“Obtaining Reliable Estimates of Duck-use Days”

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Lecture Structure

I. North American Waterfowl Management Plan
II. Duck-use Days
III. Estimating Food Resources
IV. Research Needs

Flyways and Waterfowl Trends

Flyways:
• Atlantic
• Central
• Mississippi
• Pacific

Declines:
• 1985 Reached All-time Low in Recent Years
North American Waterfowl Management Plan

United States, Canada, Mexico

Strategy to restore continental waterfowl populations to benchmark levels in the 1970s.

Achieved:
Protection, Restoration, and Enhancement

Implemented:
Joint Ventures
(Lower MS Valley)

Quantity and Quality of Waterfowl Habitat

Waterfowl Foraging Carrying Capacity

Duck-use Days
(Reinecke et al. 1989)

The number of waterfowl that can be sustained in a given area for a given amount of time.

Carrying Capacity =

\[
\text{DUD}_{\text{cropland}} + \text{DUD}_{\text{moist-soil wetlands}} + \text{DUD}_{\text{hardwood bottomlands}}
\]

1 DUD = quantity of food necessary to feed 1 duck for 1 day

Habitat Specific Carrying Capacity

(e.g., Cropland)

\[
\text{DUD}_{\text{cropland}} = \text{DUD}_{\text{seeds}} + \text{DUD}_{\text{invertebrates}} + \text{DUD}_{\text{Echinochloa crusgalli var. frumentacea}}
\]
**Quantifying Duck Use-Days**

Prince 1979
Reinecke et al. 1989
Reinecke and Loesch 1996

\[
\text{DUD} = \frac{\text{Food Available (g [dry])} \times \text{TME (kcal/g [dry])}}{\text{Daily Energy Requirement (kcal/day)}}
\]

<table>
<thead>
<tr>
<th>Available Food for Waterfowl</th>
<th>TME Constants</th>
<th>DER Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moist-soil Seeds</td>
<td>User but see handout</td>
<td></td>
</tr>
<tr>
<td>Aquatic Invertebrates</td>
<td>2.5 kcal/g</td>
<td>3.5 kcal/g</td>
</tr>
<tr>
<td></td>
<td>292 kcal/day</td>
<td></td>
</tr>
</tbody>
</table>

**Why Estimate Duck-use days?**

- To Determine if Sufficient Food Resources Exist on Migrating & Wintering Grounds to Support Continental Waterfowl Populations

- To Determine Refuge or Management Area Contributions to Fulfilling Continental Goals of NAWMP State & Regional Objectives

For Example, 13.3 million DUDs = 121,000 ducks for 110 days

- To Evaluate Management Practices

**Annual Duck-use day Estimates**

**NAWMP Goals**

**Existing Population Levels**

**Support?**

**Adjust Management**

**State Duck-use Days**

Compile (Migratory Bird Field Office)

Refuges, WMAs (and private lands)

**How do we obtain reliable estimates?**

- Seeds
- Inverts

**BOTTOM LINE**

We need reliable estimates of food production!!

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How do we obtain reliable estimates?

- Seeds
- Inverts
Quantifying Available Food

3 Methods:

1) "Constants"
   - An estimate of mass from previous direct sampling or published yields (i.e., crops).

2) Direct Estimate
   - An estimate of mass from current direct sampling in your wetland or ag areas.

3) Prediction Models
   - An estimate of mass from current indirect sampling in your wetland or ag areas.

Commonly Used "Constants"

Seed:

<table>
<thead>
<tr>
<th></th>
<th>TME</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>kcal/g</td>
<td></td>
</tr>
<tr>
<td>Croplands</td>
<td>(00)</td>
<td>140-223</td>
<td>3.34</td>
</tr>
<tr>
<td></td>
<td>(Post-harvest)</td>
<td>148-436</td>
<td>3.50</td>
</tr>
<tr>
<td>Moist-soil Wetlands</td>
<td>Rice</td>
<td>450</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>(Senescence)</td>
<td>(100-600)</td>
<td></td>
</tr>
<tr>
<td>Hardwood Bottomlands</td>
<td>20%:</td>
<td>18</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>40%:</td>
<td>36</td>
<td>3.5</td>
</tr>
<tr>
<td>Aquatic Invertebrates:</td>
<td>Crop</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>15 (1-31)</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>HBL</td>
<td>10</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Acorns</td>
<td>% Basal Area of Red Oaks</td>
<td></td>
</tr>
<tr>
<td>All Species Combined</td>
<td>Reinecke et al. 1989</td>
<td>(100-600)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Food Available in Rice Fields</td>
<td>Manley et al. (2004), Stafford et al. (2005)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>71%, 79-99% Decrease in Seed Availability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>271 kg/ha Post Harvest</td>
<td>78 kg/ha Late Autumn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Near 50 kg/ha Theoretical Threshold)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>140 kg/ha 752 DUD/ha 325 DUD/ha</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assumes no deterioration and bird uniformity.
Using Constants for Food Resources

**Advantages:**
- Easy to Use, No Fieldwork.
- Inexpensive (estimate area only)
- MAV Estimates from the 80s may not be reliable.
- refuge or unit estimates are merely a consequence of area.
- New evidence suggests they may overestimate DUD.
- Seed and invertebrate resources are not constant!
  - For seeds, what is available at senescence, may not be what is available to birds when they arrive.
  - For inverts, peak invertebrate production may not correspond to bird use (late winter, March).

**Disadvantages:**
- Refuge or Unit Estimates are merely a consequence of area.

---

Direct Estimation of Food Resources

**Seeds**
- Clipping
- Threshing

**Invertebrates**
- Collecting
- Sorting

**Field Work**

**Lab Work**

**Specialized Equipment**
- Nets, Clippers, Refrigerated Storage, Sieves, Sorting Trays, Dryer, Desiccator, Balance

**Steps:**

1. Randomly establish sampling plots.
2. Clip vegetation prior to flooding.
3. Collect invertebrates after flooding.
4. Thresh seeds from vegetation.
5. Sort invertebrates from samples.
6. Dry seeds and invertebrates.
7. Weigh seeds and invertebrates.
8. Express dry mass [kg] estimates per ha.

<table>
<thead>
<tr>
<th>Time and Monetarily Consuming</th>
<th>Need Specialized Equipment</th>
<th>Good Estimate</th>
</tr>
</thead>
</table>

**n=30 1-m²**
Direct Estimation of Seed Resources
A New Technique: The “Seed-vac”

Penny et al. : in review
88% Recovery Rate
Correction Factor = 1.14

Advantages:
• The most **accurate** method for estimating site-specific food resources.
• **Wetland-specific** estimates.

Disadvantages:
• Time Consuming
• Specialized Equipment Required
• Expensive

Most wetland managers do **NOT** have the resources to directly estimate seed and invertebrate production annually (or several times during flooding).

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Estimating Food Resources Using Prediction Models
(Laubhan & Fredrickson 1992; Gray et al. 1999a,b; Sherfy & Kirkpatrick 1999)

Seed Yield = \( \beta_0 + \beta_1 \) (Plant Measurements, Dots)
Invertebrate Biomass = \( \beta_0 + \beta_1 \) (Water Quality, Depth)
**Methods: Plant Morphological Study**

5 species: *Echinochloa crusgalli, Cyperus erythrorhizos, Polygonum hydropiperoides, Panicum dichotomiflorum, Rynchospora globularis*

\[ n = 60 \text{ plants/species/year, 1993 and 1994} \]

- Plant Height
- Inflorescence Length
- Infl. Base Diameter
- Infl. Volume
- # of Inflorescences

**New Variables**

- Number of Pedicels
- Number of Flowers
- Flower Width
- Flower Height

*Seed Processing followed L&F (1992)*

\[ R^2 > 0.78 \]

**Methods: Dot Study**

5 species: *Echinochloa crusgalli, Setaria viridis, Panicum agrostoides, Panicum dichotomiflorum, Rynchospora globularis*

\[ n = 30 \text{ plants/species/year, 1994} \]

**Preparation**

- Plant Press
- 7 days
- Room Temperature
- Pedicels Separated

**Processing**

- Dot grid (9 dots/cm²)
- Dots Obscured by Seed Counted

*Seed Processing followed L&F (1992)*

\[ R^2 > 0.92 \]

**Methods: Aquatic Invertebrate Study**

**Invertebrate Collection and Processing**

- Water-Column (5-cm diameter)
- Epiphytic Sample (0.25-m² plot)
- Benthic Core (5-cm diameter)

- 20 subsamples/playa
- 2 sampling episodes/week
- September-January
- Sorted and identified
- Dried to constant mass
- g dry inverts/playa/week/m²

*Sorted and identified*
Methods: Aquatic Invertebrate Study

Predictor Variables

Water Variables:
- Conductivity
- Dissolved Oxygen
- Temperature
- pH
- Water Depth

Induced Variables:
- Inundation duration
- Treatment (managed, unmanaged)

Seed Prediction Results: 4 Models

<table>
<thead>
<tr>
<th></th>
<th>Our Data L &amp; F</th>
<th>Best Model</th>
<th>L &amp; F (1992)</th>
<th>Dot Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2_{\text{adjusted}}$</td>
<td>0.68-0.92</td>
<td>0.78-0.97</td>
<td>0.79-0.96</td>
<td>0.92-0.97</td>
</tr>
<tr>
<td>$R^2_{\text{predicted}}$</td>
<td>0.23-0.88</td>
<td>0.31-0.97</td>
<td>NAV</td>
<td>0.91-0.96</td>
</tr>
<tr>
<td>MSE</td>
<td>0.002-0.39</td>
<td>0.001-0.18</td>
<td>NAV</td>
<td>0.001-0.099</td>
</tr>
<tr>
<td>$C_p$</td>
<td>48.2-495.0</td>
<td>3.9-6.6</td>
<td>NAV</td>
<td>NAP</td>
</tr>
<tr>
<td>VIF</td>
<td>1.1-34.8</td>
<td>3.9-12.0</td>
<td>NAV</td>
<td>NAP</td>
</tr>
</tbody>
</table>

NAV = Not Available, NAP = Not Applicable

Invertebrate Prediction Results (Single Variable Models)

Increasing $p$, Increased $R^2 \leq 0.03$
Increasing $p$, Increased VIF $> 10$

<table>
<thead>
<tr>
<th></th>
<th>$R^2_{\text{adjusted}}$</th>
<th>$R^2_{\text{predicted}}$</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>0.604</td>
<td>0.532</td>
<td>333.14</td>
</tr>
<tr>
<td>Treatment</td>
<td>0.587</td>
<td>0.562</td>
<td>347.48</td>
</tr>
<tr>
<td>pH</td>
<td>0.581</td>
<td>0.564</td>
<td>352.83</td>
</tr>
<tr>
<td>DO</td>
<td>0.494</td>
<td>0.483</td>
<td>426.40</td>
</tr>
<tr>
<td>Depth</td>
<td>0.469</td>
<td>0.451</td>
<td>449.09</td>
</tr>
<tr>
<td>Time</td>
<td>0.396</td>
<td>0.379</td>
<td>508.49</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.371</td>
<td>0.365</td>
<td>529.34</td>
</tr>
</tbody>
</table>
Summary of Results

Simple linear regression models can explain as much variation in seed yield and aquatic invertebrate biomass and predict as well or better than multiple regression models.

Seed Yield/Invert Biomass

Dots Obscured/Conductivity

Seed (g) = 0.003 x DOTS

Inverts (g) = 0.023 x COND

Steps:
1) Randomly establish sampling plots.
2) Clip 1 randomly selected plant per spp.
3) Count plant density per spp. per plot.
4) Measure water quality or depth.
5) Measure plant morphology or count number of dots covered by seed.
6) Estimate dry seed/plant & invertebrate mass/m² using prediction equations.
7) Multiply estimate of seed mass/plant/spp. by plant density for each species.
8) Convert estimates to kg/ha &

Estimating Available Food via Equations

n=30 1-m²

Species

\[ \sum \text{kg/ha} \]

Estimating Food Resources with Models

Advantages:
- Wetland-specific estimates.
- Faster, “easier”, and less expensive than direct sampling.
- Accurate estimate of food production.

(BUT, maybe only where model was developed)

Disadvantages:
- Models tend to be manager unfriendly.
  > Mathematical and botanical jargon.
  > Variables can be tedious to measure.
- Spatial dependency.
  > Can give inaccurate estimates outside of region (or management area) where model was developed.

Should use suite of equations developed closest to your site.
(MS, MO, VA)
Computing Duck-use Days

Steps:
1) Estimate food resources per ha.
2) Multiply #1 by the TME of food resource.
   - Use Published or Own Estimate(s)
3) Divide the product of #1 and #2 by the daily energy requirement of waterfowl.
   - Use Published or Own Estimate(s)
4) Compute DUD by multiplying #3 by area (ha) of wetland and ∑(DUD).
5) Express DUD as a total or daily estimate (i.e., divide by hydroperiod).

“Foraging Efficiency” Correction Factor for #1: ~50 kg/ha

Computing Duck Use-Days

<table>
<thead>
<tr>
<th>Wetland</th>
<th>Area</th>
<th>Seed Yield</th>
<th>MTE</th>
<th>DER kcal</th>
<th>DUD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandri</td>
<td>138 ha</td>
<td>150 kg</td>
<td>250 kcal</td>
<td>292 kcal/day</td>
<td>178K</td>
</tr>
<tr>
<td>Santa Teresa</td>
<td>73 ha</td>
<td>600 kg</td>
<td>250 kcal</td>
<td>292 kcal/day</td>
<td>377K</td>
</tr>
</tbody>
</table>

½ Million Duck Use-Days

6 Months Oct - March

3083 Ducks/Day

Summary of Problems with Current DUD Estimates

1) “Constants”
   - May Overestimate.
   - Not site-specific.
   - Cannot Evaluate Management.
2) Prediction Models
   - Not Manager Friendly: confusing, tedious.
   - Should Not Be Used Across Regions.
3) Direct Estimation
   - Costs too much.
Some Ideas for Future Research

Constants

Constants commonly used for seed (moist-soil, acorns, and agricultural grains) and aquatic invertebrates need to be verified.

<table>
<thead>
<tr>
<th>Constants</th>
<th>1980s Estimates</th>
<th>Current Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moist-soil:</td>
<td>450 kg/ha</td>
<td>?</td>
</tr>
<tr>
<td>Rice:</td>
<td>140 kg/ha</td>
<td>78 kg/ha</td>
</tr>
<tr>
<td>(Illinois) Sorghum:</td>
<td>325 kg/ha</td>
<td>?</td>
</tr>
<tr>
<td>Acorns:</td>
<td>292 kg/ha (Texas)</td>
<td>?</td>
</tr>
<tr>
<td>Inverts in Moist-soil &amp; Hardwood Bottomlands</td>
<td>80 kg/ha</td>
<td>?</td>
</tr>
</tbody>
</table>

(start in west Tennessee then replicate through MAY)

Some Ideas for Future Research

Prediction Models

Seed-head Area Meter: 0.067 cm² – ? Resolution

Scanner: $300

Software: $1500

Scanner: $5,000

Scanner: $8,200

Software: $15,000

Very fast and accurate

Gray et al.