Using DigitalGlobe's Open Data Against Ebola

In this notebook we'll be looking at how to use DigitalGlobe's open data to find areas in the Democratic Republic of the Congo that are at an elevated risk of an ebola outbreak.

Getting Started with DigitalGlobe's Open Data

The data for this notebook can be downloaded from the following link: https://www.digitalglobe.com/opendata/ebola-response-democratic-republic-of-the-congo/vector-data

If you haven't already, you will have to install sklearn to run this notebook.

In [1]:
```
!pip install sklearn
```

1]:
```
Requirement already satisfied: sklearn in /anaconda/envs/gbdx_py3/lib/python3.6/site-packages (0.0)
Requirement already satisfied: scikit-learn in /anaconda/envs/gbdx_py3/lib/python3.6/site-packages (from skl
[31mvcrpy 1.13.0 requires yarl, which is not installed.[0m
[31mgbdxtools 0.15.7 requires mock, which is not installed.[0m
```

[33mYou are using pip version 10.0.1, however version 18.0 is available.
You should consider upgrading via the 'pip install --upgrade pip' command.[0m

In [2]:
```
import gbdxtools
gbdx = gbdxtools.Interface()
import json
from sklearn.cluster import DBSCAN
#import geopandas as gpd
import shapely
from matplotlib import pyplot as plt
```

We can use the open data by converting it to a GeoJSON file. I did this (on a mac) by installing GDAL, cd-ing into the equateur-dynamic folder in Terminal, and running the command line `ogr2ogr -f GeoJSON equateur-dynamic.geojson equateur-dynamic.shp` (see this link for other ways to do this: https://www.igismap.com/different-ways-to-convert-shapefile-to-geojson-online-or-offline-or-api/).

To use the data in your notebook, you have to upload it to the Jupyter file tree. You can do this by clicking on the Jupyter logo in the upper left corner, then clicking the upload button in the upper right corner of the redirected page.

In [3]:
```
with open('equateur-dynamic.geojson') as f:
    dynamic = json.load(f)
```

Now we can show the vectors on a slippy map. Note that it may take a while to load, which is why I'm only showing the first 10000 vectors here.

In [4]:
```
gbdx.vectors.map(features=dynamic['features'][:10000], zoom = 11)
```

4]:

Analyzing the Building Footprints

First, let's run a clustering algorithm on all the buildings so we can distinguish between different cities.

Since clustering can take a lot of memory, I'm only running it on the first 50000 buildings in the GeoJSON file. For simplicity, I'm only using the first point in each vector.

In [5]:
```
points = [i['geometry']['coordinates'][0][0] for i in dynamic['features'][
```

In [6]:
```
#arbitrarily deciding that two buildings .005 degrees apart (roughly a thi
dbs = DBSCAN(eps=.005)
clusters = dbs.fit_predict(points)
```

Our new list `clusters` is 50000 elements long, where each element is the id of a cluster, and each index is the id of a vector.

In [7]:
```
cluster_sizes = [0 for _ in range(max(clusters)+1)]
for i in range(50000):
    cluster_sizes[clusters[i]] += 1
```

Now we have a list (`cluster_sizes`), where each element corresponds to the size of a cluster.

In [8]:
```
small_clusters = [i for i in range(max(clusters)+1) if cluster_sizes[i] <=
```

We can now map all the buildings that were in small clusters. (You may have to pan and zoom a bit to find them).

In [9]:
```
gbdx.vectors.map(features=[dynamic['features'][i] for i in range(50000) if
```

9]:

By plotting the clusters as a histogram (the x-axis represents the cluster ID, and the y-axis represents the cluster's size), we can see that most clusters are small with a few exceptions.

In [10]:
```
plt.hist(clusters, bins = max(clusters) + 1)
```

Out[10]:
```
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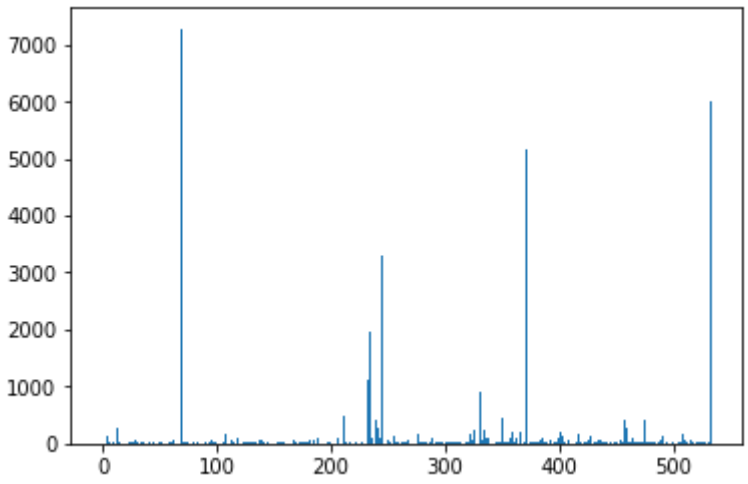
```

0]:



1 [11]:

```
plt.hist(cluster_sizes, bins = 300)
```

1]: (array([366., 61., 21., 23., 15., 9., 3., 7., 5., 2., 3.,

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        1.70320e+03, 1.72746e+03, 1.75172e+03, 1.77598e+03, 1.80024e+03,
        1.82450e+03, 1.84876e+03, 1.87302e+03, 1.89728e+03, 1.92154e+03,
        1.94580e+03, 1.97006e+03, 1.99432e+03, 2.01858e+03, 2.04284e+03,
        2.06710e+03, 2.09136e+03, 2.11562e+03, 2.13988e+03, 2.16414e+03,
        2.18840e+03, 2.21266e+03, 2.23692e+03, 2.26118e+03, 2.28544e+03,
        2.30970e+03, 2.33396e+03, 2.35822e+03, 2.38248e+03, 2.40674e+03,
        2.43100e+03, 2.45526e+03, 2.47952e+03, 2.50378e+03, 2.52804e+03,
        2.55230e+03, 2.57656e+03, 2.60082e+03, 2.62508e+03, 2.64934e+03,
        2.67360e+03, 2.69786e+03, 2.72212e+03, 2.74638e+03, 2.77064e+03,
        2.79490e+03, 2.81916e+03, 2.84342e+03, 2.86768e+03, 2.89194e+03,
```

```
        2.91620e+03, 2.94046e+03, 2.96472e+03, 2.98898e+03, 3.01324e+03,
        3.03750e+03, 3.06176e+03, 3.08602e+03, 3.11028e+03, 3.13454e+03,
        3.15880e+03, 3.18306e+03, 3.20732e+03, 3.23158e+03, 3.25584e+03,
        3.28010e+03, 3.30436e+03, 3.32862e+03, 3.35288e+03, 3.37714e+03,
        3.40140e+03, 3.42566e+03, 3.44992e+03, 3.47418e+03, 3.49844e+03,
        3.52270e+03, 3.54696e+03, 3.57122e+03, 3.59548e+03, 3.61974e+03,
        3.64400e+03, 3.66826e+03, 3.69252e+03, 3.71678e+03, 3.74104e+03,
        3.76530e+03, 3.78956e+03, 3.81382e+03, 3.83808e+03, 3.86234e+03,
        3.88660e+03, 3.91086e+03, 3.93512e+03, 3.95938e+03, 3.98364e+03,
        4.00790e+03, 4.03216e+03, 4.05642e+03, 4.08068e+03, 4.10494e+03,
        4.12920e+03, 4.15346e+03, 4.17772e+03, 4.20198e+03, 4.22624e+03,
        4.25050e+03, 4.27476e+03, 4.29902e+03, 4.32328e+03, 4.34754e+03,
        4.37180e+03, 4.39606e+03, 4.42032e+03, 4.44458e+03, 4.46884e+03,
        4.49310e+03, 4.51736e+03, 4.54162e+03, 4.56588e+03, 4.59014e+03,
        4.61440e+03, 4.63866e+03, 4.66292e+03, 4.68718e+03, 4.71144e+03,
        4.73570e+03, 4.75996e+03, 4.78422e+03, 4.80848e+03, 4.83274e+03,
        4.85700e+03, 4.88126e+03, 4.90552e+03, 4.92978e+03, 4.95404e+03,
        4.97830e+03, 5.00256e+03, 5.02682e+03, 5.05108e+03, 5.07534e+03,
        5.09960e+03, 5.12386e+03, 5.14812e+03, 5.17238e+03, 5.19664e+03,
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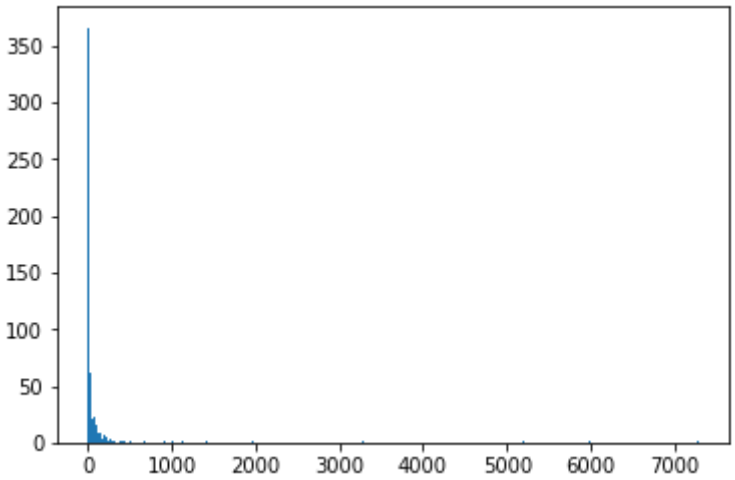
        5.34220e+03, 5.36646e+03, 5.39072e+03, 5.41498e+03, 5.43924e+03,
        5.46350e+03, 5.48776e+03, 5.51202e+03, 5.53628e+03, 5.56054e+03,
        5.58480e+03, 5.60906e+03, 5.63332e+03, 5.65758e+03, 5.68184e+03,
        5.70610e+03, 5.73036e+03, 5.75462e+03, 5.77888e+03, 5.80314e+03,
        5.82740e+03, 5.85166e+03, 5.87592e+03, 5.90018e+03, 5.92444e+03,
        5.94870e+03, 5.97296e+03, 5.99722e+03, 6.02148e+03, 6.04574e+03,
        6.07000e+03, 6.09426e+03, 6.11852e+03, 6.14278e+03, 6.16704e+03,
        6.19130e+03, 6.21556e+03, 6.23982e+03, 6.26408e+03, 6.28834e+03,
        6.31260e+03, 6.33686e+03, 6.36112e+03, 6.38538e+03, 6.40964e+03,
        6.43390e+03, 6.45816e+03, 6.48242e+03, 6.50668e+03, 6.53094e+03,
        6.55520e+03, 6.57946e+03, 6.60372e+03, 6.62798e+03, 6.65224e+03,
        6.67650e+03, 6.70076e+03, 6.72502e+03, 6.74928e+03, 6.77354e+03,
        6.79780e+03, 6.82206e+03, 6.84632e+03, 6.87058e+03, 6.89484e+03,
        6.91910e+03, 6.94336e+03, 6.96762e+03, 6.99188e+03, 7.01614e+03,
        7.04040e+03, 7.06466e+03, 7.08892e+03, 7.11318e+03, 7.13744e+03,
        7.16170e+03, 7.18596e+03, 7.21022e+03, 7.23448e+03, 7.25874e+03,
        7.28300e+03]),
    )
```

1]:



One factor in risk for Ebola outbreaks is population density. One way to estimate the density of a given cluster would be to draw a buffer around each building in a cluster, and find the number of buildings in this cluster divided by the area of the union of the buffers.

*Note that the location of the points is given in latitude and longitude. Since all of our data is near the equator, I'll just approximate a degree of latitude or longitude as 69 miles.

ı [12]:

```
densities = [0 for _ in range(len(cluster_sizes))]
buffers = [[] for _ in range(len(cluster_sizes))]
unions = [0 for _ in range(len(cluster_sizes))] #We'll use this later
for i in range(50000):
    buffers[clusters[i]].append(shapely.geometry.Point(points[i]).buffer(.
for i in range(len(buffers)):
    union = shapely.ops.cascaded_union(buffers[i])
    densities[i] = cluster_sizes[i] / (union.area * 69 * 69)
    unions[i] = union
```

Here `densities` is a list of the number of buildings per square mile for each cluster. Keep in mind that the densities may be too low because I did not incorporate all of the buildings in my analysis.

ı [13]:

```
plt.hist(densities, bins = 300)
```

3]:

```
(array([10., 41., 73., 56., 49., 33., 31., 22., 22., 16., 15., 12.,  9.,
        10.,  8.,  8.,  8.,  6.,  5.,  5.,  1.,  5.,  7.,  1.,  3.,  3.,
         1.,  4.,  2.,  4.,  3.,  0.,  3.,  2.,  0.,  3.,  3.,  3.,  1.,
         0.,  0.,  1.,  1.,  0.,  0.,  1.,  2.,  2.,  1.,  1.,  0.,  0.,
         3.,  3.,  0.,  0.,  2.,  2.,  1.,  0.,  2.,  0.,  1.,  1.,  0.,
         0.,  1.,  0.,  0.,  1.,  1.,  1.,  1.,  0.,  0.,  0.,  0.,  0.,
         1.,  2.,  0.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  1.,  0.,  0.,
         0.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  0.,  0.,
```

```
       0.,  0.,  1.,  0.,  0.,  2.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,
       1.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
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      124.00143841, 127.3005524 , 130.5996664 , 133.8987804 ,
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      189.98371835, 193.28283235, 196.58194634, 199.88106034,
      203.18017434, 206.47928834, 209.77840233, 213.07751633,
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      308.75182225, 312.05093625, 315.35005024, 318.64916424,
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      335.14473423, 338.44384822, 341.74296222, 345.04207622,
      348.34119021, 351.64030421, 354.93941821, 358.23853221,
      361.5376462 , 364.8367602 , 368.1358742 , 371.43498819,
      374.73410219, 378.03321619, 381.33233019, 384.63144418,
      387.93055818, 391.22967218, 394.52878617, 397.82790017,
      401.12701417, 404.42612817, 407.72524216, 411.02435616,
```

```
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440.71638214, 444.01549613, 447.31461013, 450.61372413,
453.91283812, 457.21195212, 460.51106612, 463.81018012,
467.10929411, 470.40840811, 473.70752211, 477.0066361 ,
480.3057501 , 483.6048641 , 486.9039781 , 490.20309209,
493.50220609, 496.80132009, 500.10043408, 503.39954808,
506.69866208, 509.99777608, 513.29689007, 516.59600407,
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585.87739801, 589.17651201, 592.47562601, 595.77474  ,
599.073854  , 602.372968  , 605.67208199, 608.97119599,
612.27030999, 615.56942399, 618.86853798, 622.16765198,
625.46676598, 628.76587997, 632.06499397, 635.36410797,
638.66322197, 641.96233596, 645.26144996, 648.56056396,
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678.25258993, 681.55170393, 684.85081793, 688.14993192,
691.44904592, 694.74815992, 698.04727392, 701.34638791,
704.64550191, 707.94461591, 711.2437299 , 714.5428439 ,
717.8419579 , 721.1410719 , 724.44018589, 727.73929989,
731.03841389, 734.33752788, 737.63664188, 740.93575588,
744.23486988, 747.53398387, 750.83309787, 754.13221187,
757.43132586, 760.73043986, 764.02955386, 767.32866786,
770.62778185, 773.92689585, 777.22600985, 780.52512385,
783.82423784, 787.12335184, 790.42246584, 793.72157983,
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823.41360581, 826.71271981, 830.0118338 , 833.3109478 ,
836.6100618 , 839.90917579, 843.20828979, 846.50740379,
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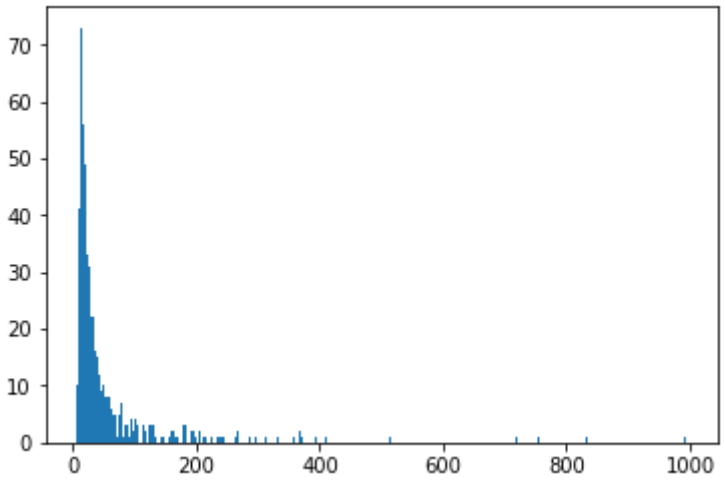
902.59234174, 905.89145574, 909.19056974, 912.48968373,
915.78879773, 919.08791173, 922.38702572, 925.68613972,
928.98525372, 932.28436772, 935.58348171, 938.88259571,
942.18170971, 945.4808237 , 948.7799377 , 952.0790517 ,
955.3781657 , 958.67727969, 961.97639369, 965.27550769,
968.57462168, 971.87373568, 975.17284968, 978.47196368,
981.77107767, 985.07019167, 988.36930567, 991.66841966,
994.96753366]), )
```

3]:



Naturally, since so many of the clusters were very small, it makes sense that their calculated density would be small as well (because each building gets buffered with a third of a mile).

Using the Human Landscape Data

We can find some interesting statistics by looking at the building footprints, but in order to really assess an area's risk of Ebola outbreaks, we need to look at access to hospitals, communication, and transportation, to name a few. We can find this information in the Human Landscape data.

ı [14]:
```
# with open('human-landscape/COD_MedicalFacilities_130215.json') as f:
#     health = json.load(f)
# with open('human-landscape/COD_InternetCafes_130215_WGS.json') as f:
#     internet = json.load(f)
with open('human-landscape/COD_Roads_130214_WGS84.json') as f:
    roads = json.load(f)
```

ı [15]:
```
gbdx.vectors.map(features = roads['features'], zoom = 11)
```

5]:

First let's take a look at road densities. Road densities have a U-shaped correlation with Ebola outbreaks, because more roads can make hospitals more accessible, but also facilitate the spread of the disease. (http://currents.plos.org/outbreaks/article/obk-16-0062-spatial-determinants-of-ebola-virus-disease-risk-for-the-west-african-epidemic/#ref12)

To find the road density of a cluster, let's buffer the roads so they have some width, and then find the percent of area they cover. This will give a rather arbitrary unit of measurement, but a consistent way to compare different clusters.

[16]:
```
road_lines = []
for i in range(len(roads['features'])):
    if isinstance(roads['features'][i]['geometry']['coordinates'][0][0], l
        for j in roads['features'][i]['geometry']['coordinates']:
            road_lines.append(shapely.geometry.LineString(j).buffer(.0001)
    else:
        road_lines.append(shapely.geometry.LineString(roads['features'][i]
all_roads = shapely.ops.cascaded_union(road_lines)
```

[17]:
```
road_densities = [(100*i.intersection(all_roads).area) / i.area for i in u
```

[18]:
```
plt.hist(road_densities, bins=300)
```

8]:
```
(array([469.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
        0.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  1.,  0.,  2.,
        0.,  0.,  1.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,
        0.,  1.,  0.,  0.,  0.,  0.,  0.,  2.,  0.,  0.,  0.,
        1.,  0.,  0.,  0.,  0.,  1.,  0.,  0.,  0.,  0.,  0.,
        0.,  0.,  0.,  0.,  1.,  0.,  1.,  1.,  0.,  0.,  1.,
        0.,  1.,  1.,  1.,  0.,  0.,  0.,  0.,  0.,  2.,  2.,
        2.,  4.,  3.,  3.,  1.,  0.,  2.,  2.,  1.,  0.,  2.,
        4.,  0.,  5.,  2.,  3.,  1.,  1.,  0.,  0.,  0.,  0.,
        0.,  0.,  0.,  0.,  0.,  0.,  1.,  1.,  0.,  0.,  0.,
        0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  1.,  1.,
        0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
        0.,  1.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
```

```
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  1.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
       0.,  0.,  1.]),
 array([0.        , 0.02661624, 0.05323249, 0.07984873, 0.10646497,
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        0.39924364, 0.42585988, 0.45247612, 0.47909237, 0.50570861,
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        0.66540606, 0.69202231, 0.71863855, 0.74525479, 0.77187103,
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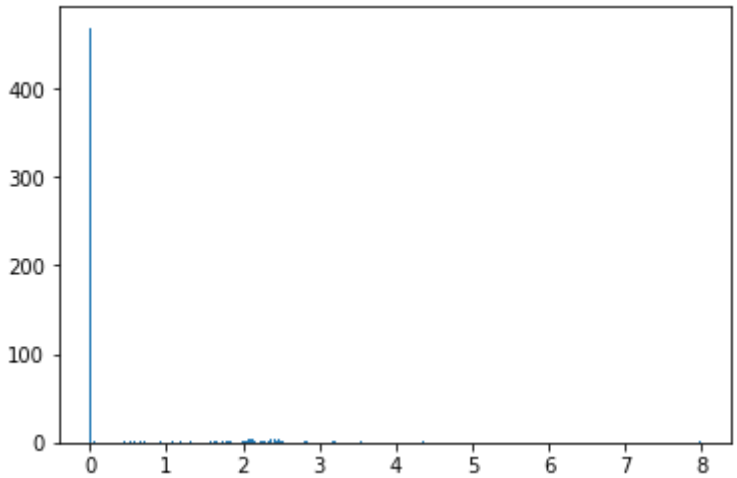

The heavy skew to 0 is probably due to the fact that most of the clusters were very small, and therefore have a small chance of intersecting the roads in our data. For these clusters, it may be more useful to look at how close they are to roads.

[19]:
```
distance_to_roads = [i.distance(all_roads) * 69 for i in unions] #factor c
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[20]:
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plt.hist(distance_to_roads, bins = 300)
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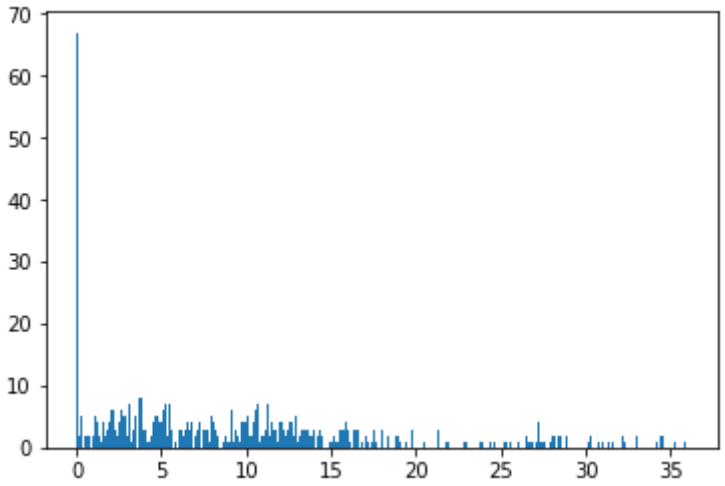

In []:

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