Description of the FREM approach

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Introduction

The following reflects my current understanding of the Future Roadkill Estimation Approach (FREM) adopted in 2018 by staff at the U.S. Fish and Wildlife Service (US FWS) South Florida Ecological Services Field Office. The approach uses a simple formula to predict future PVM over a 5-year period for an individual road segment using a past 5-year PVM, the reported AADT value for the midpoint year, and a future year's AADT projected by FDOT traffic models. The goal of this document is to increase transparency of the method by making mathematical definitions, details, and assumptions of the appraoch explicit.

Key information about inputs:

- The predictions are obtained at the level of each road segment and then summed over all road segments to be included in a larger regional prediction.
- AADT = annual average daily traffic is a common measure of traffic volume. As indicated in the name, it is meant to summarize yearly traffic volume while aggregating over within year changes (diurnal, daily, seasonal, etc.). AADT can be estimated or calculated based on data collected at monitoring stations and/or FDOT traffic modeling. Uncertainty in an estimate is expected to depend on methods used to obtain it. AADT values for the future are obtained as predictions from FDOT traffic models.
- Sources of uncertainty in estimated AADT and projected AADT are not quantified or discussed qualitatively.
- A 5-year average PVM is used as a baseline to predict an annual average PVM for a future year, by assuming the ratio of past to future 5-year PVM is equal to the ratio of past to future AADT values.
- As part of FDOT modeling of future AADT, attributions of future AADT for a road segment to a particular development included in the model is also provided. These proportions of future AADT attributed to a particular development are then translated directly into a proportion of future PVM through the FREM formula
- Predictions are made for road segments of interest with at least one PVM since year 1971. Given the FREM formula, any road segment with a baseline 5-year average of 0 PVM will have a prediction of 0 PVM in the future regardless of the projected increase in AADT.

Notation and definitions

Define quantities

$AADT_{j,t}$ = estimated AADT on road segment j in year t in the past

$\widehat{AADT}_{j,t}$ = predicted AADT on road segment j for year t in the future

$PVM_{j,[t_1,t_2]}$ = total observed PVM on road segment j over time period from year t_1 to year t_2 (inclusive)

$\widehat{PVM}_{j,[t_3,t_4]}$ = total predicted PVM on road segment j over time period from year t_3 to year t_4 (inclusive)

$\overline{PVM}_{j,[t_1,t_2]}$ = average annual PVM on road segment j over time period from year t_1 to year t_2 (inclusive)

$\widehat{\overline{PVM}}_{j,[t_3,t_4]}$ = predicted average annual PVM on road segment j over time period from year t_3 to year t_4 (inclusive)

The formula

Future 5 year annual average PVMs are predicted based on the assumption that the ratio of a projected future year's AADT to a past year's AADT is equal to the ratio of a future 5-year PVM (average or total) to a past 5-year PVM (average or total), where the year associated with the AADT is the midpoint year of the 5-year period. Using the proportional relationship, the future 5-year PVM is solved for given values of the other three quantities.

For example, for the ECMSHCP analysis, a prediction was desired for year 2060. The baseline period used for PVM was the 5-year period from beginning of March 2014 through end of February 2019, and the past AADT was taken from 2017. The predicted 5-year annual average PVM technically applies to beginning of March 2057 through end of February 2062.

The formula for road segment j, assuming t_0 is the midpoint of the baseline 5-year time interval (e.g., 2017 in the previous example) and t_f is the midpoint of the future 5-year time interval.

$$\widehat{\overline{PVM}}_{j,[t_f-2,t_f+2]} = \overline{PVM}_{j,[t_0-2,t_0+2]} \times \frac{\widehat{AADT}_{j,t_f}}{AADT_{j,t_0}}$$

To obtain a predicted PVM for a collection of J total road segments in region of interest (region), the individual segment predictions are summed:

$$\widehat{\overline{PVM}}_{region,[t_f-2,t_f+2]} = \sum_{j=1}^{J} \widehat{\overline{PVM}}_{j,[t_f-2,\ t_f+2]}$$

Accounting for contribution from specific development

Based on FDOT projections of AADT, percent contribution of projected AADT for each road segment attributed to a particular development is also modeled. Continuing with the assumption of a direct proportional relationship between AADT changes and changes in PVM, the fraction of AADT attributed to a potential development is then taken as the fraction of future PVM for each segment attributed to the potential development. The percent attribution varies by road segment and therefore the attribution calculation for 5-year average PVM is performed at the level of the individual road segment before aggregating to a regional prediction.

The percent of projected 2060 Total AADT for segment j in year t attributed by the FDOT traffic model to development k is denoted

$$prop\widehat{AADT}_{k,j,t}$$

The predicted 5 year annual average PVM for segment j attributed to potential development k is calculated as:

$$\widehat{\overline{PVM}}_{k,j,[t_f-2,t_f+2]} = \overline{PVM}_{j,[t_0-2,t_0+2]} \times \frac{\widehat{AADT}_{j,t_f}}{AADT_{j,t_0}} \times prop\widehat{AADT}_{k,j,t_f}$$

The individual segment predictions are then summed, as described above before accounting for attribution to a development.

For a segment, the predicted 5-year average PVM attributed to development k plus the predicted 5-year average PVM *not* attributed to development k is equal to the future predicted 5-year average PVM provided previously.