Population projections

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June 28, 2021

Population projections

- Estimates of future population size for a specified area
- Reflects assumptions about how population expected to change
  - Fertility (births)
  - Mortality (deaths)
  - Migration

Demographic balancing identity

- Accounting for people
- Keeping track of the number of people in a given area

- How do people enter a population?
  - Births, in-migration
- How do people exit a population?
  - Deaths, out-migration

Demographic balancing identity

- How do people enter a population?
  - Births, in-migration
- How do people exit a population?
  - Deaths, out-migration

- Pop at time 2 = Pop at time 1 + Births – Deaths + In-Migration – Out-Migration
  - $P_{t+1} = P_t + B_t - D_t + I_t - E_t$

Example: King County 2020

- Assuming a 2019 start base, how can we estimate the population in King County in 2020?
- Use the balancing identity
- $P_{2020} = P_{2019} + B_{2019} – D_{2019} + I_{2019} – E_{2019}$

- Where can we find these numbers?

Population estimates

- Population estimates available from several sources

- WA Office of Financial Management
  - https://ofm.wa.gov/washington-data-research/population-demographics/population-estimates/estimates-april-1-population-age-sex-race-and-hispanic-origin
- U.S. Census Bureau
  - American Community Survey; Population Estimates Program
  - https://data.census.gov/cedsci/

Vital statistics

- Government agencies usually maintain vital statistics / vital records
  - Births
  - Deaths

- WA State Department of Health
  - https://www.doh.wa.gov/DataandStatisticalReports/HealthDataVisualization/BirthDashboards/AllBirthsCounty
  - https://www.doh.wa.gov/DataandStatisticalReports/HealthDataVisualization/MortalityDashboards/AllDeathsDashboard

Migration data

- Migration?
- Counting the number of people that move in or out of an area is ***hard***

- WA Office of Financial Management provides rough estimates of net migration
  - Net migration = In-migration – Out-migration
  - https://ofm.wa.gov/washington-data-research/population-demographics/population-estimates/components-population-change

Cohort Component Method

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Cohorts

- Cohort = a group of people that share some defining demographic characteristic
  - For instance: birth year, year entered college/grad school, etc.

Cohort component method

- Used to produce population projections by age groups, sex, other groupings
- Divide the total population into cohorts (age, sex)
- Apply the demographic balancing identity to each cohort

- Primary way of producing population projections

Applying the cohort component method

- Requires having detailed information on populations by age, sex, other demographic and spatial details
  - Need to divide the total population into cohorts

- Births, deaths, and net migration data from WA Dept of Health, Office of Financial Management are for total population at county level
- What about for more detailed, granular geographic areas? Or for specific population subgroups?

Applying the cohort component method

- Wanted: detailed information on populations by age, sex, other demographic and spatial details

- Are there other data sources that might have population information?
- Alternatively, can you think of some other way to estimate births, deaths, and net migrants without having exact data?

Hamilton-Perry Method

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Let’s go back to the balancing identity

- Population change = Births – Deaths + Net migration

- In terms of age cohorts: births correspond to just one group of individuals (age 0)
- Deaths, migration happen at all ages, but are more prevalent at some ages than others
  - Older adults at higher risks of dying
  - Young adults may be more likely to move (school, career, etc)
- Can we make use of this observation?

Hamilton-Perry Method

- Population change = Births – Deaths + Net migration
- Population change = Births + (– Deaths + Net migration)

- Population change can be captured using change ratios
- Ratio involving births
- Ratio involving net change in population size from deaths and migration

Reference: Hamilton, C. Horace and Josef Perry. 1962. A short method for projecting population by age from one decennial census to another. Social Forces 41(2), 163-170.

Hamilton-Perry Method

- Two primary components
- Child woman ratio (CWR)
  - Fertility
- Cohort change ratio (CCR)
  - Mortality
  - Net migration

- Requires data from two time points

Child Woman Ratio (CWR)

- Proxy for fertility (number of births) and infant survival
- Estimate the size of the child population given the population of women of childbearing ages (15-45)

- For example: CWR = ${}_5P_{0,\ 2015} / {}_{30}FP_{15,\ 2015}$
- ${}_5P_{0,2015}$ = the count of the population aged 0-5 in 2015
- ${}_{30}FP_{15,2015}$ = female population aged 15-45 in 2015

Child Woman Ratio (CWR)

- CWR = $_5P_{0,\ 2015} / {}_{30}FP_{15,\ 2015}$
- $_5P_{0,2015}$ = the count of the population aged 0-5 in 2015
- $_{30}FP_{15,2015}$ = female population aged 15-45 in 2015

- Ratio of children age 0-5 to the female population of childbearing ages
- Calculated separately for male and female children

Cohort Change Ratio (CCR)

- Captures the change in population size of specified cohort from one period to the next

- For example: ${}_5CCR_{20} = {}_5P_{25,2015} / {}_5P_{20,2010}$
- ${}_5CCR_{20}$ = ratio of change for the cohort of 20-24-year-olds
- ${}_5P_{20,2010}$ = population of 20-24-year-olds in 2010
- ${}_5P_{25,2015}$ = population of 25-29-year-olds in 2015

Cohort Change Ratio (CCR)

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- $_5P_{20,2010}$ = population of 20-24-year-olds in 2010
- $_5P_{25,2015}$ = population of 25-29-year-olds in 2015

- Ratio of change in size of the population (cohort) aged 20-24, over a 5-year period, when they will have aged to be 25-29

Cohort Change Ratio (CCR)

- Captures the net effects of mortality and migration without having detailed migration and mortality data

- CCR < 1: population has shrunk during the time period through mortality and/or out-migration
- CCR > 1: population has grown through in-migration

- Calculated for each age group, and separately for males and females

Data + Methods

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King County population data

- With the Hamilton-Perry Method, only need population counts at two time points to construct CCRs and CWRs

- WA Office of Financial Management (OFM) provides population estimates for different geographic levels
  - Geographic areas: state, county, census tract
  - Demographic details: age, sex, race and ethnicity, Hispanic origin
  - https://ofm.wa.gov/washington-data-research/population-demographics/population-estimates/estimates-april-1-population-age-sex-race-and-hispanic-origin

Using the Hamilton-Perry Method for projections

- How good is this approximation?
- What assumptions does this method make about population change?

- Population change remains constant throughout projection period
- Method may be fine for areas experiencing stable dynamics
- What about places that have been experiencing considerable growth or decline during the time interval?
- Change ratios would suggest continuous growth or decline

Population change over the time interval

- Assumption: population change expected to be constant over time

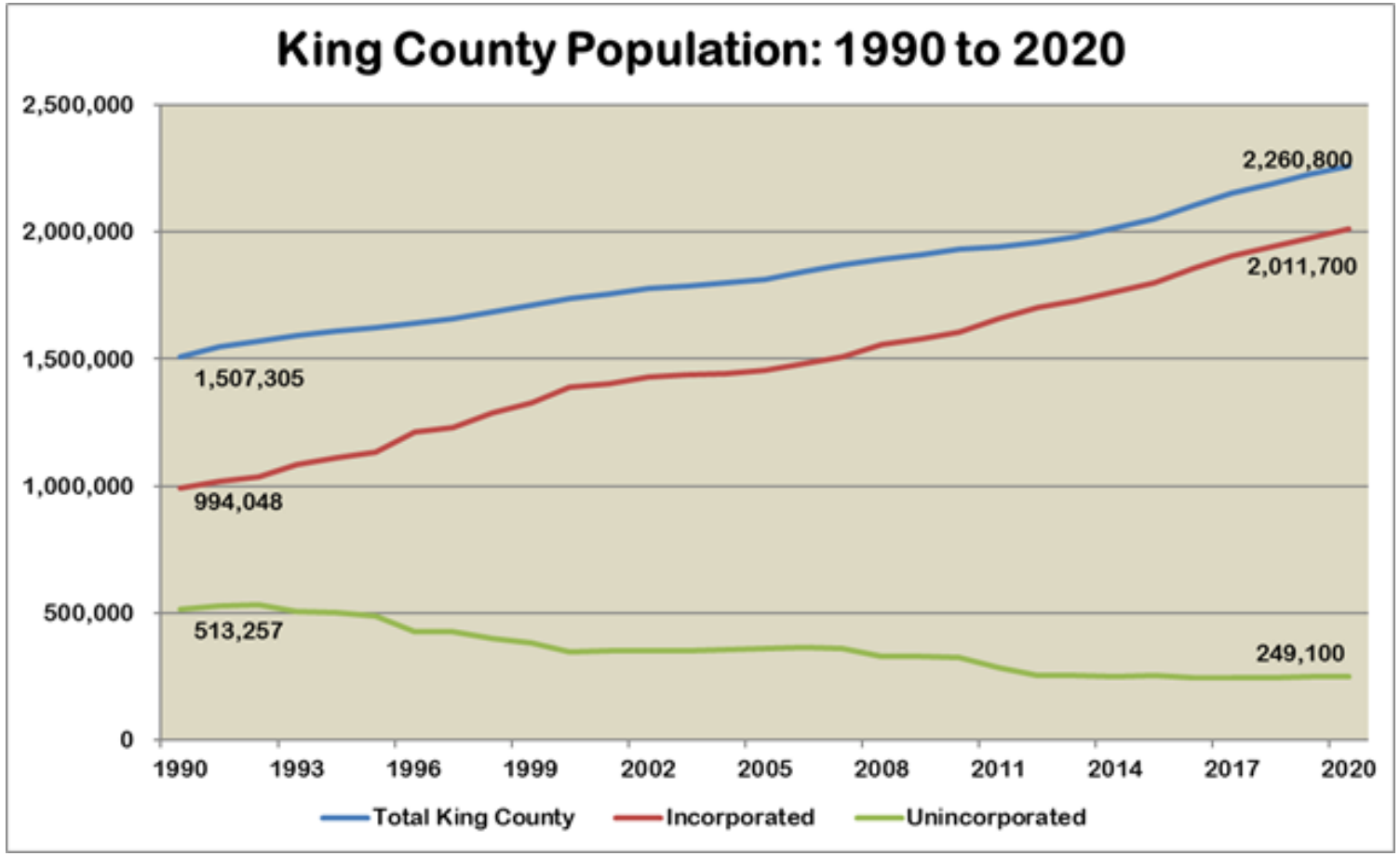
- For areas that have recently experienced considerable growth, the cohort change ratio will be greater than 1
- This growth rate is assumed to remain in place for the entire projection period
- Is this a realistic assumption?
  - Physical constraints such as housing availability, employment, etc
  - Will there be sustained in-migration?

Population change over the time interval

- Assumption: population change expected to be constant over time

- For areas that have recently experienced population decline, the cohort change ratio will be less than 1
- Population assumed to continue to decline in size for entire projection period
- Is this a realistic assumption?

Population change in King County



- Positive growth, meaning the CCR for the county is greater than 1
- Can we expect continued growth beyond 2020? At what rate?
- Reliability of projections made using Hamilton-Perry Method for King County?

Source: King County Office of Economic and Financial Analysis
https://kingcounty.gov/independent/forecasting/King%20County%20Economic%20Indicators/KC%20Population.aspx

Can the Hamilton-Perry Method be applied to King County?

- Using the Hamilton-Perry Method to produce population projections might not be a good idea for areas that have experienced considerable population growth over the observation period
- CCR, CWR to remain the same over the projection period

- In the case of King County, can predict continuous, runaway growth
- This might not be realistic

Smoothing

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Spatial distribution of population

- Population isn't evenly distributed by age, sex, race/ethnicity over space
  - U-District is mostly populated by college-aged individuals
  - Retirement communities, nursing facilities
  - Family friendly communities
  - Prisons
  - Racial/ethnic clusters as historical legacy of redlining, zoning laws, etc
- Subpopulations and small areas might grow at different rates

Smoothing

- Build on the idea that areas near each other are usually more similar than other areas located farther away
- Similarly, subpopulations tend to be distinctive

- Statistically account for outliers (potential runaway growth)
- Find underlying pattern without being influenced by outliers and other noise

Incorporating a smoothing process

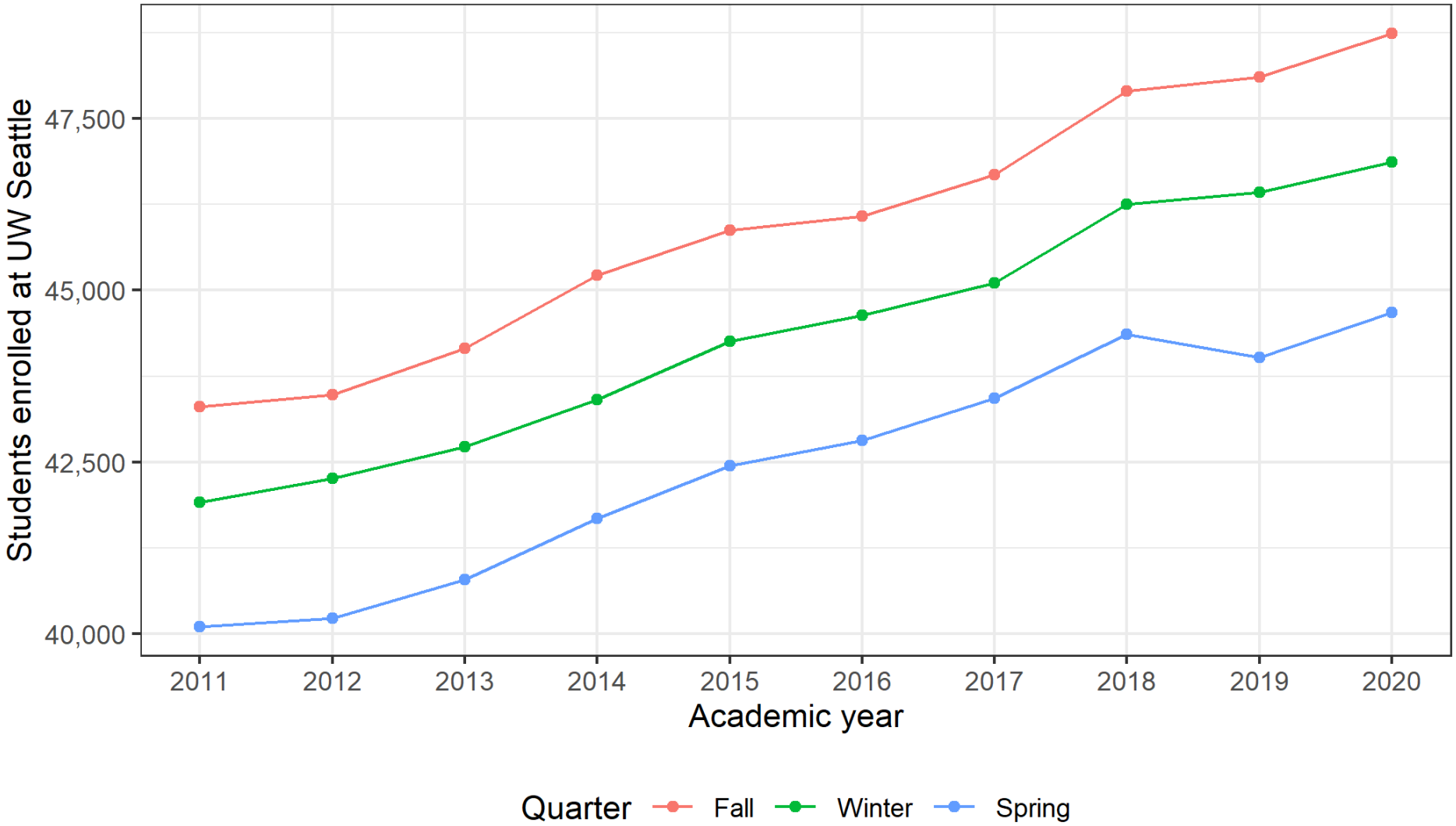
- Including a smoothing process to account for spatial differences and differential growth patterns
- Smooth group specific estimates of ratios to total population ratio

- This is done for all CCRs and CWRs
- Two stages: to account for race and ethnicity and geography

How well does smoothing work?

- Works well for most areas in King County
- However, the U-District required special attention because of its large student population
- Increased enrollment numbers at UW
  - For the U-District, CCRs > 1
- Even with smoothing, projected population was large, with odd age structure
- However, UW student population size regulated by university administrative policies

UW Seattle campus enrollment has increased



Source: https://www.washington.edu/opb/uw-data/uw-profiles-information/public-profiles-headcount-enrollment-trends/

Applied Research Fellowship 2020 Project

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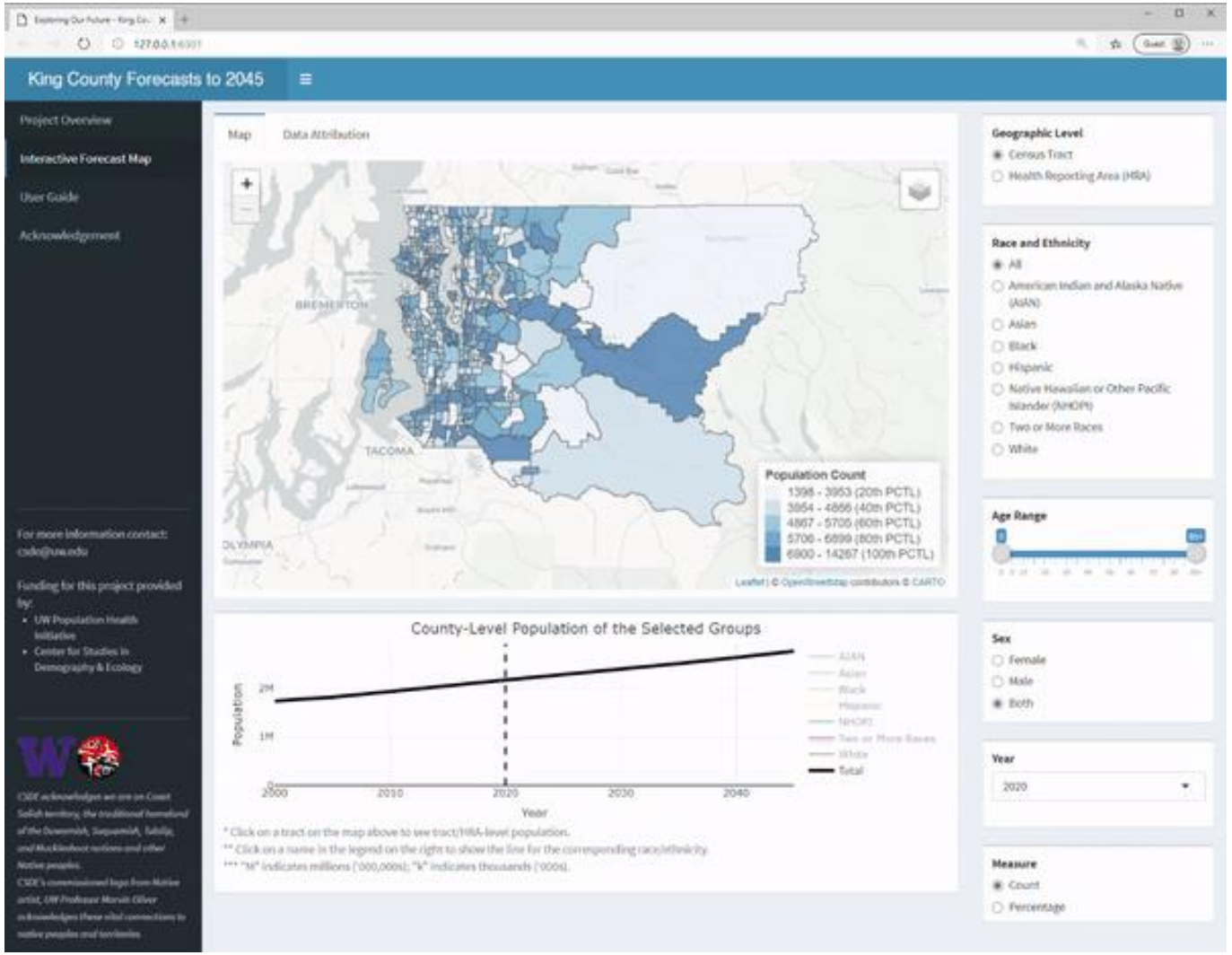
PHI 2020

- Goal: population projections with age, sex, race and ethnicity detail at the census tract level for King County

- Input data: OFM's population estimates at the census tract level
- Calculate and use smoothed tract level CCRs and CWRs to produce tract level population projections

- http://population-dynamics-lab.csde.washington.edu:8080/kc_forecast_2045/

PHI 2020 visualization tool



> **Explore By:**
  - Census-designated race and ethnicity
  - Age range of interest
  - Sex
  - Year
  - Count or Percentage

> **Overlay with:**
  - Public Health clinics
  - Community health centers
  - Public transportation hubs
  - Schools

Validation

- Validated our results using existing population projections by OFM and regional planning agency

- Aggregating tract-level projections to obtain county totals, our estimates fall between existing projected totals

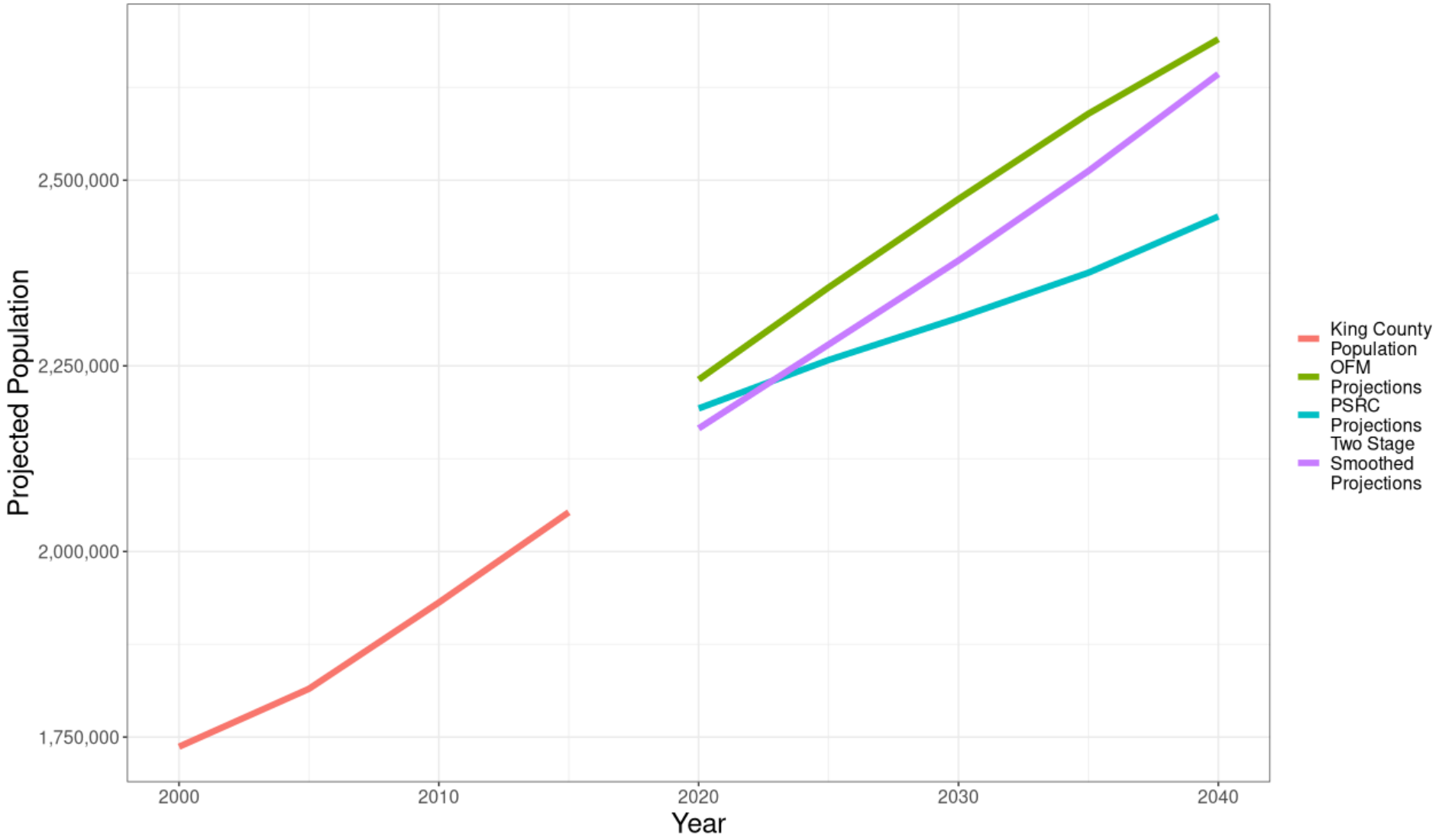
Validation data

- OFM provides **county**-level population projections with age and sex details
- Produced using a cohort component method
  - https://ofm.wa.gov/washington-data-research/population-demographics/population-forecasts-and-projections/growth-management-act-county-projections

Validation data

- Puget Sound Regional Council (PSRC) provides **tract**-level population projections, population totals only
- Produced using an econometric approach
- Projections are currently being revised and not publicly available
  - https://www.psrc.org/projections-cities-and-other-places

Validation results



Things to consider

- Accounting for
  - spatial differences
  - group differences
  - changing patterns over time
  - differential effects
  - demographic composition
  - land use and zoning legacies
  - group quarters
  - uncertainty
- Data availability

Questions?

Thanks for your attention!

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References

- **Hamilton, C. Horace and Josef Perry. 1962. A short method for projecting population by age from one decennial census to another. Social Forces 41(2), 163-170.**
- **Inoue, Takashi. 2017. A new method for estimating small area demographics and its application to long-term population projection. In D. Swanson (Ed.) The frontiers of applied demography, pp. 473-489). New York, NY: Springer.**
- **Swanson, David A., Alan Schlottmann, and Bob Schmidt. 2010. Forecasting the Population of Census Tracts by Age and Sex: An Example of the Hamilton-Perry Method in Action. Population Research and Policy Review, 29(1), 47-63.**
- Preston, Samuel H., Patrick Heuveline, and Michel Guillot. 2001. *Demography: Measuring and Modeling Population Processes*. Oxford, GB: Blackwell Publishers.
- Wachter, Kenneth W. 2014. *Essential Demographic Methods*. Cambridge, MA: Harvard University Press.