ECOLOGY NORTH Science for the People presentation

Slide 1 – Vegetation Productivity and Phenology Across The Bathurst Caribou Range

- Presenting current research into …
- Me & Robin = upcoming grads, Dept. Geography, Queen's U in Kingston, ON
- Supervisor & PI is Dr. Ryan Danby, cross-appointed w/ School of Env. Studies at Queen's
- First field season of study, therefore presentation emphasis on background investigation and this summer's fieldwork
- Expedition team: Greg King, Assist. Prof at U. Alberta's Augustana campus in Camrose; Emily Grimshaber, undergraduate at Queen's; Joel Koop, undergraduate at Augustana

Slide 2 – A Changing Arctic Climate

- Most people acknowledge that our climate is changing.
- Analyses of satellite imagery over the past few decades suggests that vegetation productivity is increasing across the global arctic.
- Simply put, vegetation "productivity" refers to amount of growth i.e., biomass.
- NDVI stands for "Normalized Difference Vegetation Index", and is a way of measuring vegetation productivity.
- The Canadian arctic has shown a trend of increasing vegetation productivity over the past (almost) 40 years.

Slide 3 – Vegetation Productivity

- Sunlight is essential for vegetation growth, but not all its light is absorbed by the plant. We perceive plants as green when our eyes detect the green wavelength light that is reflected back from a plant; plants also reflect near IR light from the electromagnetic spectrum.
- Satellites in space are capable of measuring reflected wavelengths of light across the Earth's surface, and from these we can calculate an estimate of vegetation productivity.
- NDVI is a measure of the differential reflection of red and near IR from photosynthesizing tissue. It ranges from - 1 (unvegetated land e.g., rock, water, snow) to 1. The more photosynthetically active material you have, the higher the NDVI.

Slide 4 – What's Happening On The Ground?

- Where is this increase in productivity coming from?
- Both scientific evidence and anecdotal evidence suggest that an increase in shrub vegetation is driving productivity increases at northern latitudes.
- Here in the NWT, these would primarily be birch and willow species.
- Willows are a preferred summer food source for large herbivores such as muskox, moose, and caribou; birch are less desirable due to their high resin content, which makes them relatively unpalatable to grazers.

Slide 5 – Bathurst Caribou Herd

- In addition to changes in vegetation productivity across the arctic, wildlife populations are also changing.
- The majority of global caribou populations are in decline, the Bathurst caribou herd included
- From approximately 180,000 individuals in 2003, this herd has plunged to fewer than 20,000 individuals in 2015, an incredibly steep decline over hardly more than a decade.
- Barren-ground caribou are listed by COSEWIC [define] as “Threatened”.
- This herd calves on the tundra at Bathurst Inlet, migrating south of the treeline into the forest to spend the winter.

Slide 6 – [continued]

- Several factors can be contributing to the decline of this herd: human disturbance (winter roads, mines, harvest pressure); predation; competition with other large herbivores (muskox) for food; insect pests…
- …or, habitat quality may be changing as a result of a range of environmental conditions.
- Given the extent of habitat change that has been observed across the Arctic and subarctic in recent years, it is not unrealistic to think that these changes have been partly responsible for the decline in numbers of the Bathurst herd, and others like it.

Slide 7 - Hypothesis

This rationale leads to the hypothesis underlying our research [read it out].

Slide 8 – Project Objectives

- To answer our hypothesis, the project can be broken down into the following three objectives: 1. Investigate changes in vegetation productivity (amount of growth, i.e. biomass) and phenology (timing of growth) over the past two decades to identify areas of significant change, as well as areas that haven’t changed.
2. Carry out fieldwork to gather data on plant composition and woody growth in areas of “greening” and “no change”. Essentially, ground-truth the NDVI signal picked up by satellite imagery: What plant(s) are contributing to the increased productivity?
3. Determine how caribou movements (both seasonal and annual) may be related to changes in the condition of their range.

Slide 9 – Common NDVI Products

- We chose NASA’s MODIS satellite for our NDVI measures, based on the best balance of cost, resolution and coverage – but most importantly, a relatively frequent 1-day revisit time…

Slide 10 – Challenge of Revisit Time

- At high latitudes, where the growing season is short, you want as many cloud-free images as possible during the peak growing season in order to track phenology, which is the timing of growth.

Slide 11 – [Productivity trends figure/map]

- From February 2000 until October 2017, we collected >1200 images from three (3) tiles covering the range of the Bathurst caribou herd and created 406 composite images from the best pixels taken from a set of 16 days of imagery.
- Results were further screened to isolate areas where the change in NDVI was statistically significant.
- The outcome was this map of NDVI trends across the range of the Bathurst caribou herd:
- Green colours indicate positive i.e., “greening” trends, while orange and brown indicate negative i.e., “browning” trends.
- White areas indicate pixels with statistically insignificant trends or, below the treeline, fire scars.
- Within the herd’s range, browning was sensed in 1% of the area, while greening was noted to occur in 17% of the area.
- The caribou herd’s calving grounds and annual range boundaries were defined based on the 99% utilization distributions derived from 1996 to 2015 collar data.

Slide 12 – Dendrochronology

- BUT… why not just use satellite imagery? Why follow-up with fieldwork to carry out dendrochronology? - Imagery leaves us with little idea as to HOW vegetation has changed.
- Dendrochonology is the science of analyzing tree ring growth, and is incredibly useful for learning about past climate and environmental conditions.
- Shrubs also display annual growth rings, but not as clearly as trees do – our research is pioneering shrub dendrochronology.

Slide 13 – [sampling areas map]

- In 2016, a preliminary research expedition carried out tree dendrochronology in the Wekweeti area, and investigated shrub dendro methodology around Daring Lake.
- Cross-hatched areas in this figure indicate potential future sampling locations for intensive fieldwork. This summer targeted the area around MacKay Lake, at treeline.

Slide 14 – MacKay Lake NDVI Trends

- MacKay Lake is particularly intriguing due to a pretty solid greening trend along its southern shore, in contrast to the north shore.
- Blowing up the map to a much smaller scale allowed us to identify the specific 250 m x 250 m (a quarter-square km) pixels that were showing significant greening, as well as (in orange on our blow-up map) pixels showing no significant change in productivity since 2000.

Slide 15 – Research Expedition

- There was an enormous amount of advance planning for this summer’s research expedition, including weekly Skype meetings and equipment testing/set-up through May and June; Emily put F/T hours into food and meal prep; also safety planning, transportation logistics, and establishing a route.

Slide 16 – [continued]

- Our chosen route had us out on the tundra for 36 consecutive days, traveling nearly 80 km by pakcanoe among “greening” and “no change” sites; we camped at 14 different locations, walking between 1.5 and 4 km to our plots, and spending full days sampling at the plot and collecting tree dendro samples. [Dots are plots; triangles are campsites]
- We returned to Yellowknife yesterday early afternoon.

Slide 17 – Site Sampling Objectives

- While in the field, this is what we did:
- We set up 200 m x 100 m plots, each with four linear transects, in 10 “greening sites” and 10 “no change” sites, within which we carried out vegetation sampling in three main areas: [Read them]
- We also sampled trees from each site, within the vicinity of our plots.

Slide 18 – Vegetation Characterization

- At 10 m intervals along each transect, we broadly characterized the by identifying presence/absence of rock, moss, and leaf litter, and measuring the height of any lichen, graminoid (grasses), herbaceous plant, and woody vegetation.
- While previous research has found evidence supporting increased shrubification in areas of greening, we didn’t want to rule out the possibility that other plant material could (also) be contributing to a greening trend.
- Essentially, this sampling will give us an approximate snapshot of the proportions of both woody and non-woody plant material at “greening” vs. “no change” sites.

Slide 19 – Shrub Stem Analysis

- Also along each transect, we collected stem samples from the nearest shrub: One sample at the base of the nearest stem, and the other sample halfway up the longest branch. [Show sample pair]
- Because we were interested in annual growth rings, by default we limited our samples to the minimum size stem our lab equipment can handle for processing.
- By counting growth rings on our sample pair, we can find out two things:
    1. The year the stem emerged from the ground i.e., how old it is – count number of rings at the base; and
    2. Approximate growth rate of that stem i.e., how long it took that stem to grow to half its current size – compare the difference in the number of rings between the base and the midpoint.
- Are these younger shrubs, or have they existed for a while? - How quickly have they been growing?

Slide 20 – Shrub Dendrochronology

- Stem S2 gives an example of what we hope to learn from shrub stem analysis: Counting 10 rings at the base, we learn that this particular stem emerged from the ground in approx.

2008; comparing this with 8 rings at midpoint indicates that the stem grew to half its current length in two years.
- Hypothetically, a shrub grows like this: A seed becomes established and grows into a branch; over time, the shrub puts out more branches; some die, while other branches continue to grow. Meanwhile, these stems are being nourished by an increasing root system.
- To find out approximately how old a shrub is, and to analyze annual growth over its existence, one would need to cut that shrub at the root collar i.e., the area above the roots but below the stems (where that original seed germinated).

Slide 21 – [continued]
- Unfortunately, reality isn't so clear-cut with shrubs: Stems emerge from roots, roots form runners that produce new shrubs, stems and roots intertwine in crazy root balls…
- For our purposes, we were more interested in annual growth over the past 30-40 years, so as to obtain a chronology of growing conditions during that time.
- Rather than try to locate the point of establishment of each shrub, we aimed to sample from a section that (we hoped) was at least a couple of decades old.
- At each site, we collected samples from 15 shrubs within and surrounding the plot.
- With trial and error and some practice, we managed to locate large stems from which we could cut a sample from either the underground base of the stem, at an approximate root collar, or at the topmost end of a very large single root. [Show sample]

Slide 22 – Tree Dendrochronology
- Similarly, we sampled trees for the same goal of obtaining a chronology of growing conditions over the past few decades.
- There are two ways to get annual growth rings from a tree: Smaller trees were cut down and a "cookie" was taken [circulate sample], while a Hagloff borer was used to extract a core from larger trees [circulate sample – note that this went all the way through the tree].
- The origin of the tree – it's first year of growth – is the pith; each year thereafter (for the most part), the tree adds a ring of tissue. In each ring of tissue, cell density changes over the course of the year, resulting light and dark patterns.
- By comparing the annual growth rings of older trees in the same general area, it is possible to detect trends: Years with larger (overall) rings suggestive of favourable growing conditions, and years with smaller rings suggestive of poorer conditions.
- We gathered samples from about one hundred trees across both "greening" and "no change" sites. The majority of our samples this year came from black spruce, although we did find a couple of areas with white spruce.

Slide 23 – Caribou Movement and Migration
- My name is Robin Mennell, I will be doing my Master's degree under the supervision of Dr. Ryan Danby through Queen's University.
- My research is focused on how the Bathurst caribou may be affected by Arctic Greening trends.

- Two specific objectives of my research are to determine if the Bathurst caribou are changing their migration habits based on Arctic greening trends (Objective 1), and to determine if there are any directional trends in the in the way they use their seasonal ranges (Objective 2).
- To answer these objectives I will use GPS collar data to analyze directional trends in their movements using the mapping software, ArcGIS.

Slide 24 – Belt Transects

- In the summer of 2018, I conducted four 100m belt transects at twenty sites in the MacKay lake area, Northwest Territories. Ten of the sites had strong greening trends and ten of the sites did not (non-greening).
- I would walk each transect line looking for signs of caribou use (bone, poo, antlers, and trails). After finding and observation I would record how far off the transect line the observation was.
- This information will help me determine how caribou may be using greening or non-greening sites differently.

Slide 25 – [CIMP statement and project funding/support]

- Next year, we will return to the Bathurst caribou herd's range to carry out vegetation fieldwork in greening areas closer to their calving grounds.
- But, right now, we are ready to hunker down in the lab and investigate the results of our tree and shrub dendro and ground vegetation sampling.
- Perhaps next year we can return to present on preliminary findings from this summer's investigation!
- Any questions?