Silvicultural herbicides and forest succession affect understory biomass and black-tailed deer foraging dynamics in managed forests

Amy Colleen Ulappa
Lisa Shipley
Mark Swanson
Rachel Cook
John Cook
Plant availability

Plant species composition

Harvesting rate (g/min)

Plant nutritional content

Daily nutrient intake
Probability of pregnancy increases with daily nutrient intake in the fall

Probability of pregnancy increases with daily nutrient intake in the fall.

Tollefson et al. 2010. J. Wildl. Manage. 74:974-986
Changing Northwest landscapes

Old Growth

Early Seral

Closed Canopy

Graph showing timber harvest from private and federal lands in western states.
Industrial Forest Management

- Commercial logging that creates early seral continues
- Herbicides (used 1-3 times in a rotation) replaced fire as site prep
- Important tool for foresters to meet state regulations and improve conifer growth
Herbicides change understory plant communities

Indirect effects of herbicides on ungulates rarely studied

Herbicides

Target leafy species (shrubs and ferns) that would overtop and compete with conifers
Columbian Black-tailed deer
Objectives

1) To assess the effects of forest herbicides and stand age on...
   QUANTITY OF FORAGE
     Biomass of forage
     Deer harvesting rate
   QUALITY OF FORAGE
     Deer diet composition
     Deer diet quality
   QUANTITY & QUALITY
     Daily nutrient intake

2) To compare early seral managed stands to unmanaged mid seral stands
Study design & site selection

Paired design with sites across the landscape
Age classes

Open canopy – early seral

1-3 yrs old

4-6 yrs old

7-9 yrs old

Closed canopy

10-13 yrs old

14-20 yrs old

Mid-seral*
<table>
<thead>
<tr>
<th>Age Class</th>
<th>Yrs Old</th>
<th>Vegetation</th>
<th>Deer Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-3</td>
<td>6 pairs</td>
<td>4 pairs</td>
</tr>
<tr>
<td>2</td>
<td>4-6</td>
<td>14 pairs</td>
<td>13 pairs</td>
</tr>
<tr>
<td>3</td>
<td>7-9</td>
<td>4 pairs</td>
<td>4 pairs</td>
</tr>
<tr>
<td>4</td>
<td>10-13</td>
<td>6 pairs</td>
<td>3 pairs</td>
</tr>
<tr>
<td>5</td>
<td>14-29</td>
<td>10 pairs</td>
<td>4 pairs</td>
</tr>
<tr>
<td>Total plots (pairs)</td>
<td></td>
<td>40 pairs</td>
<td>28 pairs</td>
</tr>
<tr>
<td>MS</td>
<td>30-90</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>
Herbicide treatment information

- 5 timber companies, 2 tribes, and 2 city municipalities

- Did not test the effect of
  - The type of herbicides used
  - The number of applications at a site

- Common herbicides were used on our sites:
  - glyphosate, triclopyr, imazapyr, sulfometuron, atrazine, and hexazinone

- Mid-seral sites ranged in age from 30-90 years and varied in establishment method
Methods – Sample the habitat

Forestry Measurements
• Canopy cover, TPA, Basal area, species

Available Vegetation Biomass
• Species ID and collection
• Species quality – lab analysis
Observed Foraging

- Recorded all bites for 15 min 5X per day (2 d) for each of 6 tractable deer

- Deer diet info
  - Harvesting rate (g/min)
  - Representative bite size for each plant eaten
  - Representative diets for each animal for later nutritional analysis (Digestibility, energy & protein content)
Nutritional quality lab work

• Dominant understory plants and deer diets
• Analyze
  – crude protein (CP)
  – gross energy (GE)
  – sequential detergent fiber
  – tannin-binding capacity
• Calculate
  – dry matter digestibility (DMD)
  – digestible energy (DE)
  – digestible protein (DP), (Robbins et al. 1987)
What do deer do all day...

Foraging time x harvesting rate = Daily dry matter intake (g/day)
Daily Nutrient Intake

Daily Nutrient Intake = Daily Intake Rate (g/day) 
X Dig. Nutrient Content (protein and energy)
Plant selection by deer

- **Ivlev’s electivity index**
  - Relative proportion of plant in diet compared to relative proportion of plant on landscape
  - Selected plants, neutral plants (acceptable = selected + neutral) and avoided plants

**Used**

**Available**

Related to
Data Analysis

• Obj. 1) General linear mixed model
  – Split-plot design
    • Fixed effects: treatment (sprayed or not) and age class (5)
    • Random effect: site
  – Sequentially screened:
    • Elevation (m), Cluster (5 total), Year (2012 or 2013), Date (Julian)
      – None improved the fit of the model or changed the inferences of our fixed effects

• Obj. 2) Compare mid-seral stands to each other group with Dunnet’s test
Canopy cover and understory biomass inversely related

N = 40 pairs
Conifer biomass increases with herbicide use

Understory conifer biomass

Total basal area

N = 40 pairs
Plant composition (%) on landscape

Forbs comprise more of SP biomass than in NS

Ferns and evergreen shrubs increase as stand ages

N = 40 pairs
Acceptable biomass higher in non-sprayed plots and decreases with age

**Acceptable biomass higher in non-sprayed pens**

**% Acceptable declines with age**
Deer can harvest food faster in non-sprayed stands

![Harvesting rate graph](chart.png)

- **NS** (Non-Sprayed)
- **SP** (Sprayed)

**Age Class (yrs)**: 1-3, 4-6, 7-9, 10-13, 14-20

- **Harvesting rate (g/min)**

- **N = 28 pairs**
Deer can harvest food faster when plants are more abundant.

\[ y = 0.0003x + 1.285 \]

\( p < 0.0001 \)

N = 28 pairs + 7 midseral
Deer can harvest food faster when bites are larger.

\[ y = 12.41x + 0.2691 \]
\[ R^2 = 0.84 \]
\[ p < 0.0001 \]

\( N = 28 \) pairs + 7 midseral
Deciduous shrubs and trees more abundant in non-sprayed plots and may drive harvesting rate

N = 40 pairs
Deer search more when food is scarce

Foraging time not significantly affected by treatment or age
Deer diet composition

- Deciduous shrubs and forbs make up 84% of deer diets so important
  - More shrubs in NS diets
  - More forbs in SP diets

- As the canopy closes, forbs in diet decrease and ferns and evergreen shrubs increase

N = 28 pairs
As acceptable biomass decreases, deer eat avoided plants

N = 40 pairs
Dry matter intake higher in NS, dry matter digestibility lower as tree stands age.

**Dry matter intake (g/day)**

- Age Class (yrs): 1.3, 4.6, 7.9, 10-13, 14-20

**Dry matter digestibility (%)**

- Age Class (yrs): 1.3, 4.6, 7.9, 10-13, 14-20
Digestible energy content higher in young stands, no treatment effect

N = 28 pairs
Daily digestible energy intake greater in non-sprayed stands

N = 28 pairs
What does DEI mean biologically?

Concordant % = 81.7
e(-5.70 + 0.46X)
Y = 1 + e(-5.70 - 0.46X)

Tollefson et al. 2010. J. Wildl. Manage. 74:974-986
What does DEI mean biologically?

Concordant % = 81.7

\[ Y = e^{-5.70 + 0.46X} \]

Tollefson et al. 2010. J. Wildl. Manage. 74:974-986
What does DEI mean biologically?

Tollefson et al. 2010. J. Wildl. Manage. 74:974-986
What does DEI mean biologically?

Tollefson et al. 2010. J. Wildl. Manage. 74:974-986
What does DEI mean biologically?

Tollefson et al. 2010. J. Wildl. Manage. 74:974-986
Daily protein intake different in 4-6 yr old stands between NS and SP

- Protein not limiting at any age class in the summer
How do managed stands compare to unmanaged mid-seral stands?

4-9 yrs Non-sprayed vs. 4-9 yrs Sprayed
Midseral non-conifer was similar to other closed canopy and 1-3 yr old stands.
Midseral DEI as similar to closed canopy and 1-3 yr old stands

N = 28 pairs + 7 midseral
In summary.....

• NS plots have higher:
  – acceptable biomass
  – dry matter intake
  – daily digestible energy intake

• No effect of treatment on:
  – Dry matter digestibility of diets
  – Digestible energy content in diets
  – Foraging time
In summary....

- As tree stands age:
  - Acceptable biomass decreases
  - Diet quality (digestible energy) decreases
  - Harvesting rate and Daily dig. energy intake not significantly different between age classes
    - Small sample size and high variation at young and old age classes
Management Implications

- Regardless of herbicide treatment, deer were able to consume more energy in a day in open canopy compared to closed canopy and midseral stands
  
  – Creating long-lasting, complex early seral is important
    * For ungulates and many other species as well.

- Deer highest DEI in 4-9 year old stands
  
  – Plant trees at lower densities to keep this developed understory
What does it mean for deer populations?

- At what tree stand age do effects of herbicides diminish?
- Decide how many deer the landscape should support
  - Determine if herbicide use actually affects deer populations
- Need a landscape scale assessment
  - Amount of forest stages on landscape
  - Understand mosaic
It takes a village...

- Washington Dept. Fish and Wildlife
- National Council for Air and Stream Improvement
- Muckleshoot Tribe
- Safari Club
- Washington TWS chapter
- Washington State University
...In-kind support and land access

- Weyhaeuser – Rod Meade & Mike Rochelle
- Port Blakely Tree Farms – Blake Murden
- Hancock Timber – Tim McBride
- Green Diamond – Randall Greggs
- Rayonier – Candace Cahill
- Muckleshoot Wildlife dept. – Dave Vales
- Quinault Wildlife dept. – Dan Ravenal
- Seattle Public Utilities
- City of Tacoma
Thank you

amyulappaa@boisestate.edu
Wild herbivores retain wild instincts

Spalinger et al. 1997
Data collected

<table>
<thead>
<tr>
<th>Objective</th>
<th># Samples</th>
<th>Process method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>824 2 m² plots</td>
<td>Clip, dry, weigh all species, enter data</td>
</tr>
<tr>
<td>Diets</td>
<td>3,000 foraging trials</td>
<td>Record and enter data</td>
</tr>
<tr>
<td></td>
<td>~2,000 bite wts</td>
<td>Dry, weight, enter data</td>
</tr>
<tr>
<td></td>
<td>330 diets (2012)</td>
<td>Freeze-dry, grind, ODM, DMD, GE, protein, tannins</td>
</tr>
<tr>
<td></td>
<td>295 diets (2013)</td>
<td>Freeze-dry, grind, ODM, DMD, GE, protein, tannins</td>
</tr>
<tr>
<td></td>
<td>~ 1500 hrs of deer activity obs.</td>
<td>Data entered Calibration</td>
</tr>
<tr>
<td>Nutritional Carry Capacity</td>
<td>~400 individual plant samples</td>
<td>Freeze-dry, grind, ODM, DMD, GE, protein, tannins Use FRESH model</td>
</tr>
<tr>
<td>Forest Measurements</td>
<td>98 pens</td>
<td>Data entered, GPS data mapped, area for each pen calculated</td>
</tr>
</tbody>
</table>
Quality and quantity together

FRESH-deer model – Hanley et al. 2012

Useable biomass

Minimum nutritional requirement

Starts with a histogram of the understory biomass along a gradient of quality.
Forbs more abundant in young stands

Forb biomass not affected by herbicide use

N = 40 pairs
Not all that is green is good

Thorns – physical defense

Fiber – structural defense

Toxins – chemical effects

Limit intake, accessibility to nutrients and quality
Plant availability affects intake.

Intake rate = grams/minute
Plant availability affects intake

Intake rate = grams/minute
Plant species composition affects intake

- Different plant species have different sized leaves
- Leaf size constrains bite size
- Herbivores take thousands of bite a day

Bite size can impact intake 10 fold!

Gross et al. 1993
Intake rate and plant quality determine daily digestible energy intake (DEI)

- Intake rate (g/min)
- Dietary digestible energy content (kJ/g)
- Foraging time (min/day)

Plant availability and species composition

= Daily Digestible Energy Intake (MJ/day)
Enclosed deer in 1-acre pens