University of Colorado Denver
College of Liberal Arts and Sciences

Denver Hate Crime Mapping
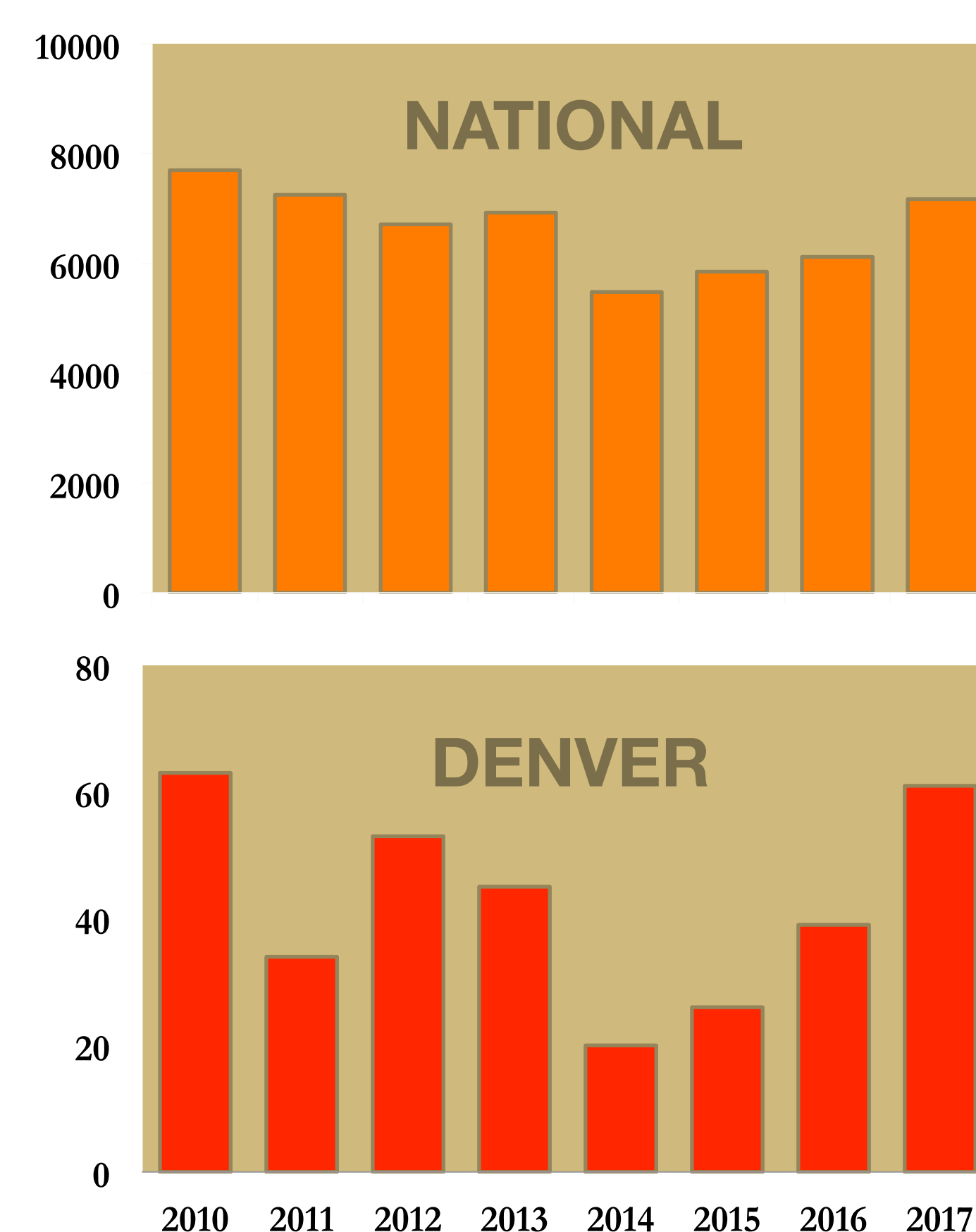## Visualizing Fluctuations Through Linear Programming

Kathleen Gatliffe Mathematical and Statistical Sciences, University of Colorado Denver

Bias Motivated Crime

- Crime committed against a person or persons in an attempt to victimize an entire group of people

- Commonly called hate crime.

- In Colorado, protected categories include: disability, ethnicity, gender identity, race, religion, and sexual orientation.

- The Denver Police Department takes part in the national hate crimes database

- National statistics compiled monthly by the FBI as part of the Uniform Crime Reporting (UCR) program and released in a yearly report

Reported Hate Crimes 2010-2017

Reported hate crimes in Denver tend to follow national trends, but due to the relatively small number of reported crimes, fluctuations can appear magnified

Linear Programming:

Techniques for finding the optimal solution to sets of linear equations

Assignment Problem:

A class of linear program that can be used to show shifts over time, such as the location of hate crimes in Denver

Let i denote the crimes in the earlier year, and j be the crimes in the following year, then

Letting the Euclidean distance between locations be c_{ij}; our objective function minimizes the summation of all distances

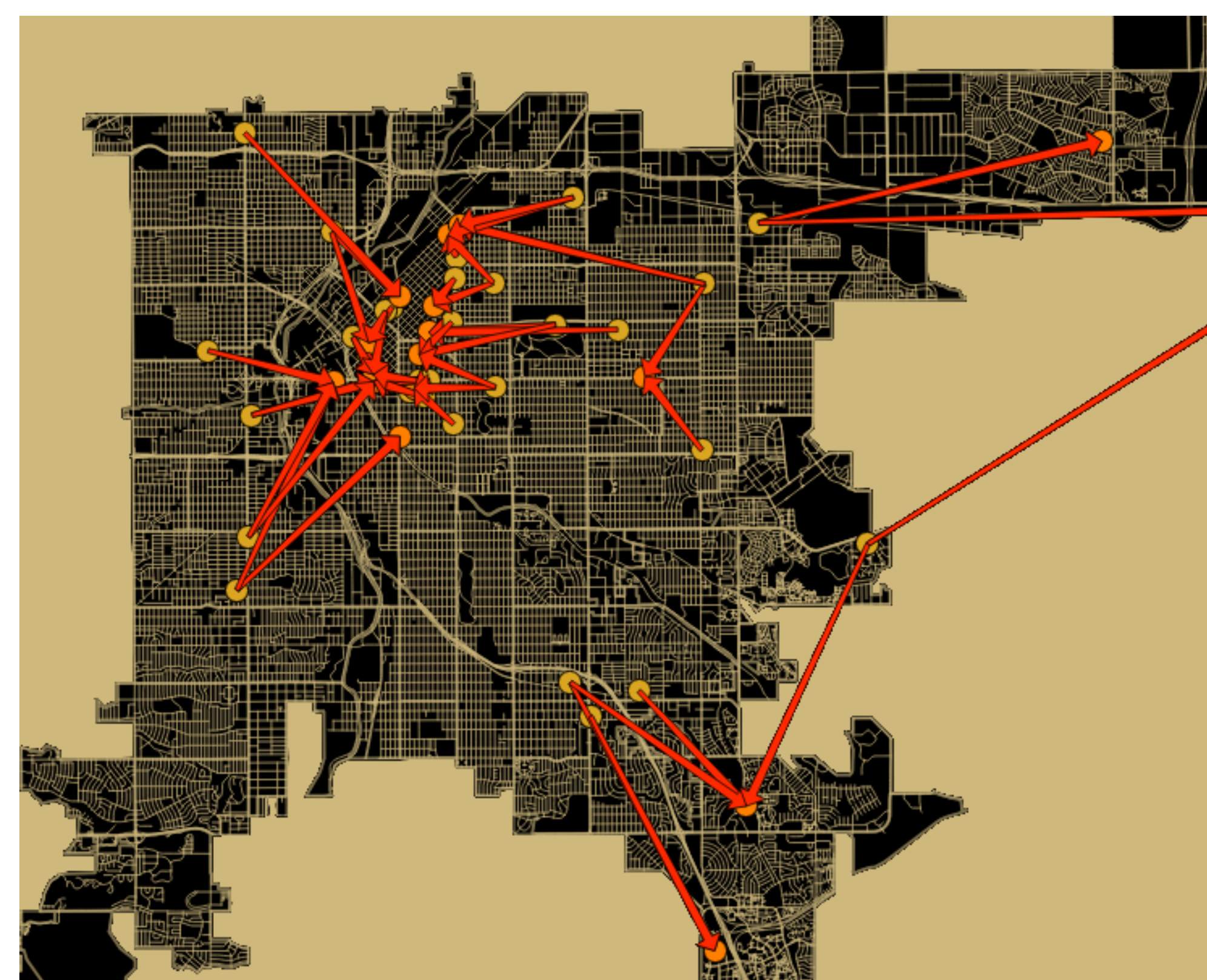$$\sum_{i \in S} \sum_{j \in D} c_{ij} x_{ij}$$

Our constraints are then that the assignments from each origin equal one,

$$\sum_{i \in S} x_{ij} = 1 \qquad \text{For all} \quad i \in S$$

And that the assignments to each destination are equal to the ratio between the number of origins and destinations
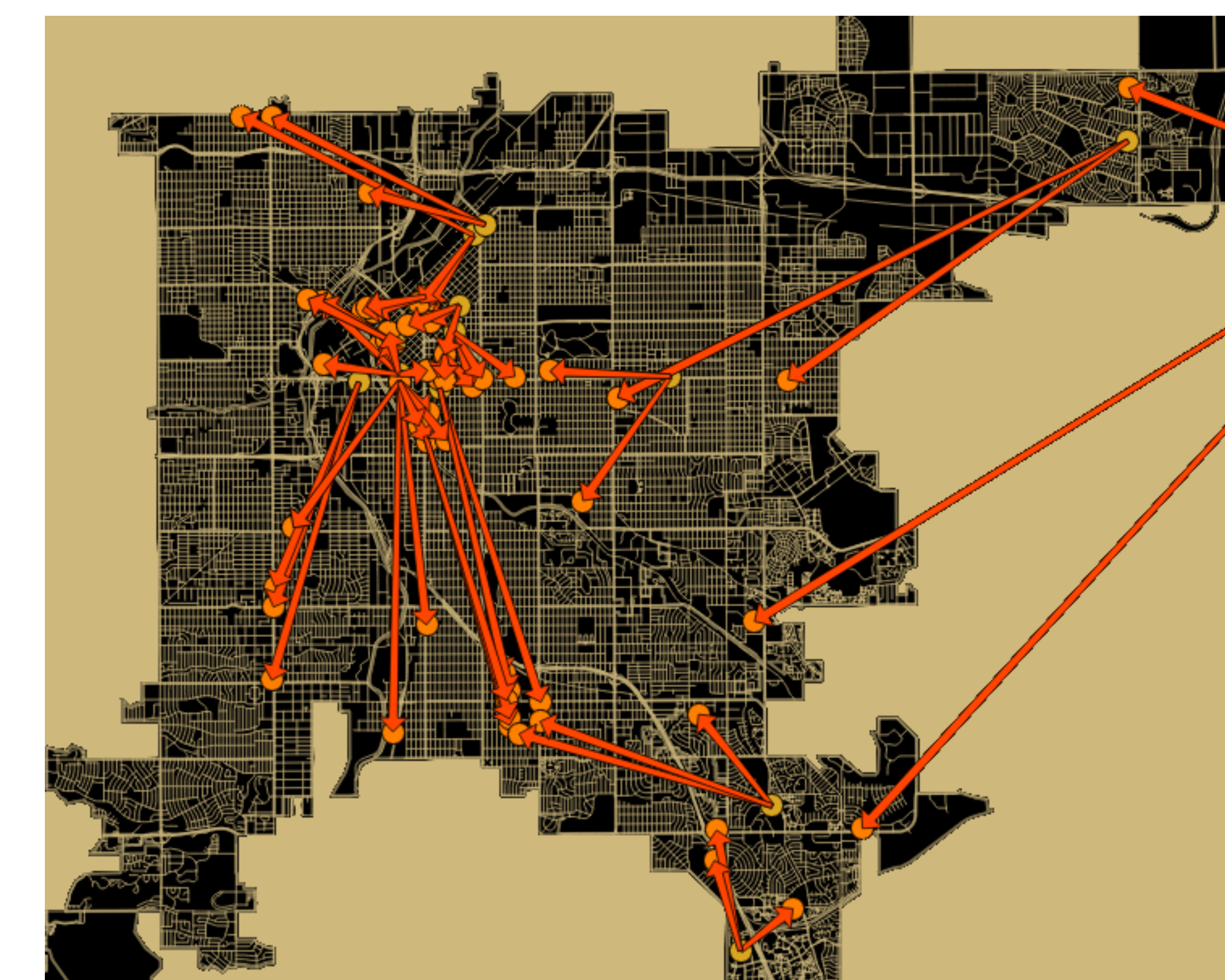
$$\sum_{j \in D} x_{ij} = \frac{n_D}{n_S} \qquad \text{For all} \quad j \in D$$

Case Study 2011-2014

- Yellow dots depict reported crimes 2011 and orange dots depict crimes in 2014.

- Bias motivated crime was high at the beginning of the decade but declined over the next several years

- Reported hate crimes were scattered throughout the city in 2011, often occurring near major roadways

- In 2014, we see hate crime condensing into downtown with isolated incidents in less travelled areas

- Hate crimes in Five Points and North Capitol Hill moved onto side streets in 2014
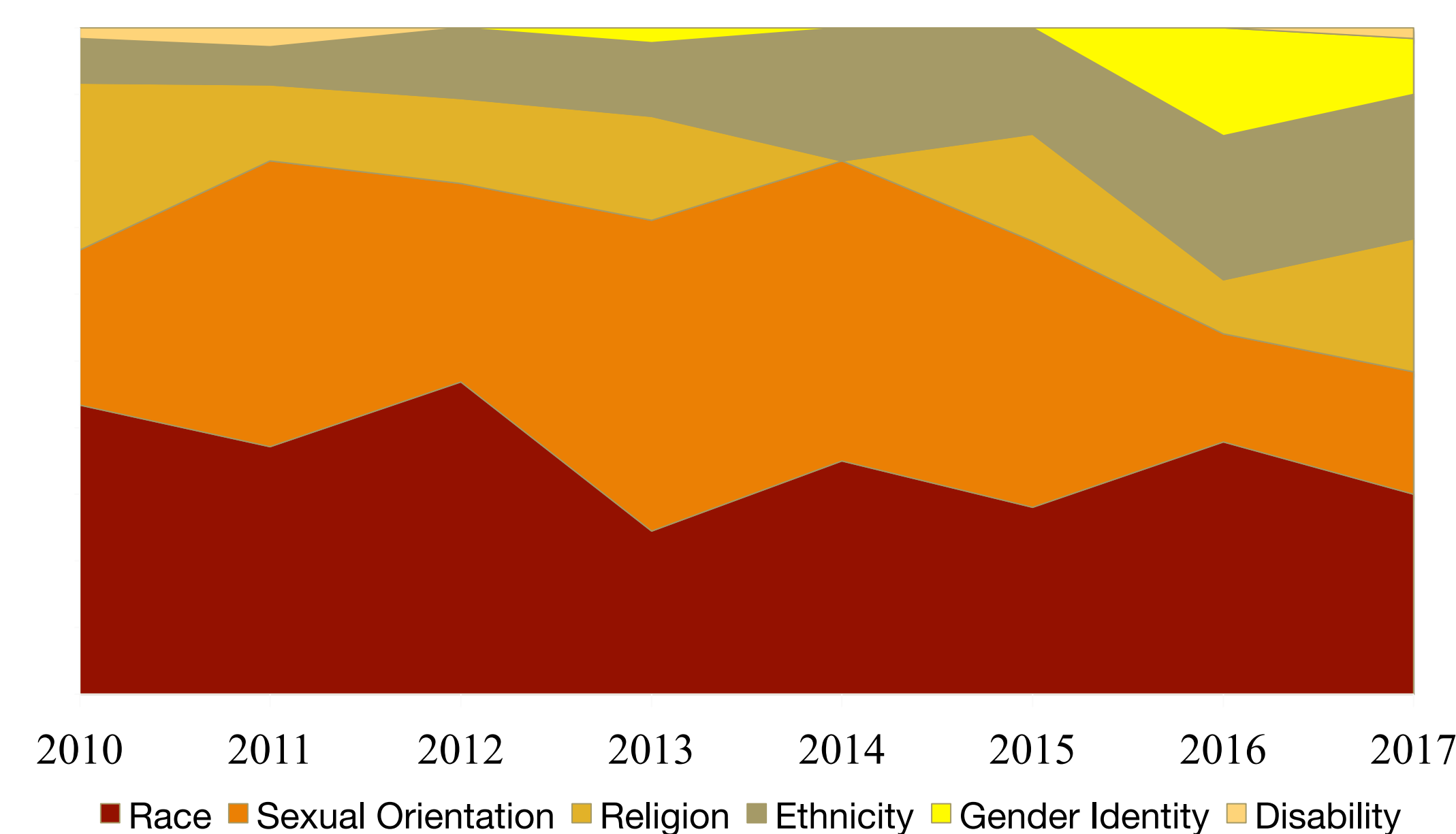
Case Study 2014-2017

- Yellow dots depict reported crimes in 2014 and orange dots depict crimes in 2017.

- In 2016-2017 reported hate crimes increased across the city

- New hot spots developed in 2017, including Hampden and the neighborhoods near Ruby Hill

- Denver University is a hot spot with numerous reports of anti-Jewish activities

- Hate crimes remain in Downtown but now center on Union Station and Arapahoe

- The increase in 2017 seems to be primarily driven by increased reports of criminal mischief

Percentage Reported Hate Crimes in Denver by Social Bias Type

- The percentage makeup of bias motivated crime in Denver tends to be much lower than the national average for crimes against race and religion

- Denver tends to report a higher percentage of crimes related to sexual orientation than the national average

- Since 2010, crimes related to ethnicity have increased in Denver, exceeding the national average

- Denver has seen a dramatic increase in crimes related to gender identity in 2016-17

Primary References

- www.DenverGov.org/opendata

- Ucr.fbi.gov/hate-crime

- Luenberger, D.G. and Ye, Y. 1973. *Linear and Nonlinear Programming*. Springer.

For Further Information
Please contact Kathleen Gatliffe:
kathleen.e.gatliffe@ucdenver.edu