Quantifying greenscapes: spatiotemporal patterns of phenology shape green wave surfing in migratory mule deer

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Photo credit: Joe Riis
Forage quality is key

Intake

Digestibility

Forage biomass

Fryxell 1991
Fitness benefits of migration

Topographic Diversity
Albon and Langvatn 1992, Mysterud et al. 2001

Resident vs Migratory
Hebblewhite et al. 2008
The Green Wave Hypothesis

Drent et al. 1978, Owen 1980, Van der Graaf et al. 2006
Quantifying the green wave

Optimal surfer

Forage Quality (IRG)

Bischof et al. 2012
Testing the green wave hypothesis: red deer

Migrants *JUMPED* the green wave!

Bischof et al. 2012
Does green wave surfing occur across a spectrum?

Stopover use in Mule deer

Bischof et al. 2012
Sawyer and Kauffman 2011
Testing the green wave hypothesis: mule deer
Elevational gradient = gradient in plant green-up
Days from peak IRG
0 = surfing
Mule deer surf the green wave
Green wave surfing occurs across a spectrum

Jumpers

Surfers

Bischof et al. 2012
Mule deer surf the green wave... but there is variability
Learning hypothesis

The Learning hypothesis

Days from peak IRG vs. Age

State-dependent hypothesis

Days from peak IRG vs. Nutritional condition
The greenscape hypothesis

- **Duration** of green-up
- **Order** of green up

![Graphs showing the comparison between Non-consecutive Green-up and Consecutive Green-up](image)
Results: the greenscape hypothesis

Green Wave Surfing
(Days from Peak IRG)

Green-up order

Less consecutive

More consecutive

Perfect

Mis-matched

2013
2014
2015
• Green wave surfing is key to the foraging benefit of migration

• The migration route provides critical habitat; timing is key

• The greenscape determines the habitat quality of a route
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Wyoming Animal Damage Management Board
Questions?

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Spring Migration

Growing Season

Estimated Slope

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<th>Year</th>
<th>2013</th>
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\( \ln(\text{Days from peak}) \)

Days to peak green-up

(c)
Dry year

Wet year

Low snowpack, wet spring

(d)  (e)  (f)
Green-Up Duration

Winter Range 1 2 3 4 Summer Range

Forage Quality

Julian Day
Green-Up Order

Consecutive Green-Up

Forage Quality vs. Julian Day for Winter Range and Summer Range.
Green-Up Order

Non-Consecutive Green-Up

Winter Range 3 1 4 2 Summer Range

Forage Quality

Julian Day
Drought = Shorter duration of green-up

$p = 0.0087$
$r^2 = 0.45$
Drought =

- Shorter duration of green-up
- Non-consecutive green-up

\[ p = 0.023 \]
\[ r^2 = 0.36 \]