Climate Change & Effects on Wildlife: A Case Study with Moose
Most impacts on wildlife will likely be *indirect* as wildlife species respond to slow changes in plant communities. **MOOSE ARE NOT BURNING UP!**

The range of insect species will also be influenced, as suspected in the northward expansion of black-legged (deer) ticks in the past 10-15 years. **Parasite impacts on wildlife will be faster than plant impacts – winter ticks (AND OTHERS) and moose!**
Moose in the world: status and concerns.

Ecological relationships of winter ticks, moose, and climate change.

Moose research and management in NH/NE.

But to get your attention........

Global moose range: **boreal forest** across the northern hemisphere.

Scandinavia is centrally located in moose range, whereas NH is on the southern fringe of range in North America – this is a key point to remember!

Sweden and Norway are “moose central”!
Moose meat represents the primary red meat in the diet of many Norwegians. Landowners sell access/moose ($10,000s).

Most moose hunting is with Norwegian elk (moose) hounds, a rich tradition.

Elg is Norwegian for moose!
Cultures Differ!

Elkhound in US

Elkhound in Norway!
Global Moose Issues

- **Scandinavia:** slowly declining populations from all-time highs in Norway and Sweden
  - habitat (forestry) changes
  - “moose sickness”
  - deer keds
  - forestry impacts (“sprucification”)

- **Russia:** poaching & exploitation, lack of management, remote

- **Canada:** BC, Manitoba, and Nova Scotia major declines
  - Quebec, Alaska, & Maine: pretty stable
  - Minn & NH, western states: declining – reduced hunting
>100 moose biologists (Sweden-Alaska)
  - Declining populations
  - Parasites/diseases
  - Forest impacts
New Hampshire Moose Research

“Moose Graduate Students”: Mike Pruss, Kip Adams, Judy Silverberg, Tony Musante, David Scarpitti, Dan Bergeron, Haley Andreozzi, Henry Jones & >100 undergrads

Deer-moose interactions, habitat use, population dynamics, ecotourism & education, winter ticks, forest regeneration…..

ALL SUPPORTED BY NH FISH & GAME DEPARTMENT

Moose are integral to the social and economic fabric of northern NH!

- Model I (radio-marked fecundity) and Model II (harvest fecundity) using (a) lower 95% CI of winter survival rate of calves and yearling/adults and (b) lower 95% CI of fall survival rate of yearling/adults

Both models predicted a declining population – it is 2014! Should we be surprised??? 35 - 40 years is our moose history!
NH IS GOOD MOOSE HABITAT!

- “Mountainous” terrain (250-1000m) bordered by lowland valleys; many ponds, rivers, and streams
- Transition zone: deciduous and northern coniferous boreal forests
- Most privately owned and harvested commercially; irregular small-large patches of seral vegetation.
- Winter tick has most influence on population, not habitat.
Ghost Moose and Blood-Sucking Ticks: As Global Warming Creeps!

“GHOST MOOSE” – Dr. Bill Samuel of the Univ. of Alberta is arguably the world’s expert about the relationships between moose and winter ticks.

The “white hairs” on ghost moose are actually tips of broken guard hairs. Guard hairs are shed as frequently as 100 per day to dislodge winter ticks. The “white hairs” are the tips of 400 such hairs a day.

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A blood-sucking feast!

“For all moose, but most certainly for calves, ticks suck!”
Winter Tick Life Cycle (1 host-1 year)

**APRIL - LATE SUMMER**
Engorged females drop off, lay eggs, larvae hatch, and moose are tick-free.

**SEPT - NOV (DEC?)**
Larvae ascend vegetation and quest for host (moose).

**JAN - MARCH**
Nymphs feed, molt to adults, both sexes feed, then mate.

**NOV - JAN**
Larvae feed and molt to nymphs.
Almost 20% host >50,000 ticks!

Calves have disproportionately more ticks than adults.

Ticks may suppress appetite (cattle).
Tick-related Problems for Calves

Excessive grooming = hair loss/damage and reduced feeding

Blood loss and anemia

Lungworm infestations

April

Mortality!
OBJECTIVE: Estimate the metabolic (protein & energy) impact of adult female winter ticks on calves.

Blood loss was estimated over an 8-wk period (1 March-25 April).
Estimating metabolic (protein & energy) impacts (a physiological approach)

1. 150 and 175 kg calves
2. Low-severe (10,000-70,000) tick load.
3. 25% ticks are female
4. Engorged weight = 0.5 g (conservative)
5. Blood loss = 2-3X engorged weight
6. 0.2 g protein/mL blood, 4.3 kcal/g protein, 75% metabolic efficiency to replace blood
7. Cost to replace blood = 1.15 kcal/mL
8. Total blood vol. = 8% BW or 13-14 L
9. 134 kcal/kg^{0.75}/d (ER)

- 15% loss in weeks 0-2
- 25% in weeks 2-4
- 50% in weeks 4-6
- 10% in weeks 6-8

Figure 5.1. Moose hides were scored into squares.
Energy Cost of Blood Loss

Severe Tick Load (70,000)
- average daily cost = 10% of daily ER
- peak cost = ~20% of daily ER in 2 week “surge”
Protein Loss = 50>100% of daily requirement!!!
This is not good – forage (twigs) has low protein in March-April!
Calves are most susceptible to blood loss due to anemia and weight loss; blood loss in 2 weeks can equal their entire blood volume almost ensuring death from acute anemia!

NOTE HIGH DENSITY OF WINTER TICKS ON NECK & UNDER LEGS of RADIO-COLLARED CALF IN NH!
Although mortality of yearling (and especially) adult moose is uncommon compared to calves, the productivity of both yearling and adult cows has dropped measurably during the past decade in NH. We suspect this reflects 1) the annual metabolic drain caused by winter ticks during the last trimester of pregnancy when forage protein is still limited on the landscape, and 2) the failure of yearlings to gain adequate weight for sexual maturity.
The annual “balance” between host & parasite is heavily dependent on weather & snow conditions in both fall & spring that influence tick survival/activity.

**FIGURE 1.1.** One can think of the equilibrium that exists in most host-parasite relationships, wherein host and parasite usually co-exist quite well, as a teeter-totter with the environment as a fulcrum.

This delicate balance can be thrown out of kilter when there is a change in the environment—say, a bad winter—that puts stress on the host’s food supply and moves the fulcrum to favour the parasite. Host resistance then works to fight the infection and rebalance the relationship.
How could global warming possibly influence tick # & mortality of moose?

- Survival of adult ticks increases if they drop on “bare” ground vs. snow during spring (April); bare ground conditions should produce more ticks the following fall.

- During longer & milder autumns, ticks will be active & quest longer, increasing the probability of infesting moose.

- In combination, shorter winters on both ends produce conditions optimal for high tick #s & heavier infestations of moose.

- Rather than a sporadic acute event, the impact may be continual if winters are persistently shorter.
Annual indices of tick loads are estimated from 1) roadside hair-loss surveys in May, and 2) tick counts on harvested moose in October.

In combination with analysis of weather-snow patterns, we hope to predict epizootics that typically cause major calf mortality.
Spring Roadside Surveys: annual hair loss index (HLI)
Counting Winter Ticks On Harvested Moose

Annual Index of Tick Load
2014: 43 cows/calves in NH and 60 in Maine – repeat in 2015

- Productivity of cows
- Neonatal survival
- Annual survival/mortality
- Cause of mortality
- Tick loads/HLI
- Weather modelling
Net-Gunning Moose

Moose muggers with net gun and nets – professional rodeo cowboys!

The helicopter pilot is the key – these guys are just crazy!
AND AWAY WE GO!
“Moose Sickness” or BRAINWORM

- Neurological disease of moose caused by the meningeal worm or “brainworm”
  - *(Parelaphostrongulus tenuis)*

- *P. tenuis* is carried by white-tailed deer (*Odocoileus virginianus*)

Relation to Climate Change

- Winter length & severity are key factors controlling deer # at their northern limits
  - Deer & moose were more separated historically by latitude and winter conditions
  - Land use change and milder winters have allowed deer to increase in # and expand range northward

- Summer weather/climate (precipitation & length of summer) determine:
  - Survival of parasite outside the host
  - Survival, abundance & mobility of gastropods
  - Suitability & length of snow-free period when transmission is possible

Combined, both lead to higher incidence of brainworm in the environment.
Higher incidence of brainworm in moose is associated with increased #s of white-tailed deer that are linked to milder winters in moose range.

Climate change could speed this interaction - it is argued that such is implicated and occurring in Minnesota where moose populations continue in long-term decline!

However, the assertion that warmer temperatures alone stress moose and cause death and reduced productivity is unfounded and highly suspect!