Deer densities consistent with the natural regeneration of balsam fir – white birch forest on Anticosti Island

Are deer impacts directly proportional to their density?

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Cervids as driving disturbances in forest ecosystems

Overabundant populations worldwide threaten forest integrity

Key components of forests

Population should reach carrying capacity, crash or enter a cyclic regime in relative phase with resources
The paradox in Anticosti deer-forest system

POPULATION

1900 1920 1940 1960 1980 2000

Fir

Birch

Deciduous
**Litterfall as an alternative food source...**

<table>
<thead>
<tr>
<th></th>
<th>Biomass (kg/ha ± se)</th>
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<tbody>
<tr>
<td><em>Alectoria + Bryoria</em></td>
<td>6.4 ± 1.3</td>
</tr>
<tr>
<td><em>Ramalina</em></td>
<td>3.3 ± 0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9.7 ± 1.7</td>
</tr>
<tr>
<td><em>Balsam fir twigs</em></td>
<td>11.9 ± 4.1</td>
</tr>
</tbody>
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777 ± 87 kg of lichens and 1110 ± 210 kg of browse per winter at the scale of the home range of a doe

Could sustain 8.5 to 17.2 does/km²

... and an ecological subsidy uncoupling deer from resources

Deer act as a diffuse disturbance, independent from resources, which slowly undermine forest resilience
Hypothetical structures of deer-forest relationships

Classical succession

Complex systems

Intermediate disturbance

Complex systems with thresholds

Multiple equilibrium
A controlled grazing experiment at the scale of multiple forest stands

*In situ* density
- A, C = 56 deer/km²
- B = 27 deer/km²

- 3 deer: 7.5 deer/km²
- 0
- 3 deer: 15 deer/km²

3 replicates
Monitored for 3 years (YAG)
Exponential growth of deer-induced seedlings mortality

<table>
<thead>
<tr>
<th>Deer density (deer/km²)</th>
<th>Mortality rate</th>
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<tr>
<td></td>
<td>0.0</td>
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<td></td>
<td>0.1</td>
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<td>0.2</td>
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<td>0.5</td>
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</tbody>
</table>

Cumulative mortality rate = 74 ± 8 at 56 deer/km²
64 ± 11% from browsing
Heterogeneity in tree species responses

Indirect impact: changes in plant-plant interactions
Unbrowsed (resistant) species gain apparent competitive advantage
Change to the field layer community assemblage

- cutover
- ▲ understory
- 1 YAG
- 2 YAG
- 3 YAG

Epilobium angustifolium

- Aboveground biomass (g/m²)
- Deer density (deer/km²)

Indirect impact: changes in plant-plant interactions
Tolerant species gain apparent competitive advantage
Summing up: complex nonlinear ecological relationships within a simple system

- Exponential decay or growth of most indicators of integrity in cutover after 2-3 years
- Cannot rule out intermediate disturbance hypothesis
  - Recovery phase
  - Less likely in systems with short history of herbivory
- No response thresholds or <7.5 deer/km²
- Change in plant-plant interactions
- Tend to support multiple equilibrium hypothesis
A conceptual framework based on the catastrophe theory

High integrity dynamic regime

Low integrity dynamic regime:
- positive feedbacks

Cusp catastrophe
i.e. potentially irreversible threshold

Deer act as slow disturbance

t₀ cutover

Low integrity dynamic regime:
positive feedbacks
$t_0 = \text{cut}$
Low integrity dynamic regime: positive feedbacks

Cusp catastrophe i.e. potentially irreversible threshold
In conclusion

- Local deer density >15deer/km² for >3 years after a canopy disturbance may not be sufficient to allow restoration of forest integrity.

- When compared to density estimate from aerial survey, it could correspond to densities of 10 to 12 deer/km² (30-40% availability bias).

- Restoration of altered forest system may require direct intervention.

- The perspective of catastrophic regime shifts calls for a precautionary approach in the management of deer-forest systems.
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+ the love labo and friends