

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!

Biological Invasions
February 2010, Volume 12, Issue 2, pp 353–371

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

Authors Authors and affiliations

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

Diversity and Distributions, (Diversity Distrib.) (2016) **22**, 274–287

Functional Ecology

Standard Paper

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, Shawn J. Leroux

BIODIVERSITY RESEARCH

Positive plant and bird diversity response to experimental deer population reduction after decades of uncontrolled browsing

Simon Chollet[1,2*], Sophie Padié[1], Stephen Stockton[3], Sylvain Allombert[1], Anthony J. Gaston[4] and Jean-Louis Martin[1]

Conservation Biology

Explore this journal >

A Natural Experiment on the Impact of Overabundant Deer on Forest Invertebrates

SYLVAIN ALLOMBERT, STEVE STOCKTON, JEAN-LOUIS MARTIN

AoB PLANTS The open-access journal for plant sciences

Research Article

Community-level impacts of white-tailed deer on understorey plants in North American forests: a meta-analysis

Christopher W. Habeck[1*] and Alexis K. Schultz[2]

Ecology, 94(12), 2013, pp. 2852–2860

IAVS

Journal of Vegetation Science **27** (2016) 524–534

Moose browsing, understorey 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,[1,2,4] Jean-Pierre Tremblay,[1,3] and Steeve D. Côté[1]

Case study of how herbivores shaped restoration options on the island of Newfoundland

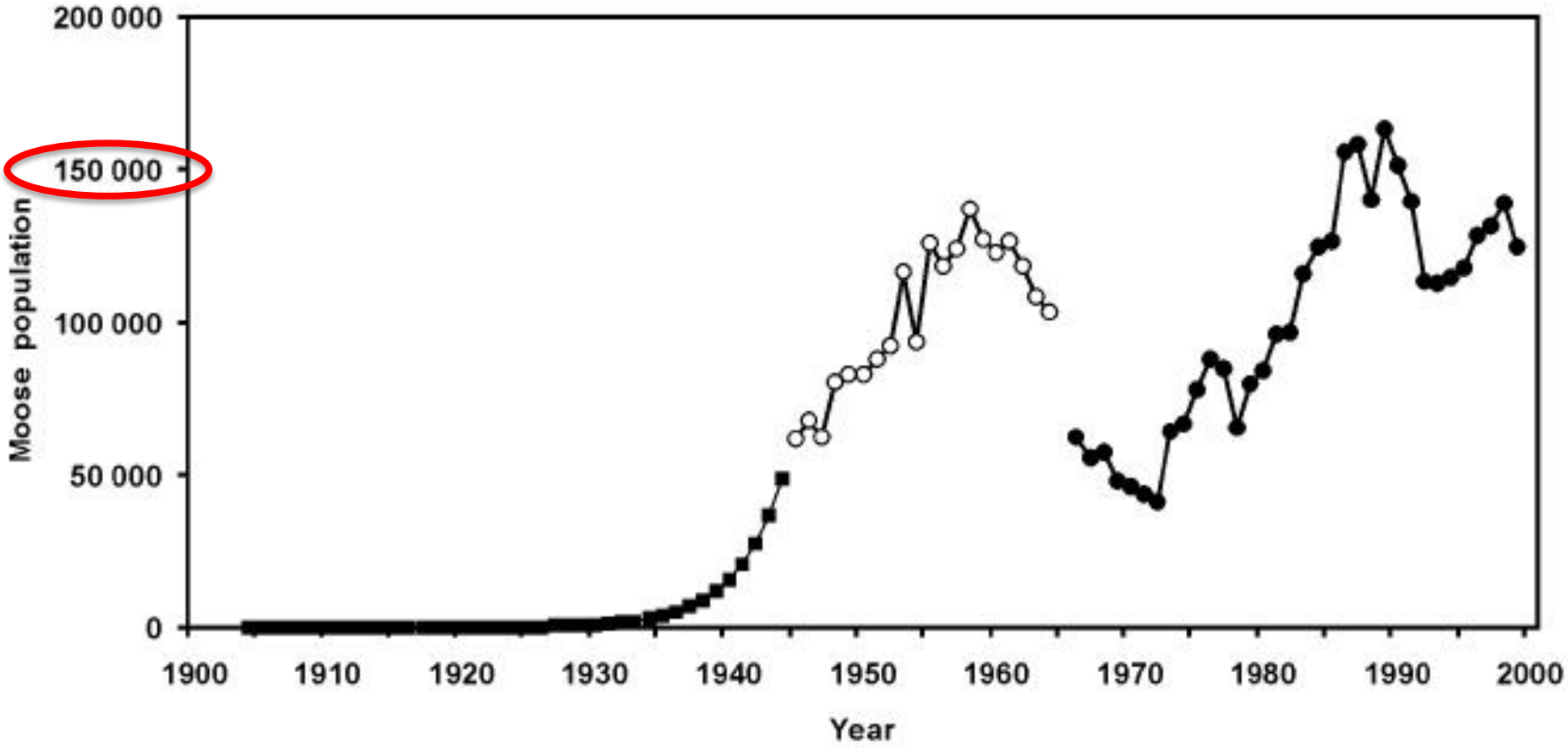
THE ISLAND OF NEWFOUNDLAND

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

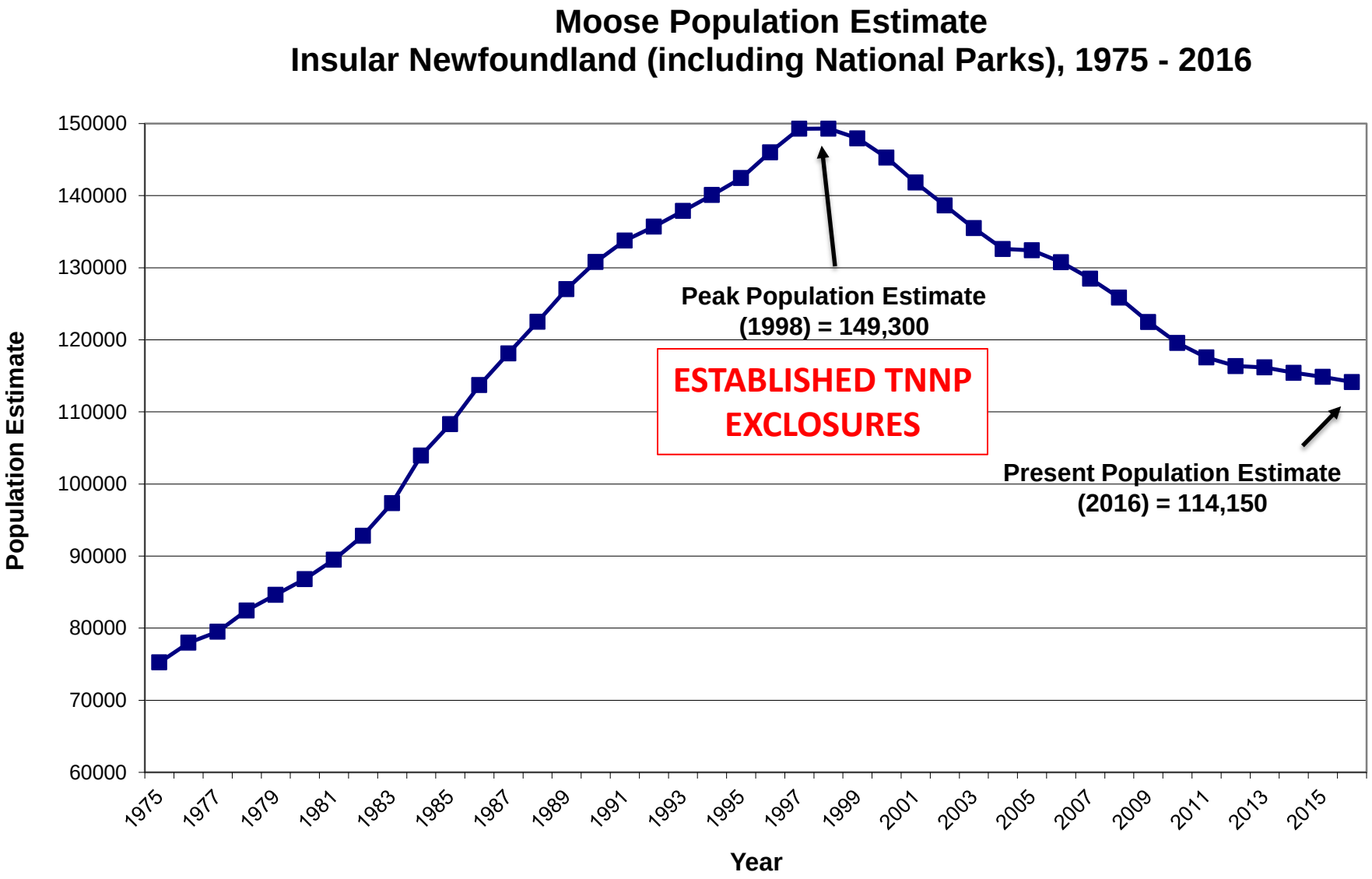
Moose Population Estimates, Newfoundland, 1900 – 2000



Area Island of Newfoundland = 108,860 km^2

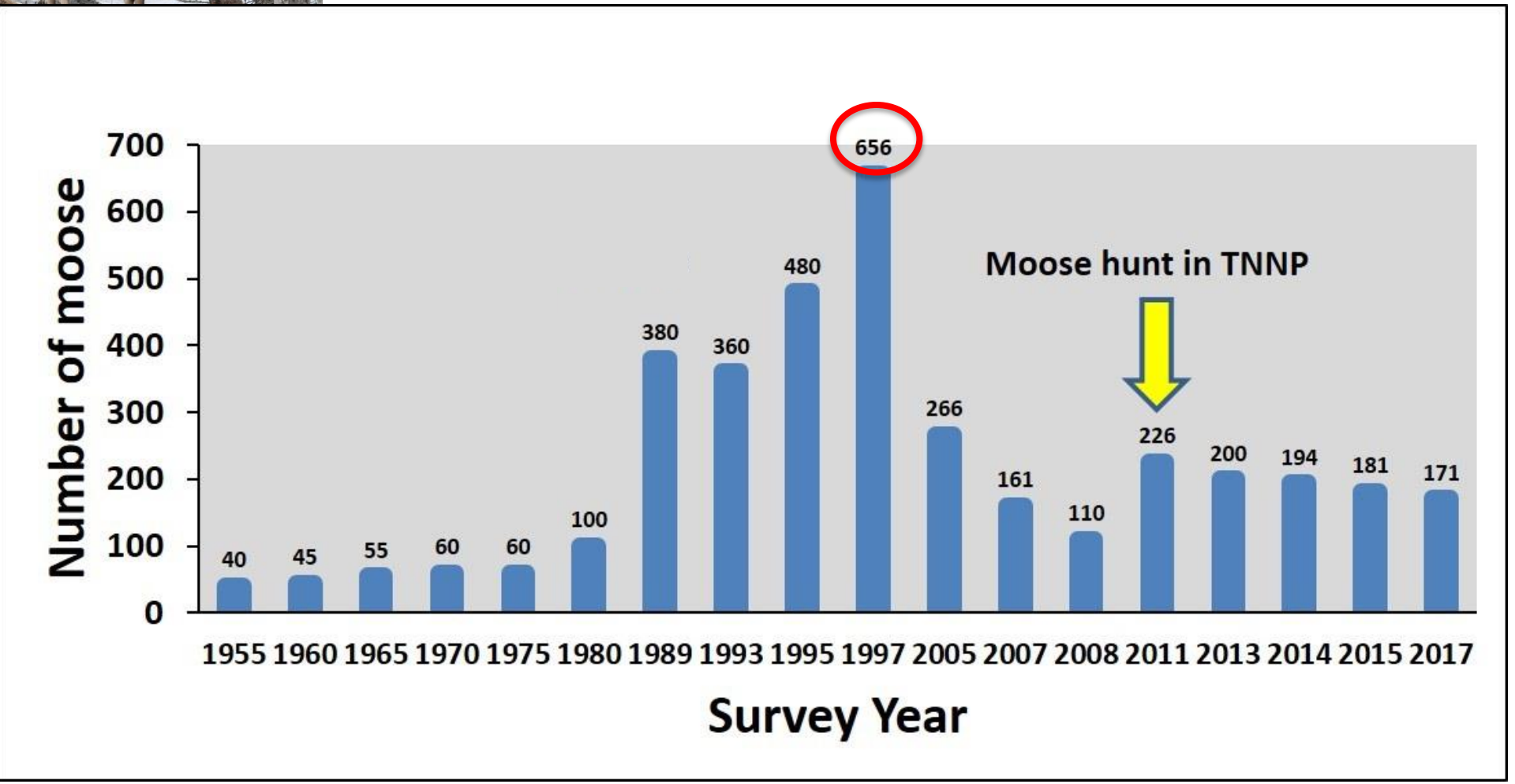
McLaren *et al*. 2006

Up to date moose population estimate 1975-2016



Courtesy of Emilie Kissler

Moose numbers in Terra Nova NP

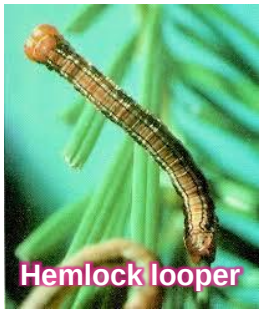


→ Moose concentrate in balsam fir forests in the park

TNNP = 400 km^2 – water/non forest – bS dominated forest = ~75km^2 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]



→ **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

Creation of moose meadows

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**


Orange Hawkweed (non-native)


Goldenrod (native)

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


NL marten


Red crossbill


Orchids


Boreal felt-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!

RESTORATION TAKE HOME - BEFORE YOU START
→ KNOW YOUR HERBIVORES & INVASIVE SPECIES!

SCOPE OF PROBLEM ON THE ISLAND OF NEWFOUNDLAND – the "INVADERS"

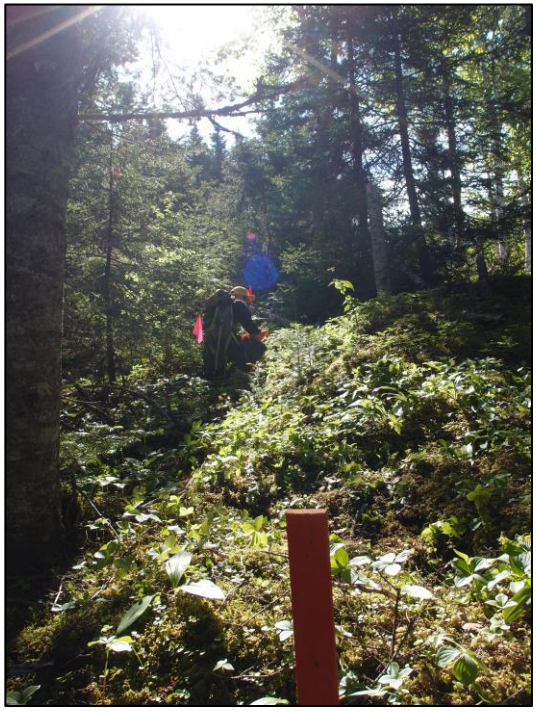
- **ANIMALS** – ~half of island's mammals (12/24)
  → ***moose, red squirrel, snowshoe hare, red-backed vole, shrew****, mink…*
- **INSECTS/INVERTS** – who knows!!!! (**SLUGS!**)
- **PLANTS** – ~1/3 non-native!!! (~500/1500)

LONG HISTORY OF COLONISATION

- avenues of entry…..ports, railways, roads
- purposeful, or not…. ***BUT WILL INCREASE!***

RESTORATION TAKE HOME →

Who Is eating what stage??



Seed

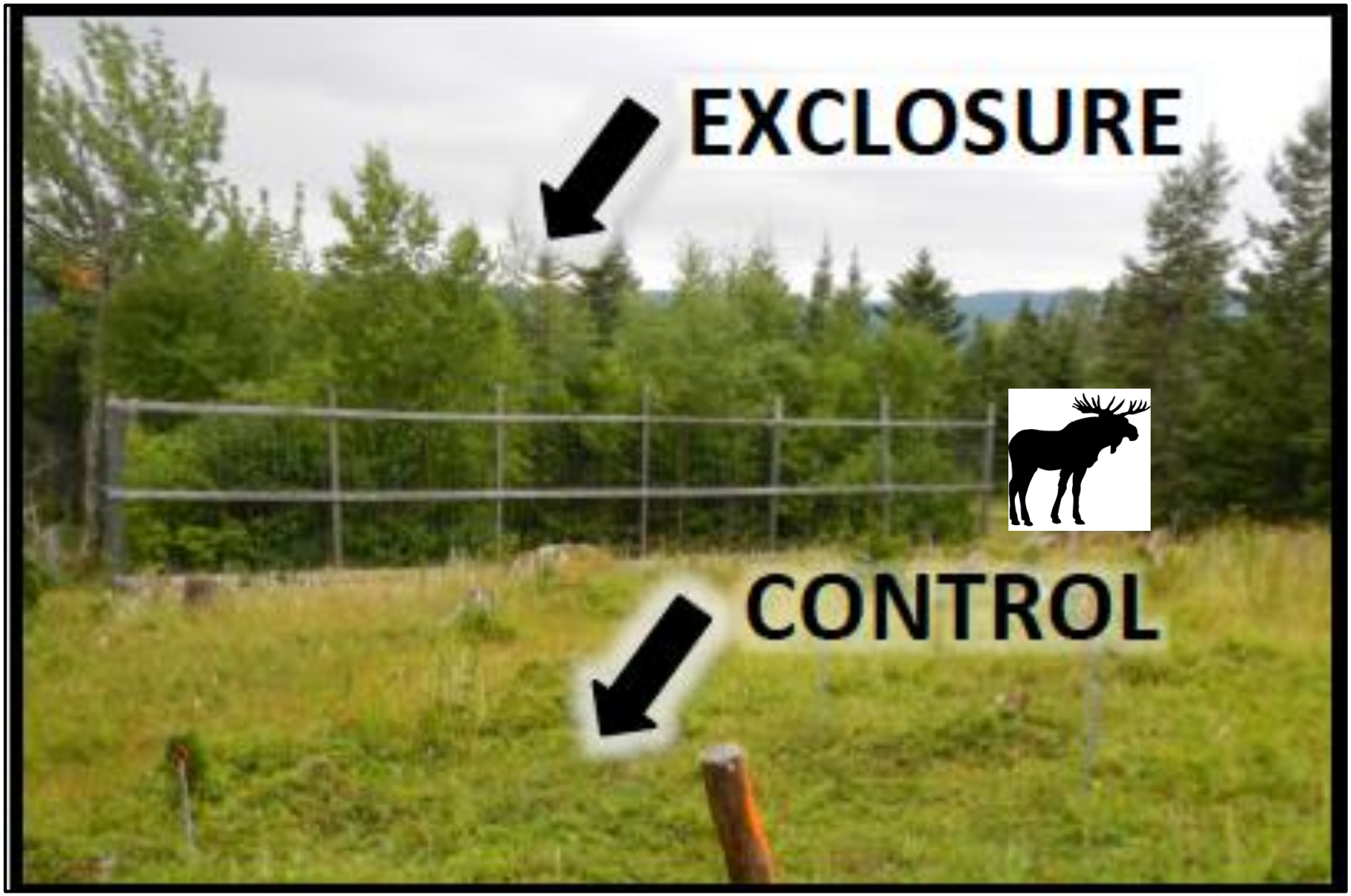
Seedling

Sapling

Mature adult

Balsam fir life cycle

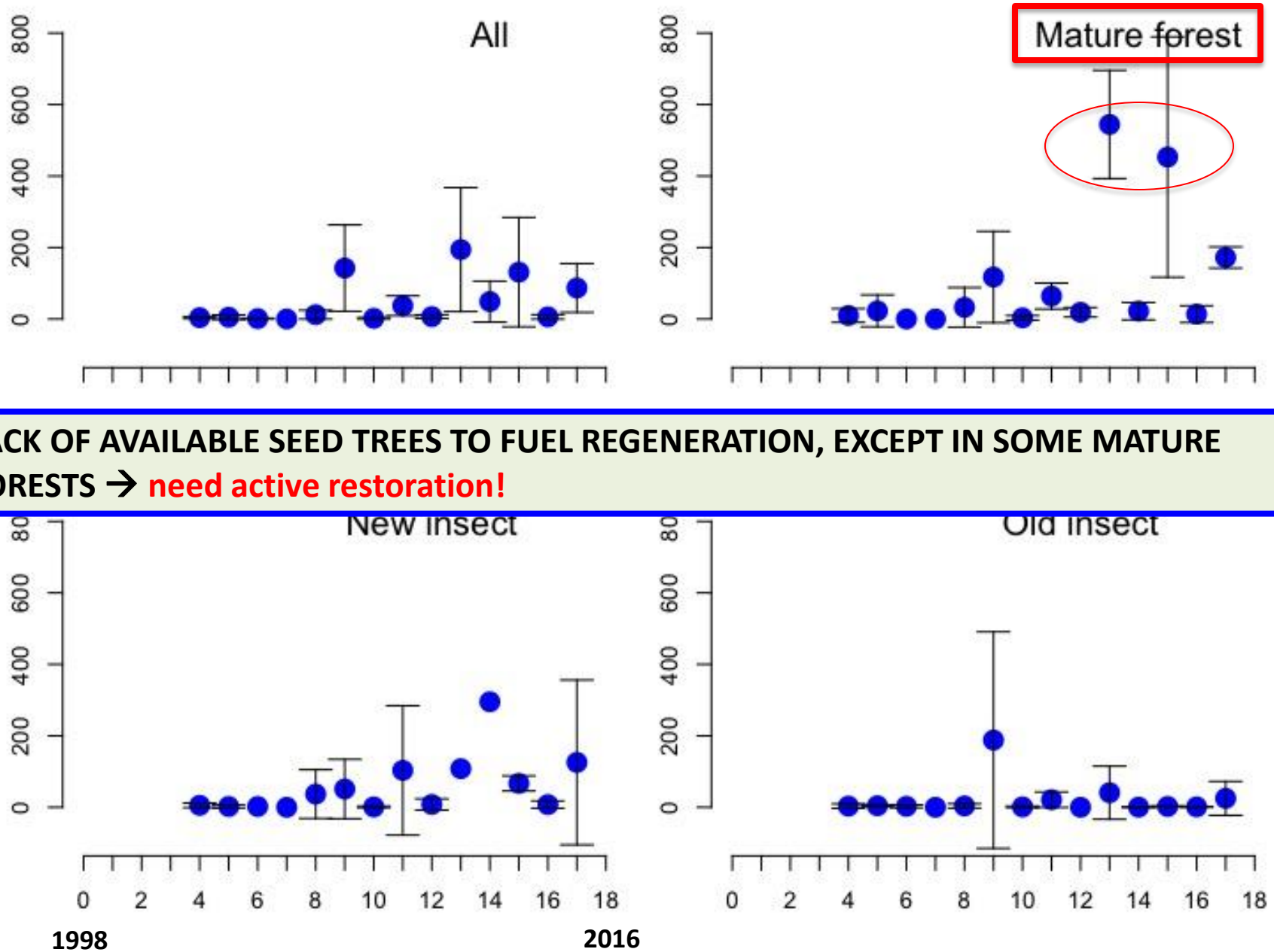
HOW BAD IS IT IN TERRA NOVA NP? EXTREME HERBIVORY!



Natural- levels of post-insect regeneration

Natural Seedling - Sapling density

Change in bF SEED RAIN (m^2) since fencing establishment (1998)



LACK OF AVAILABLE SEED TREES TO FUEL REGENERATION, EXCEPT IN SOME MATURE FORESTS → need active restoration!

PRE-DISPERSAL CONE/SEED PREDATION

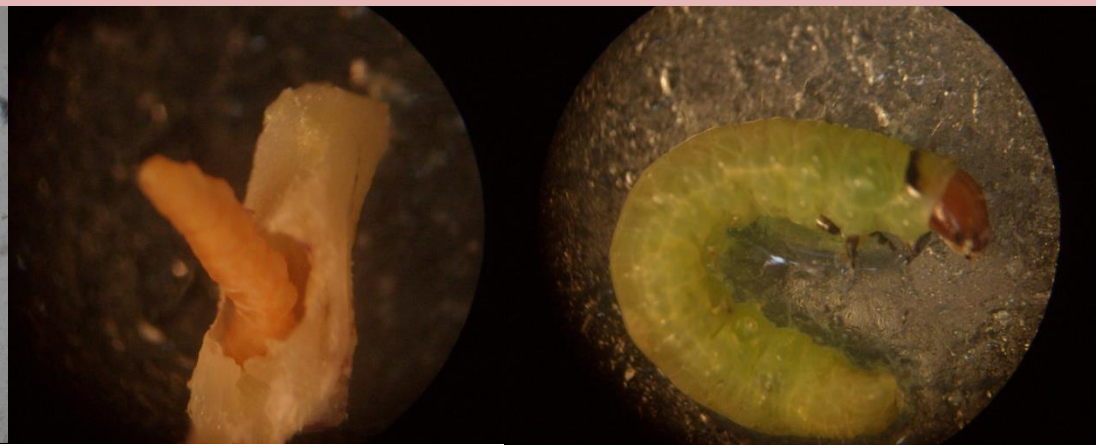
- **Non-native *RED SQUIRREL***

→**EATS POLLEN CONES AND HARVESTS IMMATURE CONES**

- ***LOTS OF DIFFERENT CONE INSECTS***

→ INFEST IMMATURE CONES

Loss of > 50% of pollen and immature cones



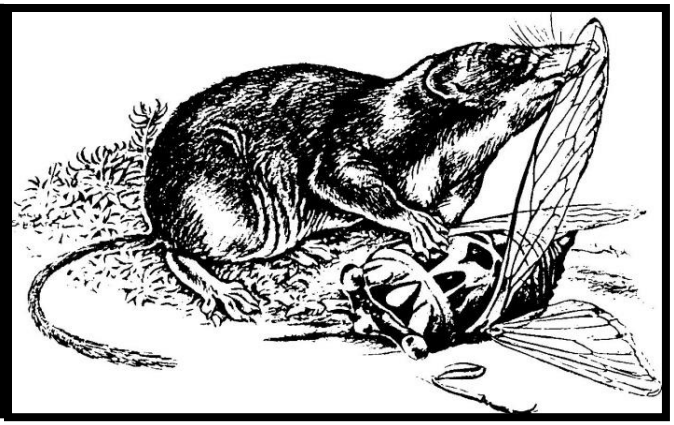
Boa-Antwi MSc 2009

POST-DISPERSAL SEED PREDATION

- **Non-native and Native *RODENTS***

Masked Shrew

Red backed vole



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

Holloway HBSc 2008

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**

Noel MSc 2004; Humber MSc 2009; Humber & Hermanutz (2011) Biol. Invasions

BIG PROBLEM!

IMPORTANT LESSON - STUDIES INDICATED CAN'T PLANT SEEDS OR SMALL SEEDLINGS DUE TO LOSS TO HERBIVORES

Adult balsam fir

- Few seed producing trees (<100 ha)[1]
- 4% adult mortality/year[1]
- Pre-dispersal seed predation by red squirrels and insects on female cones[2,3]

Limited seed rain & post dispersal seed predation[2]

Seedling stage (<10 cm)

- ~50% mortality from non-native slugs and small mammals[3]
- Seedbed degradation by non-native plants and grasses[1]

Limited seedling recruitment

Sapling stage

- 97% of understory fir are browsed to <60 cm by moose across all disturbance classes[1]
- <1000 stems/ha in severely impacted sites[1]

No saplings recruited to adults

Gosse et al. 2013. Nat. Areas J.

Seed

Seedling

Sapling

Mature adult

Disruption of natural balsam fir lifecycle

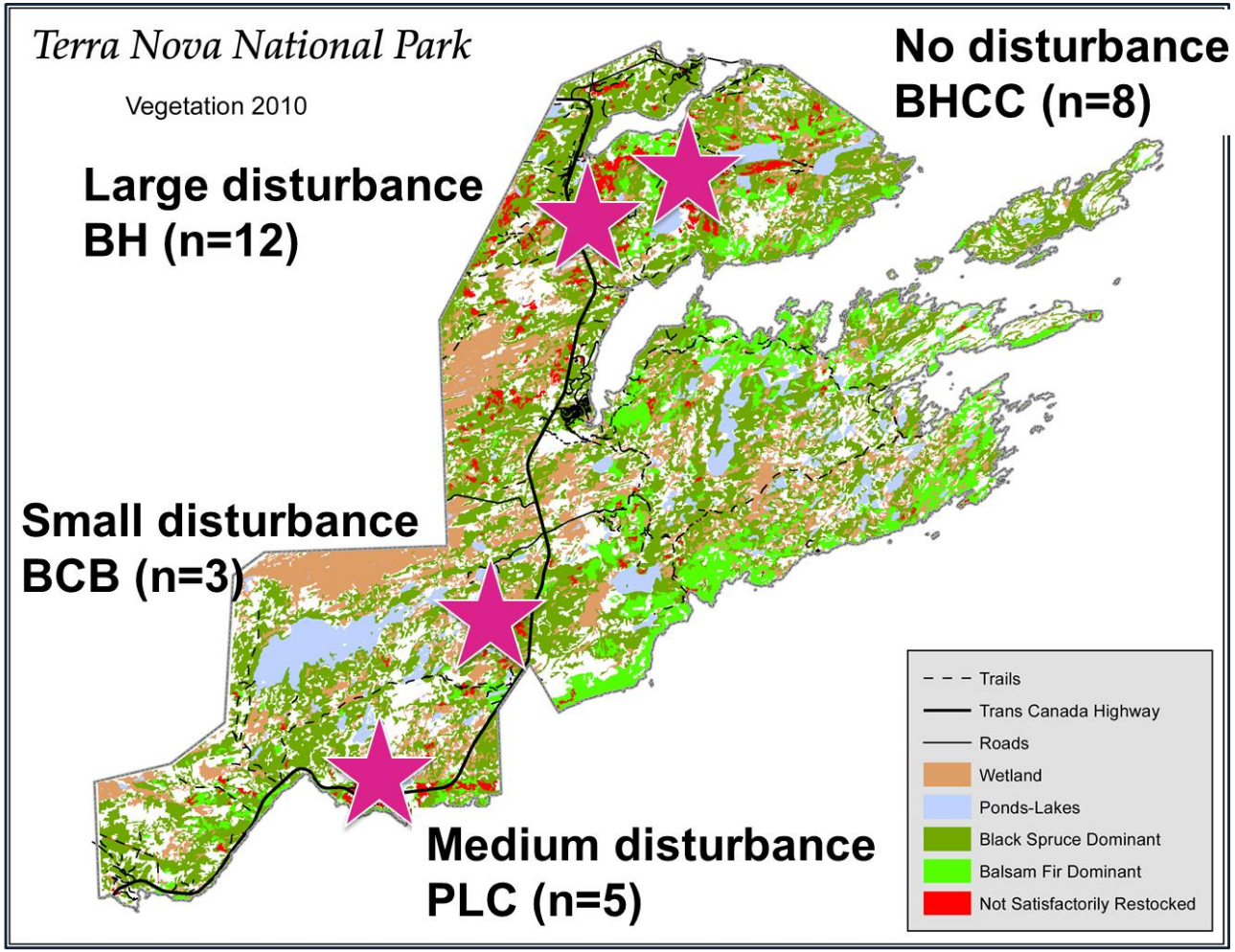
Re-establishment of balsam fir multi-aged forests

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



STUDY SITE WERE SELECTED BASED ON DISTRUBANCE REGIME

Undisturbed

Disturbed

- Closed canopy forest: 

  Blue Hill Closed Canopy (control)
- Small openings by wind action: 

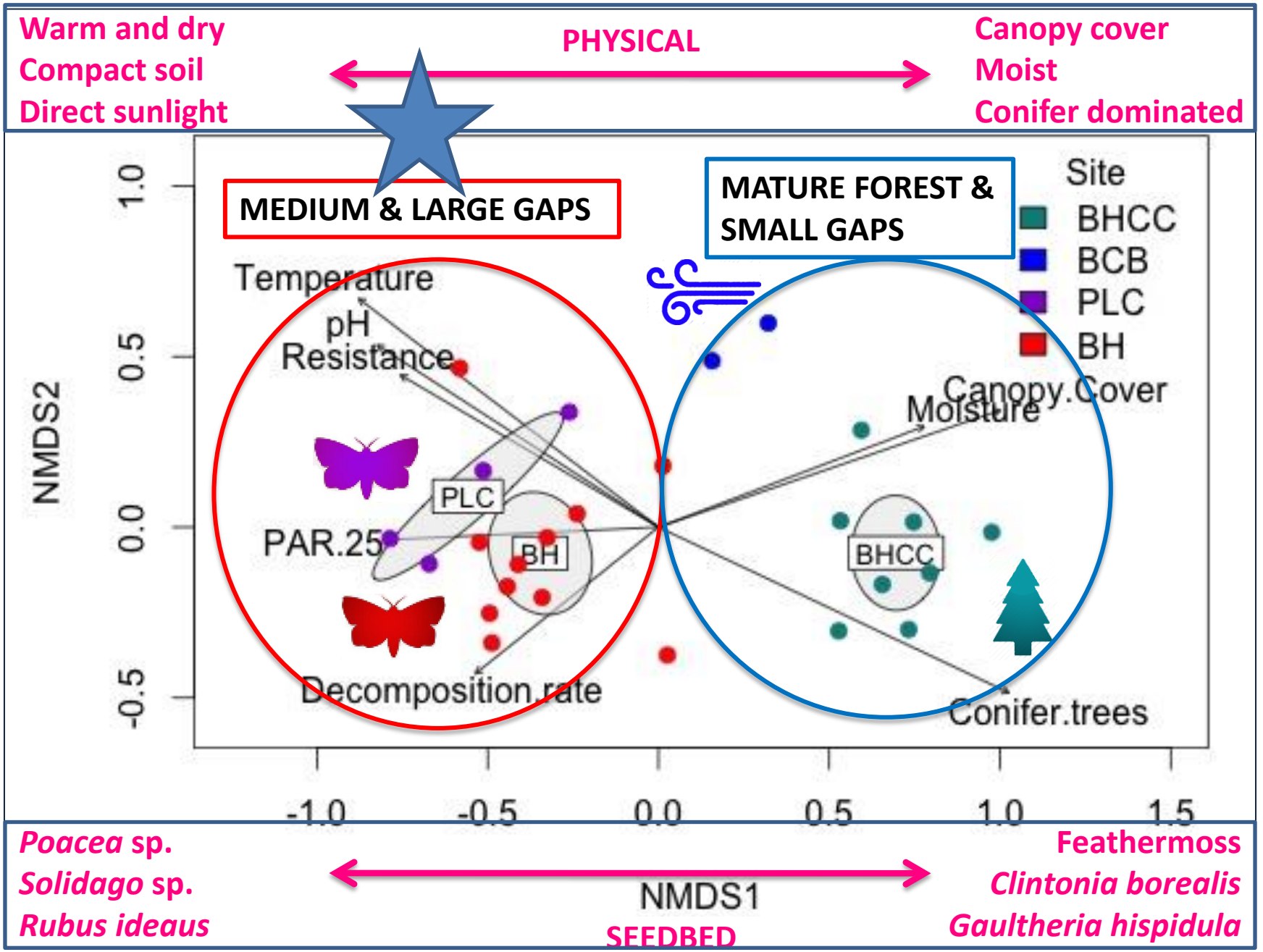
  Bread Cove Brook
- Medium opening formed by insects: 

  Platters Cove
- Large opening formed by insects: 

  Blue Hill Open Canopy

Measured physical (temp., pH, light, resistance) and biological (all vegetation layers, decomposition rate) factors

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

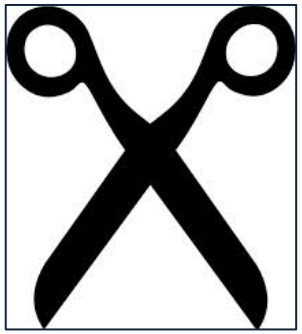
What is the best protocol to restore seedbed?

→ Ground preparation

Control

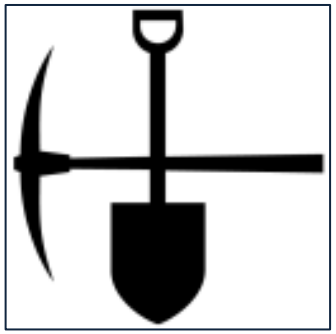
Seedling planted directly into the ground

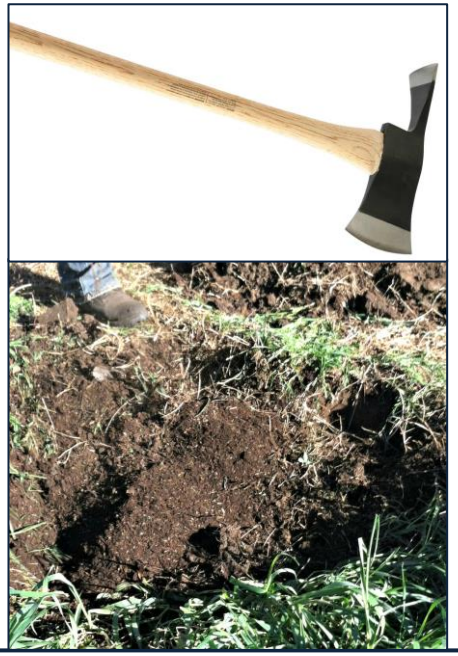
Aboveground cut



Aboveground beg was cut prior to planting
→ Reduce AB competition

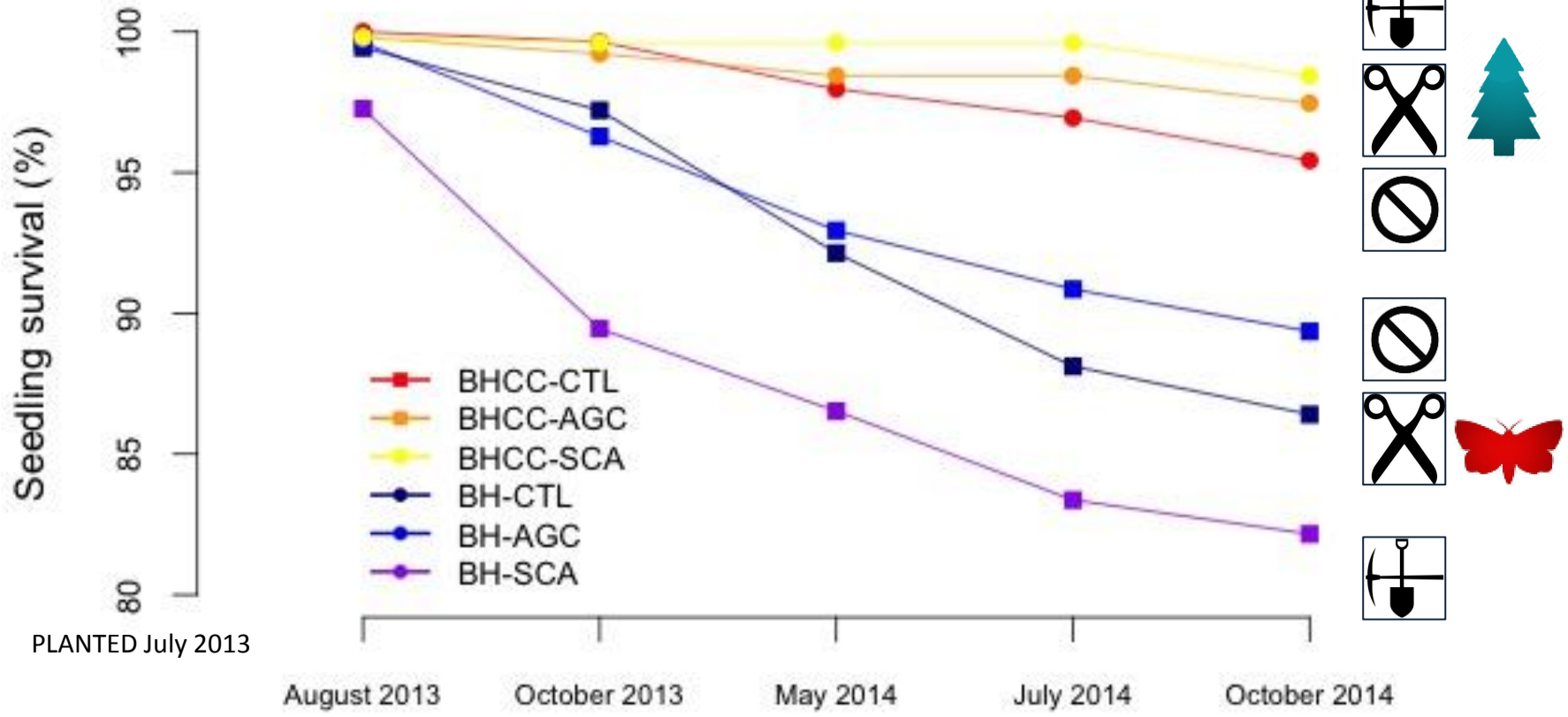
Scarification





Soil scarified prior to planting
→ Reduce AB/BL competition

SEEDLING SURVIVAL AFTER 2



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!

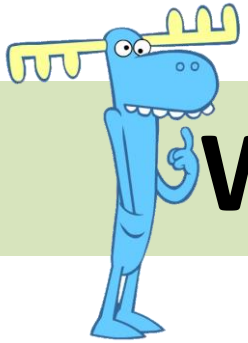
→ **Expect least palatable species to recover first after moose numbers drop**

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

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

	Response to fencing		Moose palatability	Shade tolerance
	Height	Growth form		
Balsam fir		10	6	11
Birch	3	2	3	3
Red maple	5	7		8
Mountain maple		5	4	5
Serviceberry		4	8	9
Mountain holly	4	8		5
Trembling aspen		3	1	1
Pin cherry	1	6	7	1
Red elderberry	2	9	2	5
Mountain ash		11	5	3
Northern wild raisin		1		9

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??