular Visualisation Pseudo-Mercator
- method: Popular Visualisation Pseudo Mercator
Datum: World Geodetic System 1984 ensemble
- Ellipsoid: WGS 84
- Prime Meridian: Greenwich
```

In [48]:
```
# Make
df_large = df[df['FIRE_SIZE'] > 100]
malheur_fires = df_large[df_large['FIPS_NAME'] == 'Malheur County']
malheur_fires.crs
```

Out[48]:
```
<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
```

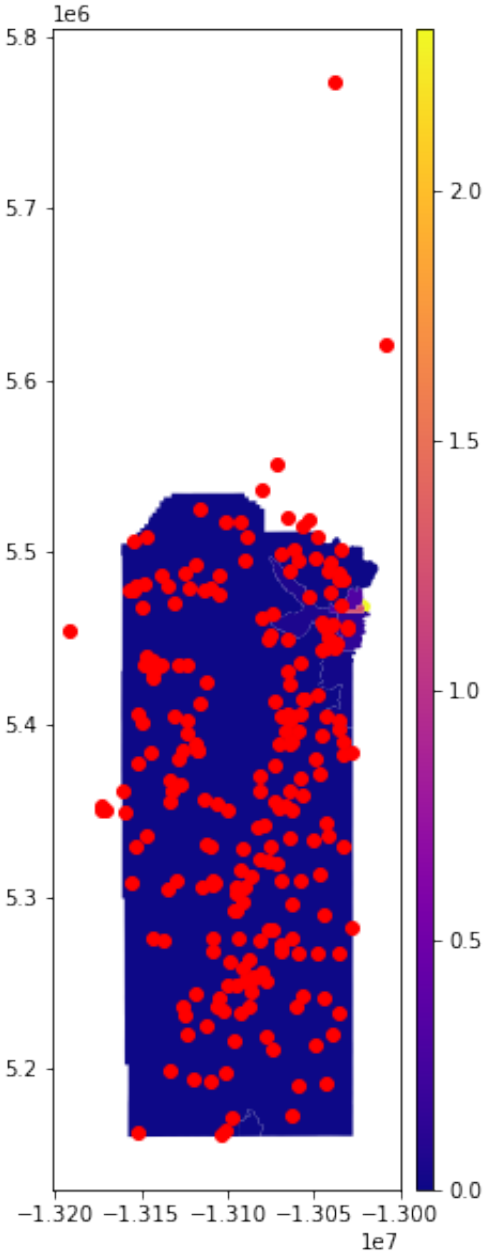
In [49]:
```
malheur_fires_proj = malheur_fires.to_crs('EPSG:3857')
malheur_fires_proj.crs
```

Out[49]:
```
<Derived Projected CRS: EPSG:3857>
Name: WGS 84 / Pseudo-Mercator
Axis Info [cartesian]:
- X[east]: Easting (metre)
- Y[north]: Northing (metre)
Area of Use:
- name: World between 85.06°S and 85.06°N.
- bounds: (-180.0, -85.06, 180.0, 85.06)
Coordinate Operation:
- name: Popular Visualisation Pseudo-Mercator
- method: Popular Visualisation Pseudo Mercator
Datum: World Geodetic System 1984 ensemble
- Ellipsoid: WGS 84
- Prime Meridian: Greenwich
```

Type *Markdown* and LaTeX: α^2

In [50]:
```
# Plot map
f, ax = plt.subplots(1, 1, figsize=(10,10))

# These two lines make the colorbar the same size as the axes.
divider = make_axes_locatable(ax)
cax = divider.append_axes("right", size="5%", pad=0.1)

malheur_pop.plot('pop_density', ax=ax, cmap='plasma', legend=True, cax
malheur_fires_proj.plot(ax=ax, c='red')
```

Out[50]: <AxesSubplot:>

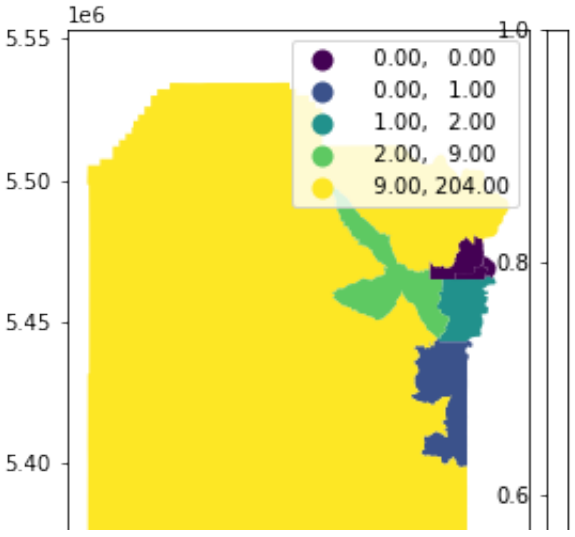


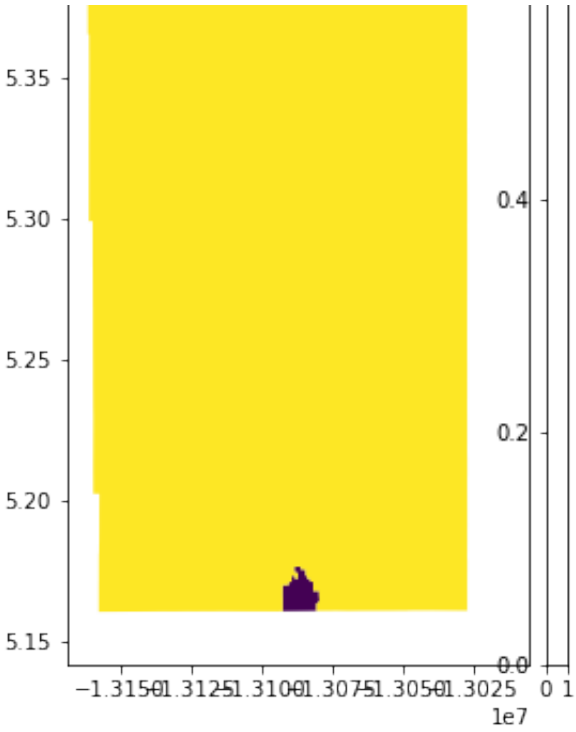
The diagram below is a choropleth map showing the fire count in Malheur County. As we can see most of the fire occur in the rural areas, with some fires near Ontario.

In [51]:
```
# Spatial join
joined_df = gpd.sjoin(malheur_fires_proj, malheur_pop, how='inner', pr

# Groupby tract
tract_count = joined_df.groupby(['tract'], as_index=False)['OBJECTID']
tract_count.columns = ['tract', 'fire_count']

# Merge back to original DataFrame
merged_df = malheur_pop.merge(tract_count, on='tract', how='left')

# Clean up data by filling NaNs with 0
merged_df['fire_count'].fillna(0, inplace=True)

# Plot map
f, ax = plt.subplots(1, 1, figsize=(10,10))
divider = make_axes_locatable(ax)
cax = divider.append_axes("right", size="5%", pad=0.1)
merged_df.plot('fire_count', ax=ax, cmap='viridis', legend=True, cax=c
```

```
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/sit
e-packages/mapclassify/classifiers.py:1718: UserWarning: Warning: Not
enough unique values in array to form k classes
  Warn(ms, UserWarning)
/Users/jack/Documents/Anaconda3/anaconda3/envs/lab2/lib/python3.8/sit
e-packages/mapclassify/classifiers.py:1719: UserWarning: Warning: set
ting k to 5
  Warn("Warning: setting k to %d" % uvk, UserWarning)
```

Out[51]: <AxesSubplot:>




5.35
5.30
5.25
5.20
5.15
0.4
0.2
0.0
−1.3150
1.3125
1.3100
1.3075
1.3050
1.3025
0 1
1e7

In [ ]: