Weather Severity Indices For Projecting Changes in Autumn-Winter Distributions of Dabbling Ducks in the Mississippi and Atlantic Flyways During the 21st Century
Co-authors: Michael Notaro et al., Lena Van Den Elsen, John Coluccy, Michael Mitchell, and Robb Mcleod; Additional Co-PIs: Judah Cohen, Rick Kaminski, Charles Wax, Mike Brown, Andrew Raedeke, and David Graber

FUNDING AND SUPPORT

Gulf Coastal Plains and Ozarks LCC

ADDITIONAL SUPPORT

National Science Foundation
NOAA
Western Science
Mississippi State University
Waterfowl are ecologically, environmentally, culturally, and economically important.

**Ecologically**
- Cultural symbols
- Decoys as art
- Waterfowl enthusiasts

**Environmentally**

**Culturally**
- Cultural symbols
- Decoys as art
- Waterfowl enthusiasts

**Economically**
- 47M birders spend $41B/year
- 1.5M waterfowl hunters spend $1.4B/year
- Economic impact in MS is $86.6M/year
- AR, LA, MS Duck Stamps ~$2.3M/year
Where have all the ducks gone?

‘Southerners’ singing the duck day blues....
Where have all the ducks gone?

‘Southerners’ singing the duck day blues….

Black duck winter distribution change
    Brooks et al. 2007
Changes in duck abundance in the
    Mississippi Alluvial Valley
    Reinecke et al. 2006
Where have all the mallards gone?
    Kaminski et al. 2005
Objectives
(completed objectives in bold)

1/ Develop Weather Severity Indices (WSIs) that reasonably predict autumn-winter migration by dabbling ducks (Schummer et al. 2010 JWM, Van Den Elsen 2016 MS Thesis)

2/ Describe historic changes to weather known to influence duck migration (Schummer et al. 2014 Wildfowl, Schummer et al. In Review WSB)

3/ Provide an open-access web-based tool to query WSI data (Schummer et al. In Review WSB)

4/ Estimate how WSI influences waterfowl enthusiast (birders and hunters) participation and satisfaction to forecast economic impact of climate change

5/ Forecast future spatial distributions of dabbling ducks based on climate change scenarios (Notaro et al. 2016 PLOS ONE)
Completed Objectives

1/ Develop Weather Severity Indices (WSIs) that reasonably predict autumn-winter migration by dabbling ducks (Schummer et al. 2010, Van Den Elsen 2016)
2/ Describe historic changes to weather known to influence duck migration (Schummer et al. 2014, Schummer et al. In Review)
3/ Provide an open-access web-based tool to query WSI data (Schummer et al. In Review)
4/ Estimate how WSI influences waterfowl enthusiast participation and satisfaction to forecast economic impact of climate change

**NE Climate Science Center Funding**

5/ Forecast future spatial distributions of dabbling ducks based on climate change scenarios (Notaro et al. 2016 PLOS ONE)
Development of WSIs

• For Mallards in Missouri, published in 2010 as a Cumulative WSI
• Calculated daily and selected as maximum between two waterfowl surveys
Development of WSIs

- For Mallards, Cumulative WSI

Schummer et al. 2010 JWM
Van Den Elsen 2016 used data across the Mississippi and Atlantic Flyways from 25 locations in the United States and Canada to develop WSIs

Y-axis = rate of change in duck abundance, X-axis = WSI

PC1 and Cumulative WSI
- Temperature
- # days < 0° C
- Snow depth
- # days with > 1” snow

WSIMean
- Mean Temp. between two surveys
- # days < 0° C
- Snow depth
- # days with > 1” snow
Development of Web Application

- Used North American Regional Reanalysis data throughout eastern North America, 1979 – 2013
- 32 km x 32 km resolution
- Provides broad spatial and temporal scales to develop comparisons between WSI and waterfowl populations & waterfowl enthusiast demographics
- Web application, daily September 1979 – April 2013
WSI Web Application Data Query

http://gisweb.ducks.org/wsi/app/
WSI Web Application Data Query

- Available at LCC, JV, Flyway, or State spatial scales
Changes in WSI - Mississippi & Atlantic Flyways 1979 – 2013

- **Oct-Nov-Dec = reduced severity**
  - American wigeon, green-winged teal, northern shoveler

- **Nov-Dec-Jan = reduce severity**
  - Mallard, American black duck, northern pintail

- **Feb-Mar-Apr = reduced severity**
  - mallards, American black ducks, gadwall, American wigeon, green-winged teal, and northern shoveler

**EXAMPLES:**

- **Nov-Dec-Jan**
- **Feb-Mar-Apr**
EXAMPLES: Nov-Dec-Jan for American Black Ducks

3-months > foraging pressure at mid- to northern latitudes in an area about the size of the state of Indiana
Climate Change Models

- Notaro et al., Nelson Institute Center for Climatic Research

- Intergovernmental Panel on Climate Change models are largely based on coarse Global Climate Models (GCMs), too coarse to simulate lake-effect snow

- Lack of quality predictions for snowfall and depth previously hindered our predictions for waterfowl

- Used 6 GCMs (RCP 8.5), dynamically downscaled using high-resolution regional climate model (RCM) to 25-km resolution

- Notaro et al. 2013a, b and Vavrus et al. 2013 substantiated the RCM (i.e., it reasonably simulated the spatial and temporal patterns of snowfall and lake ice in the Great Lakes basin).
Climate Change Models

Produced for 3 periods:
Late 20\textsuperscript{th} (1981-2000),
Mid-21\textsuperscript{st} (2046-2065), and
Late 21\textsuperscript{st} (2081-2100) centuries.

By species and month:
1/ Probability of declining duck abundance (i.e., migration)
2/ % Change in probability of migration
3/ Measures of model agreement (STD)
Projected % Change in Snowfall Within the Great Lakes Region by the Mid- and Late 21\textsuperscript{st} Century

The snow season will be greatly compressed
Example: Northern Shoveler – Great Lakes Basin

Probability of Negative Population Rates / Southward Migration: **Northern Shoveler** (Early Migrants)

Probability of negative population rates in Great Lakes region

- **Probability of migration for northern shoveler in October reduces from 78% during late 20th century to 19% during late 21st century within Great Lakes region.**
Example: Black Duck – Great Lakes Basin

Probability of Negative Population Rates / Southward Migration: **American Black Duck** (Late Migrants)

*Probability of migration by American black ducks in December reduces from 56% during late 20th century to 20% during late 21st century within Great Lakes region.*
Increased use of mid-lats

Increased use of Canada & Great Lakes

Change in Probabilities

Change in Probabilities
<table>
<thead>
<tr>
<th>Duck Species</th>
<th>Mean Migration Date: Late 20th Century</th>
<th>Change: Mid-21st Century Minus Late 20th Century</th>
<th>Change: Late 21st Century Minus Late 20th Century</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Duck</td>
<td>10 Dec (Late Migrant)</td>
<td>+19 days</td>
<td>+33 days, if ever</td>
</tr>
<tr>
<td>Wigeon</td>
<td>16 Oct</td>
<td>+15 days</td>
<td>+27 days</td>
</tr>
<tr>
<td>Gadwall</td>
<td>5 Nov</td>
<td>+13 days</td>
<td>+24 days</td>
</tr>
<tr>
<td>GW Teal</td>
<td>15 Oct</td>
<td>+16 days</td>
<td>+25 days</td>
</tr>
<tr>
<td>Mallard</td>
<td>9 Dec</td>
<td>+19 days</td>
<td>+40 days, if ever</td>
</tr>
<tr>
<td>Pintail</td>
<td>4 Nov</td>
<td>+12 days</td>
<td>+23 days</td>
</tr>
<tr>
<td>Shoveler</td>
<td>2 Oct</td>
<td>+15 days</td>
<td>+29 days</td>
</tr>
<tr>
<td>Duck Species</td>
<td>Mean Migration Date: Late 20th Century</td>
<td>Change: Mid-21st Century Minus Late 20th Century</td>
<td>Change: Late 21st Century Minus Late 20th Century</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------</td>
<td>-------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Black Duck</td>
<td>10 Dec (Late Migrant)</td>
<td>+19 days</td>
<td>+33 days, if ever</td>
</tr>
<tr>
<td>Wigeon</td>
<td>16 Oct</td>
<td>+15 days</td>
<td>+27 days</td>
</tr>
<tr>
<td>Gadwall</td>
<td>5 Nov</td>
<td>+13 days</td>
<td>+24 days</td>
</tr>
<tr>
<td>GW Teal</td>
<td>15 Oct</td>
<td>+16 days</td>
<td>+25 days</td>
</tr>
<tr>
<td>Mallard</td>
<td>9 Dec</td>
<td>+19 days</td>
<td>+40 days, if ever</td>
</tr>
<tr>
<td>Pintail</td>
<td>4 Nov</td>
<td>+12 days</td>
<td>+23 days</td>
</tr>
<tr>
<td>Shoveler</td>
<td>2 Oct</td>
<td>+15 days</td>
<td>+29 days</td>
</tr>
</tbody>
</table>
Climate adaptation recommendations

• Changes in non-breeding habitat needs by latitude
  – Incorporate changes in distributions into NAWMP, revise acres needed by latitude
  – In mid to south latitudes, put emphasis on wintering foraging needs for gadwall (herbivore), American wigeon (herbivore), green-winged teal (small natural seeds), and northern shoveler (carnivore) rather than mallards.
Understanding Economic Impacts

• Forecast future waterfowl enthusiast participation (birders and hunters) among latitudes based on climate change scenarios
Thank you

Contact information

michael.schummer@oswego.edu

585-319-6763

http://gisweb.ducks.org/wsi/app/