

Yearly trends

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Yearly trends in peep population

The original Canham et al. (2021) paper provided yearly population trends of WESA and DUNL at Brunswick Point. These same population trends are extended here with 2020-2022 data, using the same population models derived in the original paper (i.e., no north vs. south component). Values represent population indices (with 95% confidence intervals) calculated as predicted values for each year from final models for each species, with independent variables held at median values for each year. Daily total counts (not broken down by survey station) are used as the data for this model.

WESA model:

$$\log(WESA) \sim year + dos + I(dos^2) + scale(elev.range) + scale(flow) + scale(u) + (dos + I(dos^2)|year)$$

DUNL model:

$$\log(DUNL) \sim year + dos + I(dos^2) + scale(elev.range) + scale(flow) + scale(u) + (dos + I(dos^2)|year)$$

WESA population trend

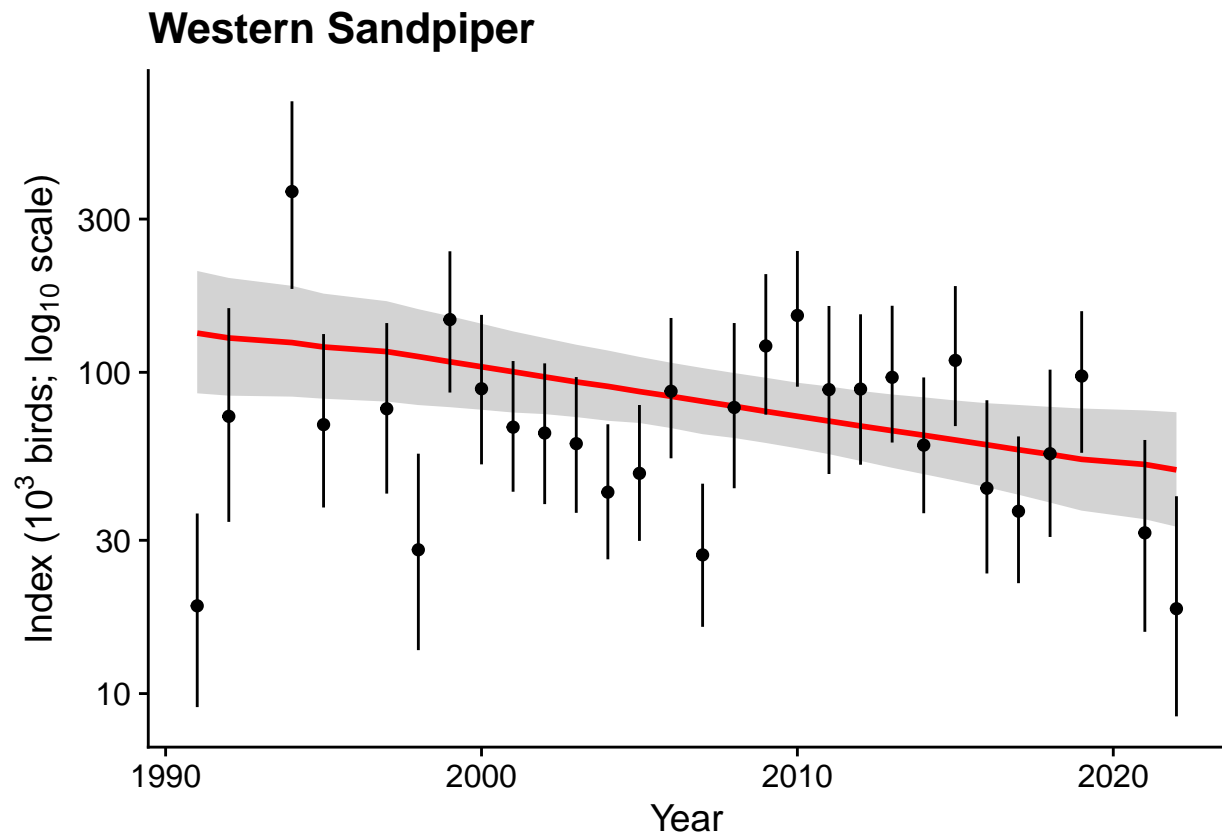
Western sandpiper populations continue to show yearly declines in population. Since 1991, western sandpiper populations have fallen by 62.5% (-2.2% per annum). In the last ten years the rate of decline has slowed. Since 2012, western sandpiper populations have fallen by 27% (-0.9% per annum).

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## log_wesa ~ year_c + dos + I(dos^2) + scale(elev_range) + scale(flow) +
##       scale(u) + (dos + I(dos^2) | year)
##   Data: dt
## Control: lme4::lmerControl(optimizer = "bobyqa")
##
## REML criterion at convergence: 1368.8
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -5.5659 -0.3638  0.0501  0.4639  2.9835
##
## Random effects:
##   Groups   Name                Variance Std.Dev. Corr
##   year     (Intercept)  0.3168   0.5628
##           dos          0.3875   0.6225   0.19
##           I(dos^2)     0.3256   0.5706  -0.36  0.13
```

```

## Residual          0.5649   0.7516
## Number of obs: 513, groups: year, 29
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   11.25963   0.11695  21.05803  96.280 < 2e-16 ***
## year_c        -0.26055   0.09608  25.58475  -2.712  0.01179 *
## dos           -0.35263   0.14122  35.73022  -2.497  0.01727 *
## I(dos^2)       -1.61297   0.11568  24.63154 -13.944 3.44e-13 ***
## scale(elev_range) -0.12398  0.03965 462.70123  -3.127  0.00188 **
## scale(flow)     -0.19699  0.09291 119.65754  -2.120  0.03605 *
## scale(u)         0.07340  0.03698 443.55600   1.985  0.04776 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) year_c dos      I(d^2) scl(_) scl(f)
## year_c         0.033
## dos            0.170 -0.027
## I(dos^2)       -0.409 -0.003  0.065
## scl(lv_rng)   -0.015 -0.014 -0.049  0.009
## scale(flow)   -0.081  0.110 -0.455  0.043  0.061
## scale(u)      -0.005 -0.003 -0.003  0.002 -0.077  0.068

```



DUNL population trend

As in the original Canham paper, however, **year** remains insignificant in the DUNL model.

Pacific Dunlin populations continue to show yearly declines in population, though the trend is not statistically significant. Since 1991, Pacific Dunline populations have fallen by 32.4% (-1.1% per annum). In the last ten years the rate of decline has slowed. Since 2012, Pacific Dunline populations have fallen by 11.8% (-0.4% per annum).

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## log_dunl ~ year_c + dos + I(dos^2) + scale(elev_range) + scale(flow) +
##       scale(u) + (dos + I(dos^2) | year)
## Data: dt
## Control: lme4::lmerControl(optimizer = "bobyqa")
##
## REML criterion at convergence: 1342.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -5.9607 -0.3995  0.0388  0.4567  2.9302
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## year (Intercept) 0.3471 0.5892
## dos 0.4707 0.6861 0.00
## I(dos^2) 0.4234 0.6507 -0.69 0.18
## Residual 0.5294 0.7276
## Number of obs: 513, groups: year, 29
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 9.26902 0.12062 23.85827 76.848 < 2e-16 ***
## year_c -0.10402 0.08158 28.01040 -1.275 0.212745
## dos -1.32980 0.14952 35.69018 -8.894 1.39e-10 ***
## I(dos^2) -0.72078 0.12913 25.60351 -5.582 7.68e-06 ***
## scale(elev_range) -0.12978 0.03863 459.69967 -3.360 0.000845 ***
## scale(flow) -0.24995 0.08684 102.81184 -2.878 0.004863 **
## scale(u) 0.07435 0.03575 446.20883 2.080 0.038119 *
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr) year_c dos I(d^2) scl( ) scl(f)
## year_c 0.026
## dos 0.026 -0.020
## I(dos^2) -0.679 -0.010 0.122
## scl(lv_rng) -0.016 -0.003 -0.050 0.007
## scale(flow) -0.073 0.103 -0.414 0.038 0.075
## scale(u) -0.004 -0.006 0.003 0.002 -0.077 0.058
```

