A MULTITUDE OF HERBIVORES DETERMINE RESTORATION STRATEGIES

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Why should restoration professionals be worried about Herbivores?

**HERBIVORES CAN AFFECT MANY ASPECTS OF ECOSYSTEMS**

- Vegetation community *structure & composition*
- Nutrient availability
- All trophic levels
- Facilitate invasive species
  → **Undermine restoration efforts!**

*Selective foraging by herbivores* can shift ecosystems to alternate and/or lower nutrient states, cause trophic cascades, loss of vertebrate and invertebrate habitat, displace rare species...... includes everything invert “pests”, boar, ungulates, goats etc etc
Globally many herbivores are overabundant!!
Many impacts, not just vegetation!

Top-down and bottom-up consequences of unchecked ungulate browsing on plant and animal diversity in temperate forests: lessons from a deer introduction

Authors
Jean-Louis Martin, Stephen A. Stockton, Sylvain Allombert, Anthony J. Gaston

Biodiversity Research
Positive plant and bird diversity response to experimental deer population reduction after decades of uncontrolled browsing
Simon Chollet, Sophie Padié, Stephen Stockton, Sylvain Allombert, Anthony J. Gaston and Jean-Louis Martin

Research Article
Community-level impacts of white-tailed deer on understory plants in North American forests: a meta-analysis
Christopher W. Hobeck and Alexis K. Schultz

Ecology, 94(12), 2013, pp. 2852-2860
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Functional Ecology
Moose directly slow plant regeneration but have limited indirect effects on soil stoichiometry and litter decomposition rates in disturbed maritime boreal forests
Nichola M. Ellis and Shawn J. Leroux

Conservation Biology
A Natural Experiment on the Impact of Overabundant Deer on Forest Invertebrates
SYLVAIN ALLOMBERT, STEVE STOCKTON, JEAN-LOUIS MARTIN

Moose browsing, understory structure and plant species composition across spruce budworm-induced forest edges
Caroline M.A. Franklin & Karen A. Harper

A large herbivore triggers alternative successional trajectories in the boreal forest
BERT HIDDING, JEAN-PIERRE TREMBLAY and STEEVE D. CÔTE
Case study of how herbivores shaped restoration options on the island of Newfoundland
THE ISLAND OF NEWFOUNDLAND

BOREAL FOREST (coastal BALSAM FIR and BLACK SPRUCE)
Moose not native on the island of Newfoundland, but it is an iconic Boreal element!
Overabundant moose on the island of Newfoundland
Moose Population Estimates, Newfoundland, 1900 – 2000

Area Island of Newfoundland = 108,860 km²
Up to date moose population estimate 1975-2016

Moose Population Estimate
Insular Newfoundland (including National Parks), 1975 - 2016


Present Population Estimate (2016) = 114,150

Established TNNP Exclosures

Courtesy of Emilie Kissler
Moose concentrate in balsam fir forests in the park

TNNP = 400 km² – water/non forest – bS dominated forest = ~75km² bF!
Overabundant populations of non-native ungulates threaten the integrity of natural ecosystems

In Newfoundland, the cumulative effects of natural insect disturbance generates gaps in balsam fir dominated forests [nature disturbance regime]

\[ \rightarrow \text{FOLLOWED BY} \]

- selective browsing by overabundant moose

- RESULTS in a lack of foundation tree regeneration, and transition to alternate state of open spruce savannah
TERRA NOVA NATIONAL PARK

COASTAL BALSAM FIR FORESTS

NO REGENERATION

TCH

- Trails
- Trans Canada Highway
- Roads
- Wetland
- Ponds-Lakes
- Black Spruce Dominant
- Balsam Fir Dominant
- Not Satisfactorily Restocked

0 2 4 8 km
Creation of moose meadows

Lack of regeneration in balsam fir forests

HIGH MOOSE IMPACT
BLUE HILL

NO MOOSE IMPACT
SWALE ISLAND

Photos: TNNP
Conversion from balsam fir closed canopy forest to open spruce meadows, Blue Hill, TNNP

RESTORATION TAKE HOME → CAN’T USE SEEDS ON TRANSFORMED SITES!

Seedbed shift from optimal feathermoss → impenetrable grass/herb – INHIBITS GERMINATION OF BALSAM FIR!
- Facilitates invasive species → *negative* impacts on seedbed

- Negatively affects the habitats of rare native fauna and flora (birds, mammals, orchids, lichen...)

**Active restoration**, combined with *moose density reductions via hunting inside the park* was determined to be the best way forward to regenerate the forested ecosystems within the park.
NOT ALL blame can be put on moose!
There are also MANY other invasive species that are having an effect on vegetation & seedling regeneration!
SCOPE OF PROBLEM ON THE ISLAND OF NEWFOUNDLAND – the “INVADERS”

- **ANIMALS** – ~half of island’s mammals (12/24)
  - moose, red squirrel, snowshoe hare, red-backed vole, shrew, mink...

- **INSECTS/INVERTS** – who knows!!!! (SLUGS!)

- **PLANTS** – ~1/3 non-native!!! (~500/1500)

LONG HISTORY OF COLONISATION

- avenues of entry.....ports, railways, roads
- purposeful, or not....  **BUT WILL INCREASE!**
Who is eating what stage?

- Seed
- Seedling
- Sapling
- Mature adult

Balsam fir life cycle

Photo: Ben Ojoleck
HOW BAD IS IT IN TERRA NOVA NP?
EXTREME HERBIVORY!
Natural- levels of post-insect regeneration
Natural Seedling - Sapling density

No seed bank but a seedling-sapling bank!
Change in \( bF \) SEED RAIN (m\(^2\)) since fencing establishment (1998)

LACK OF AVAILABLE SEED TREES TO FUEL REGENERATION, EXCEPT IN SOME MATURE FORESTS \( \rightarrow \) need active restoration!
**PRE-DISPERSAL CONE/SEED PREDATION**

- Non-native **RED SQUIRREL**
  - EATS POLLEN CONES AND HARVESTS IMMATURE CONES

- **LOTS OF DIFFERENT CONE INSECTS**
  - INFEST IMMATURE CONES

Loss of > 50% of pollen and immature cones

Boa-Antwi MSc 2009
POST-DISPERSAL SEED PREDATION

- Non-native and Native **RODENTS**
  - **Masked Shrew**
  - **Red backed vole**

- Non-native **SLUG species** (~10 species)
SEEDLING HERBIVORY

- WHO? Native and Non-native *RODENTS AND SLUG* species

- Using planted seedlings, Noel found that >95% were eaten by rodents (~85%) & slugs (~8%)

- Humber found of the 65% of seedlings that died, 95% as due to rodents and slugs

BIG PROBLEM!

- adult balsam fir
- few seed producing trees (<100 ha)
- 4% adult mortality/year
- pre-dispersal seed predation by red squirrels and insects on female cones

Important lesson - studies indicated can’t plant seeds or small seedlings due to loss to herbivores

- limited seed rain & post dispersal seed predation

No saplings recruited to adults

Sapling stage
- 97% of understory fir are browsed to <60 cm by moose across all disturbance classes
- <1000 stems/ha in severely impacted sites

Limited seedling recruitment

Seedling stage (<10 cm)
- ~50% mortality from non-native slugs and small mammals
- Seedbed degradation by non-native plants and grasses

Gosse et al. 2013. Nat. Areas J.
Disruption of natural balsam fir lifecycle

Seedling → Sapling → Mature adult

http://good-wallpapers.com/animals/20595
http://www.newfoundlandlabrador.com/ThingsToDo/Moose
Re-establishment of balsam fir multi-aged forests

1- Moose hunting
   • Initiated in 2011-12 hunting season
   • Alone, not enough to show a return of the forest

2- Active restoration by planting of balsam fir seedlings
PRIORITISING RESTORATION SITES

Terra Nova National Park
Vegetation 2010

Large disturbance
BH (n=12)

Small disturbance
BCB (n=3)

Medium disturbance
PLC (n=5)

No disturbance
BHCC (n=8)
STUDY SITE WERE SELECTED BASED ON DISTURBANCE REGIME

- **Undisturbed**
  - Closed canopy forest: Blue Hill Closed Canopy (control)
  - Small openings by wind action: Bread Cove Brook
  - Medium opening formed by insects: Platters Cove
- **Disturbed**
  - Large opening formed by insects: Blue Hill Open Canopy

Measured physical (temp., pH, light, resistance) and biological (all vegetation layers, decomposition rate) factors
Poacea sp.
Solidago sp.
Rubus ideaus

Feathermoss
Clintonia borealis
Gaultheria hispidula

Warm and dry
Compact soil
Direct sunlight

Canopy cover
Moist
Conifer dominated

PHYSICAL

MEDIUM & LARGE GAPS

MATURE FOREST & SMALL GAPS

Charron and Hermanutz (2016) FEM
DEVELOPING PROTOCOLS FOR ACTIVE BALSAM FIR FOREST RESTORATION

- Can’t sow seeds
- Can’t plant small seedlings

→ 10,000, 3-4 yr old seedlings planted under various seedbed treatments, into closed canopy and large insect gaps

Charron & Hermanutz. 2016. Restoration Ecology
What is the best protocol to restore seedbed?

→ **Ground preparation**

**Control**
- Seedling planted directly into the ground

**Aboveground cut**
- Aboveground beg was cut prior to planting
  → Reduce AB competition

**Scarification**
- Soil scarified prior to planting
  → Reduce AB/BL competition
SEEDLING SURVIVAL AFTER 2 Summers PLANTED July 2013

- Very high seedling survival (~85%) but growth higher in open areas!
- Biologically no difference between TREATMENTS and CONTROL
- So planting directly into the seedbed was the EASY MANAGEMENT ACTION!
**TARGET:** Recover the entire “FOREST” ecosystem, not just balsam fir!

- Expect least palatable species to recover first after moose numbers drop

**So indicators of success must not only include foundation species such as bF**

**NEED TO CONSIDER** other FOREST SPECIES and their response to herbivory!

<table>
<thead>
<tr>
<th>Species</th>
<th>Response to fencing</th>
<th>Moose palatability</th>
<th>Shade tolerance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Height</td>
<td>Growth form</td>
<td></td>
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<tr>
<td>Balsam fir</td>
<td></td>
<td>10</td>
<td>6</td>
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<tr>
<td>Birch</td>
<td>3</td>
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<td>Red maple</td>
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<td>Mountain maple</td>
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<td>Mountain holly</td>
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<td>Mountain ash</td>
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<tr>
<td>Northern wild raisin</td>
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<td>9</td>
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</tbody>
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McLaren et al. (2009) FEM
What to do about herbivores!

- Know ALL the potential herbivores at your restoration site before you start! From the smallest to the largest!!

- Understand the life cycle of your target species and what species attack what stage

- Continue to monitor species for browsing / grazing loss and develop strategies to deal with them

- As with moose, it may be that you need to do some “pre-treatment” to decrease the herbivory pressure prior to restoration begins
Hey!
That’s my twig

QUESTIONS??