Barcode-assisted Assessments of Lepidopteran Diversity in British Columbia

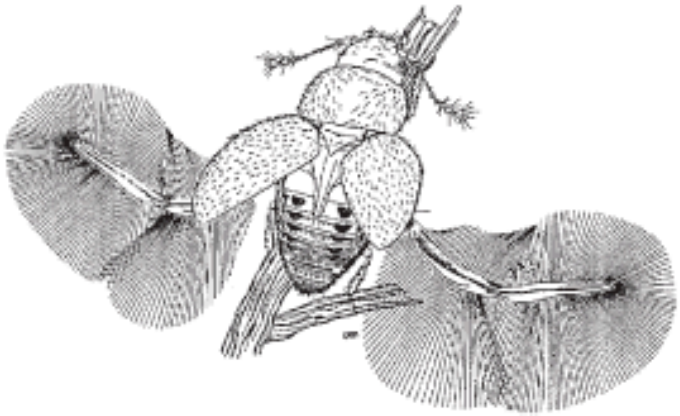
Jeremy deWaard, Jean-François Landry and Leland Humble

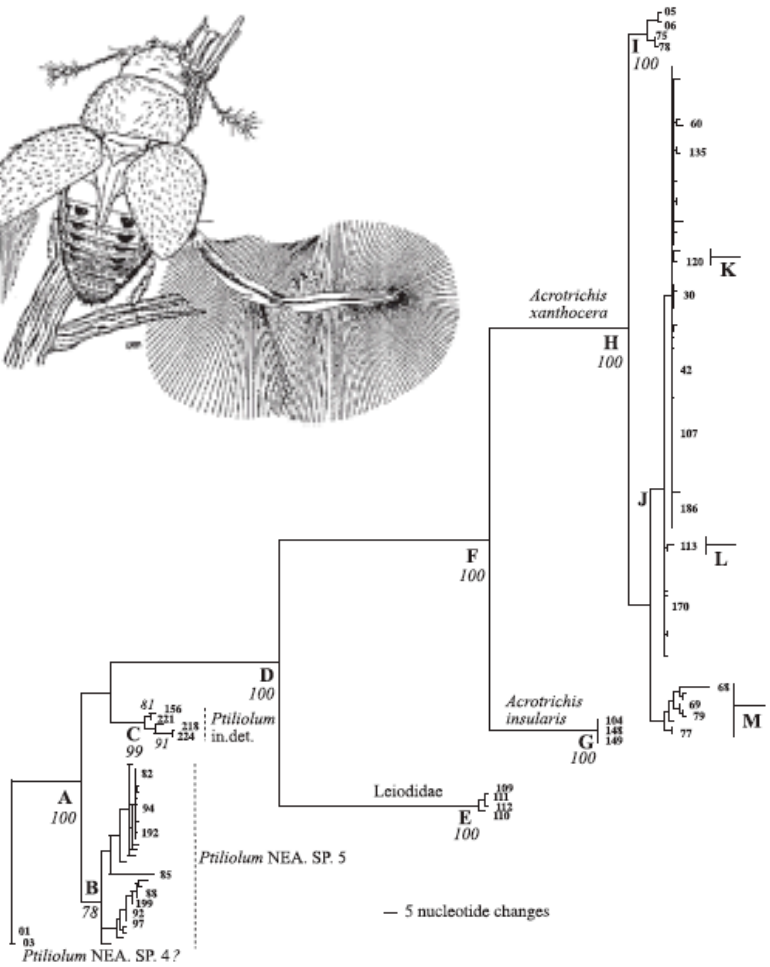
Inventories & assessments

- formidable task for terrestrial arthropods
  - sorting/prep time 40X longer than sampling time (Marshall *et al.* 1994)
  - identification time usually longer
    - large samples, damaged specimens, many species at low density
    - lack of trained taxonomists => lack of usable keys

Genetic techniques: sorting

- Caesar *et al*. 2006
  - feather-wing beetles (Ptiliidae)
  - informed sort
    - only 25% of specimens required examination by specialist

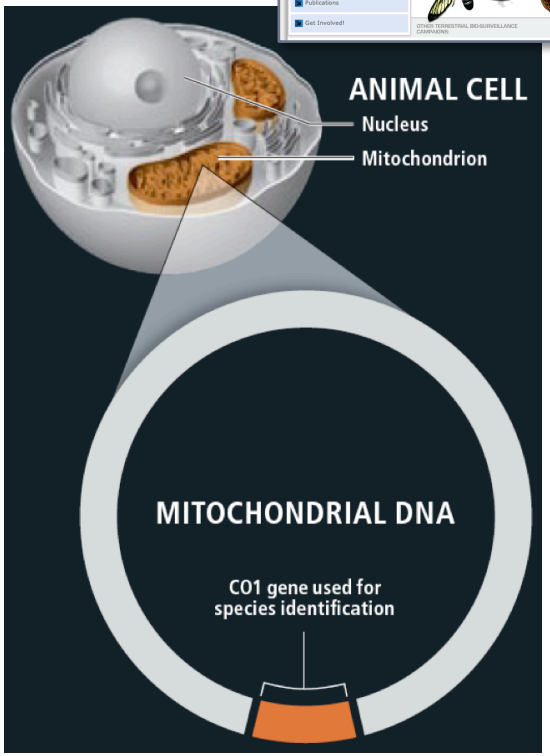




COI tree (Caesar et al 2006)

DNA barcoding: sorting & IDs

- DNA barcoding as a tool for inventories (e.g. Janzen *et al.* 2005)
  - informed sorting and tentative species identification
  - minimize specialist time



Urban park moth inventory

- Stanley Park, Vancouver in 2007

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ORIGINAL PAPER

In the dark in a large urban park: DNA barcodes illuminate cryptic and introduced moth species

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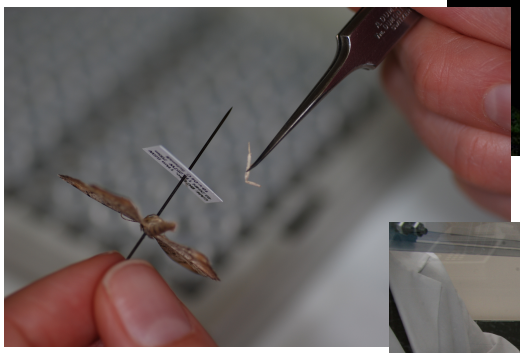
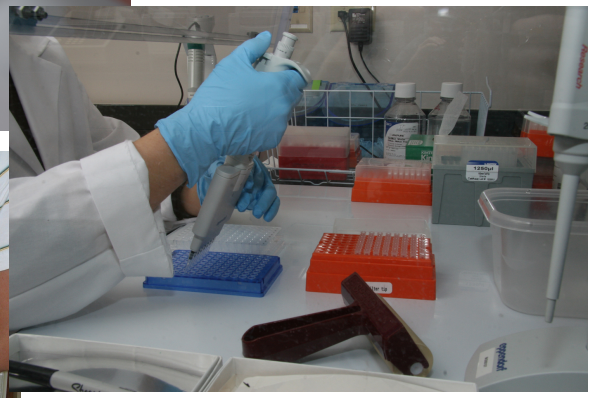
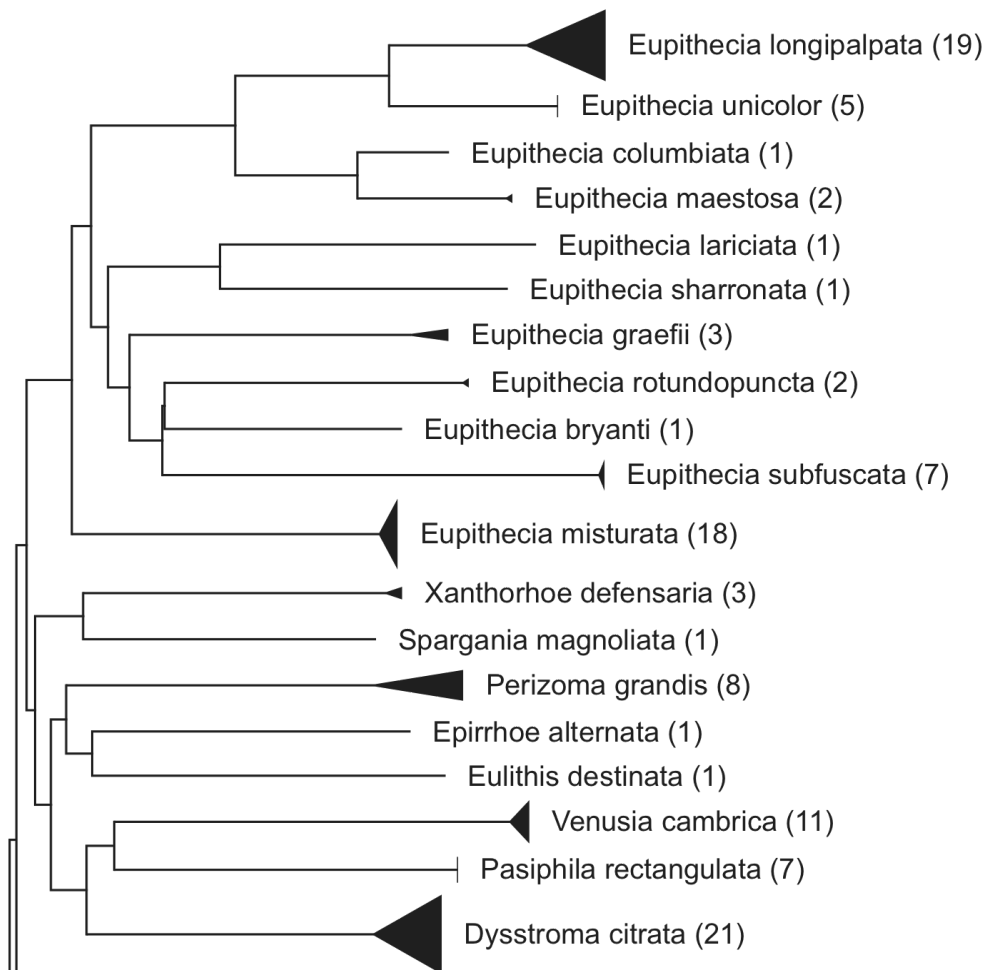
Methods: collection & analysis

- MV light / sheet collecting
- synoptic each collection night
- DNA barcoded all 925 specimens
- BOLD-ID for IDs (where possible)
- confirmed morphologically





Results: species assignment



- 190 clusters, 124 assigned to species, 61 to genus using BOLD-ID
- 66 remaining clusters identified
  - 25 with brief comparison
  - 41 with genitalic dissections

* first (and only) step for specialist; 7% of specimens

Results: highlights of inventory

Prays fraxinella

Dichelia histrionana

Paraswammerdamia lutarea

Argyresthia pruniella

- 190 species
- 21 families
- 71 singletons

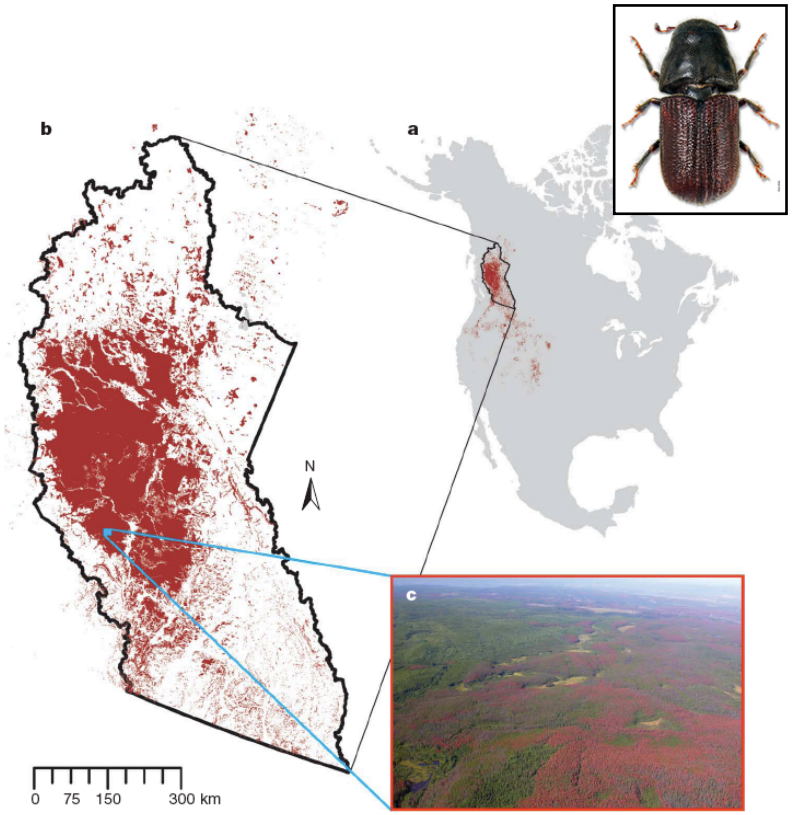
* taxonomically diverse; many at low density

* 4 non-indigenous

* not complete, but solid start

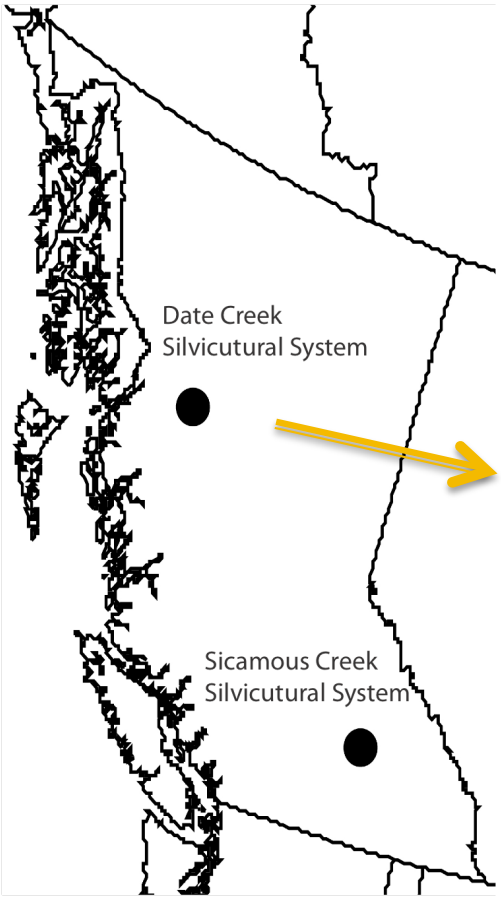
Diversity effects of disturbance

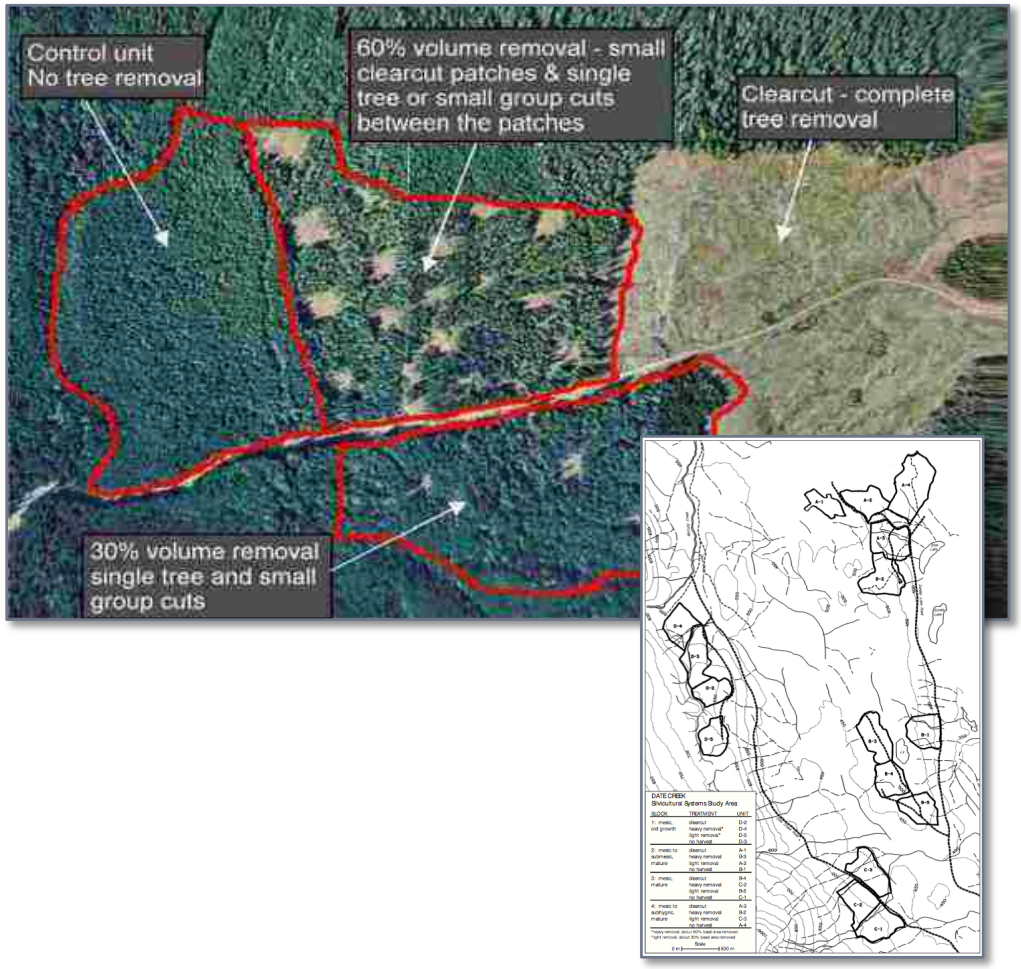
- how do anthropogenic and natural disturbances affect forest biodiversity?
  - we can now rapidly assess diversity changes in hyper-diverse assemblages



Natural disturbance example: native pest outbreak of mountain pine beetle (Kurz et al 2008; NRC)

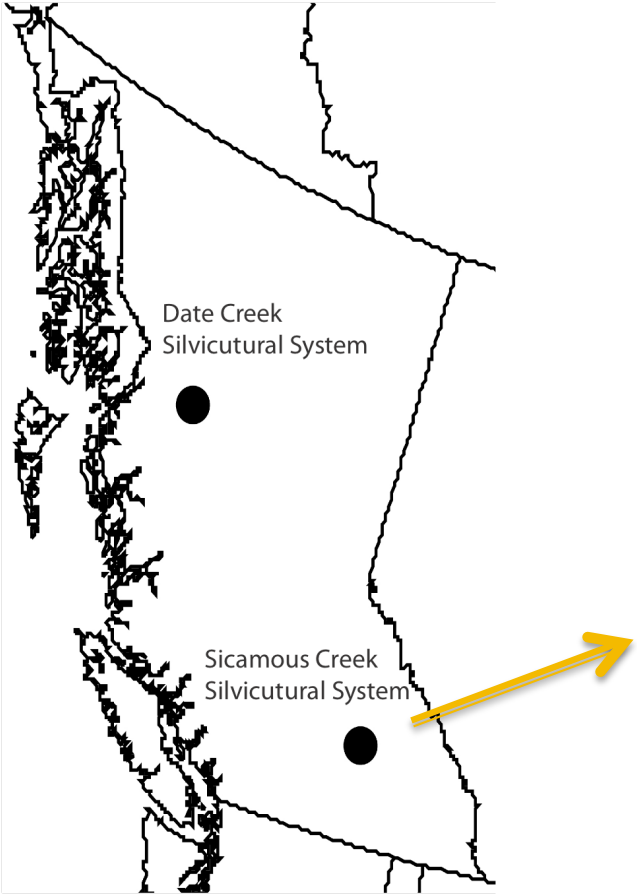
The effect of harvest types on lepidopteran diversity

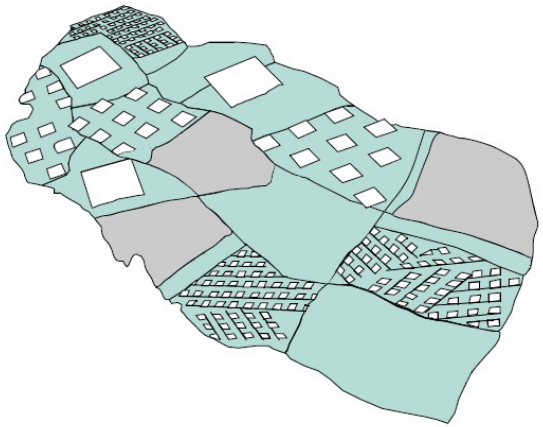


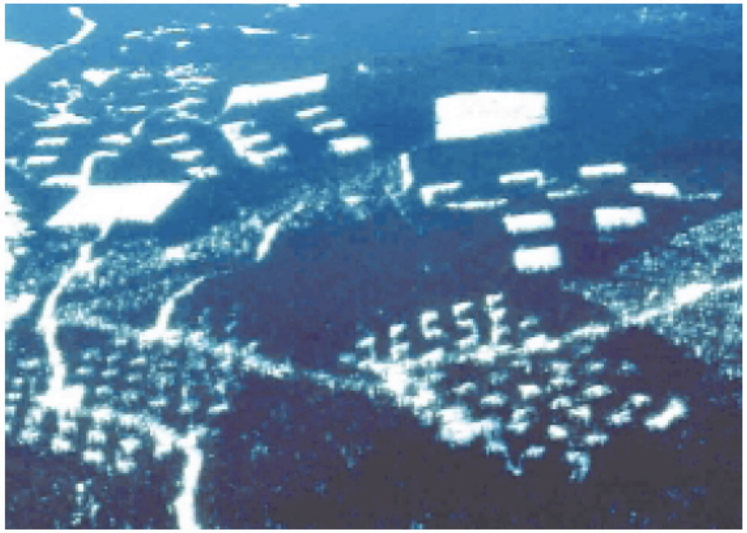


Date Creek Silvicultural System (Coates et al 1997): Interior Cedar–Hemlock, ~450m

The effect of harvest types on lepidopteran diversity







Sicamous Creek S.S. (Huggard & Vyse 2002): Engelmann Spruce - Subalpine Fir, ~1650m

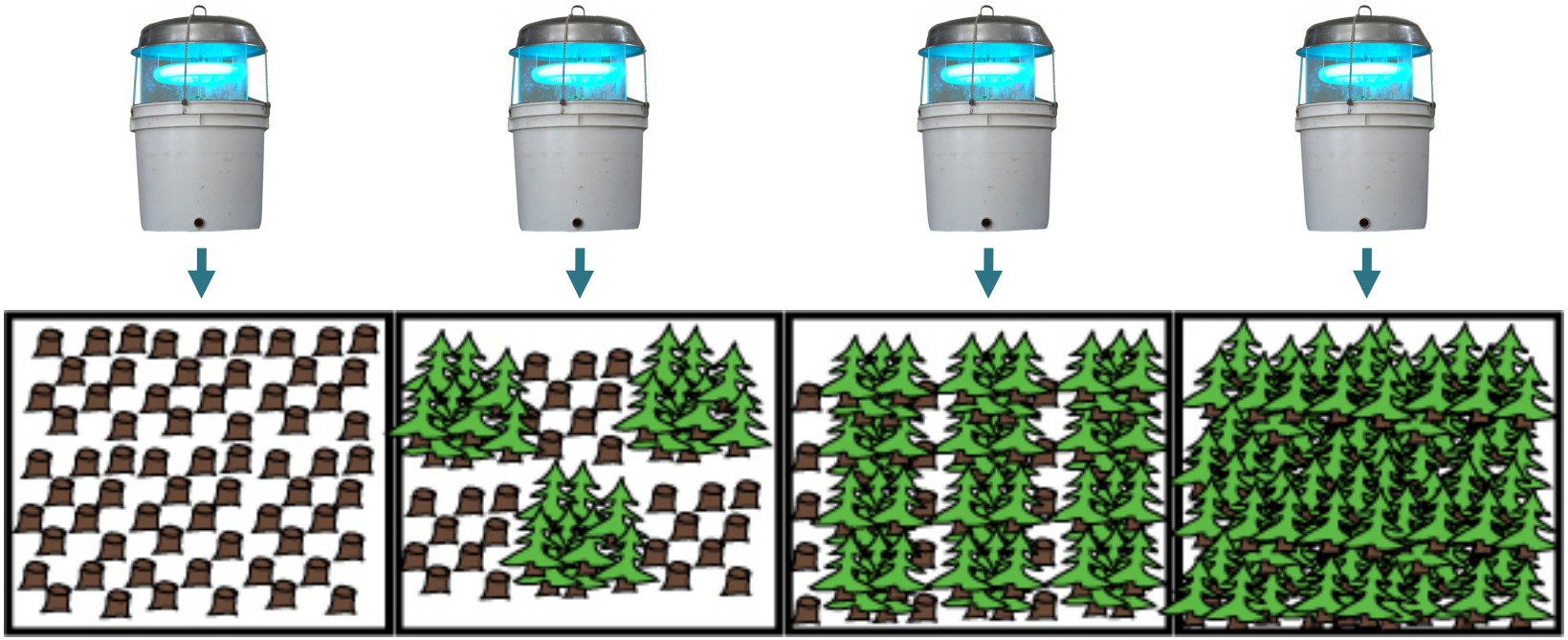
Harvest treatments

- 3 treatments, 1 control
  - **CC** – clear-cut
  - **HR** – heavy removal (patch cut)
  - **LR** – light removal (individual tree selection)
  - **NH** – no harvest (350 year old stand)

Date Creek treatments

Methods: trapping

- UV light traps allow standardized effort
- single trap per treatment, far from edges
- 8 traps per night; ~tri-weekly through flight season



CC LR HR NH

X 2

Methods: sorting

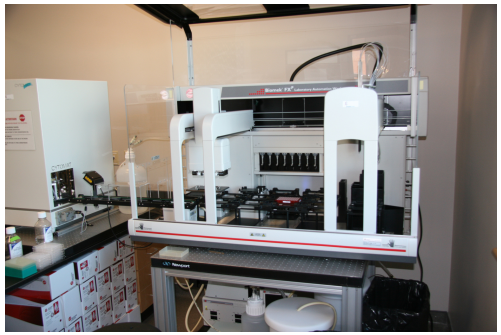
- 27 complete comparisons (CC vs HR vs LR vs NH)
  - 108 traps
  - 10,904 specimens
  - field-pinned nearly all
  - sorted to morphospecies

Methods: sampling

- for barcoding, we analyzed a synoptic of each trap
- analyzed all specimens not confidently placed to single morphospecies (e.g. rubbed specimens; tough genera)
- imaged, sampled and vouchered 6117 specimens

Methods: lab

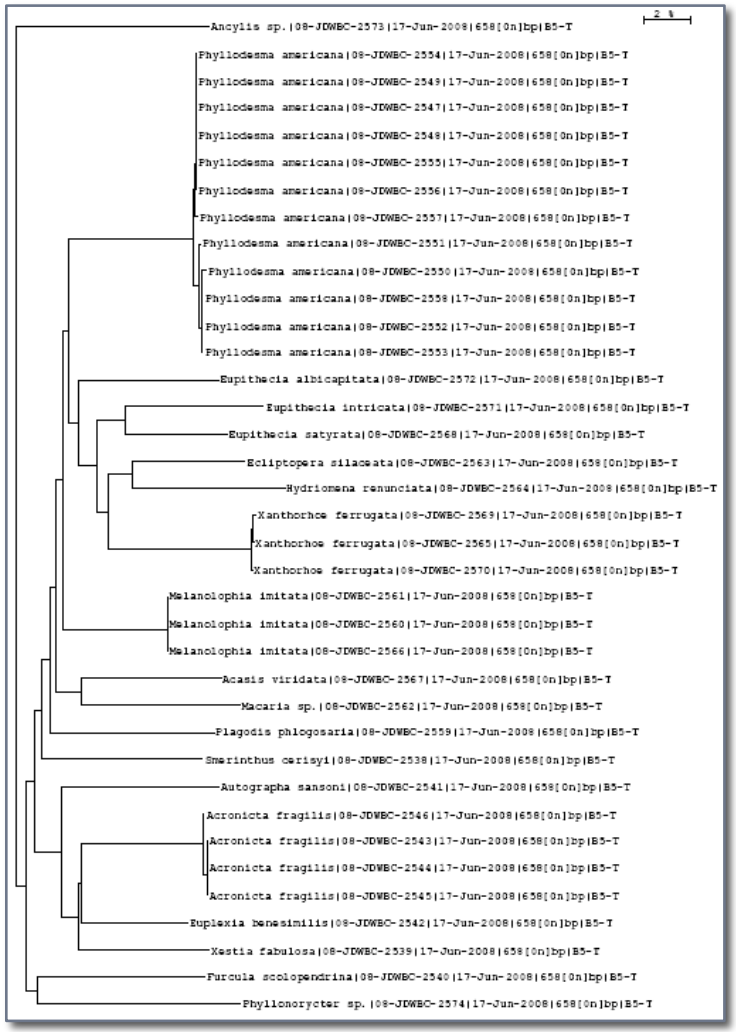
- completed at Canadian Centre for DNA Barcoding in Guelph, ON
- amplified and sequenced COI using standard protocols
- all sequence data, images, and collection data stored on BOLD



Results: barcoding

- 6101/6117 successfully barcoded
  - remaining 16 were easily assigned to species
- most* matched single species / monophyletic cluster in BOLD

* confirmation/identification ongoing



BOLD TaxonID tree for trap LR5

Results: 2 inventories

- Date Creek (DC)
  - 7978 specimens
  - 340 spp.
- Sicamous Creek (SC)
  - 2926 specimens
  - 211 spp.

Parornix DRD30

Hyles gallii

Neoarctia beanii

Highlights of inventories

- high diversity – 26 families, 219 genera
- e.g.
  - *Walshia miscecolorella* (Cosmopterigidae)
  - *Batrachedra praeangusta* (Batrachedridae)
  - *Scythris noricella* (Xyloryctidae)

- single trap at Date Ck – 100 spp.

Highlights of inventories

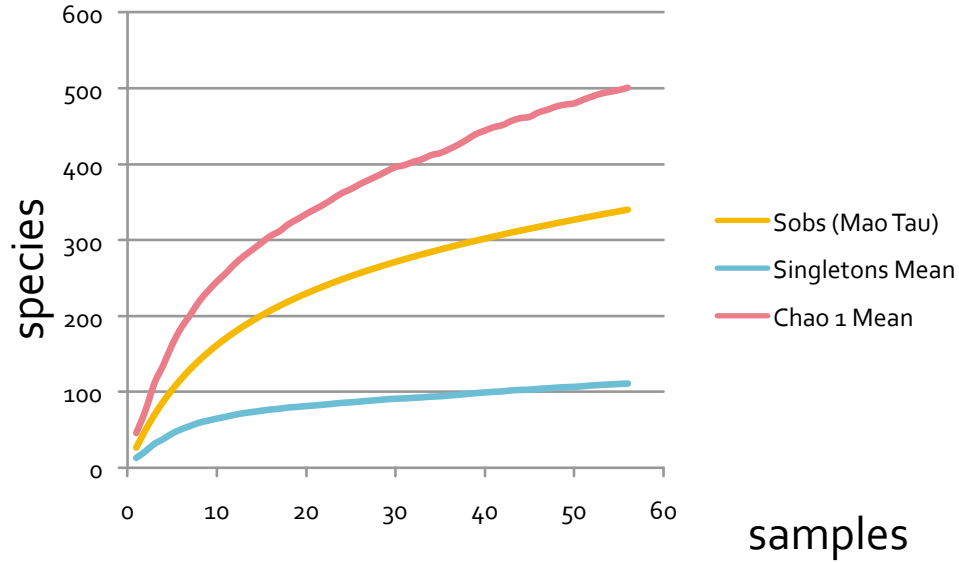
- several difficult genera
  - *Euxoa spp.* (*divergens*)
    - 8 spp. in just 11 individuals at SC
  - *Eupithecia* spp. (*gelidata*)
    - 12 spp. at DC, 13 spp. at SC
  - *Epinotia* spp. (*plumbolineana*)
    - 16 spp. at DC

Highlights of inventories

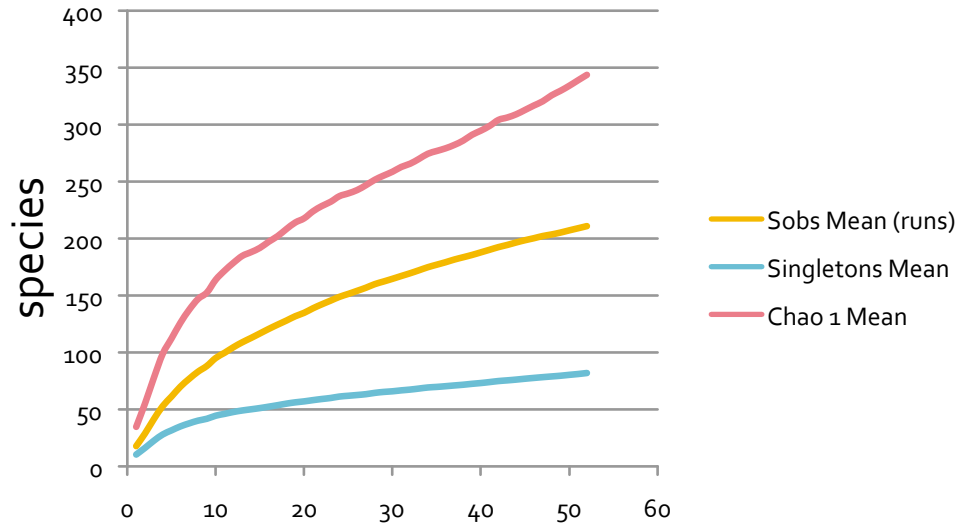
- many pest species in moderate abundance
  - hemlock looper (*Lambdina fiscellaria*)
  - aspen leaf miner (*Phyllocnistis populiella*) (* 481 in 1 trap at DC)
  - western spruce budworm (*Choristoneura occidentalis*)

Completeness of inventories

- Date Creek
  - 501 spp. estimated
  - 340/501 = 68%
  - 111 singletons

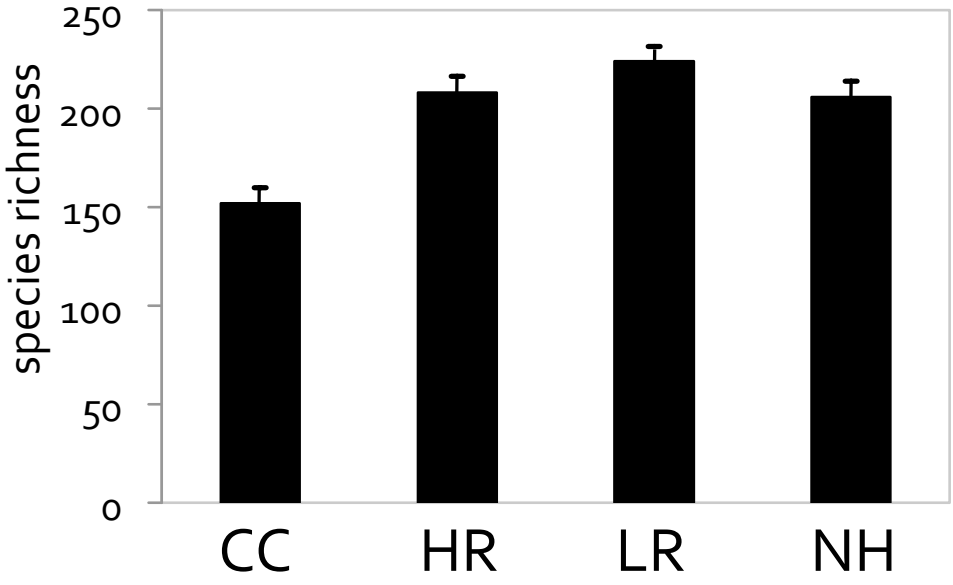


- Sicamous Creek
  - 344 spp. estimated
  - 211/344 = 61%
  - 82 singletons

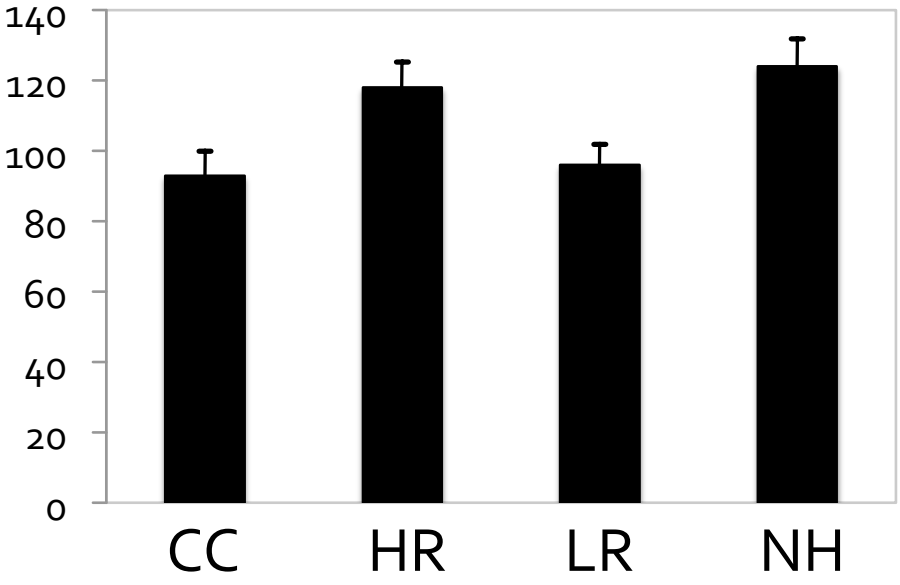


Harvest effects on species richness

Date Creek:



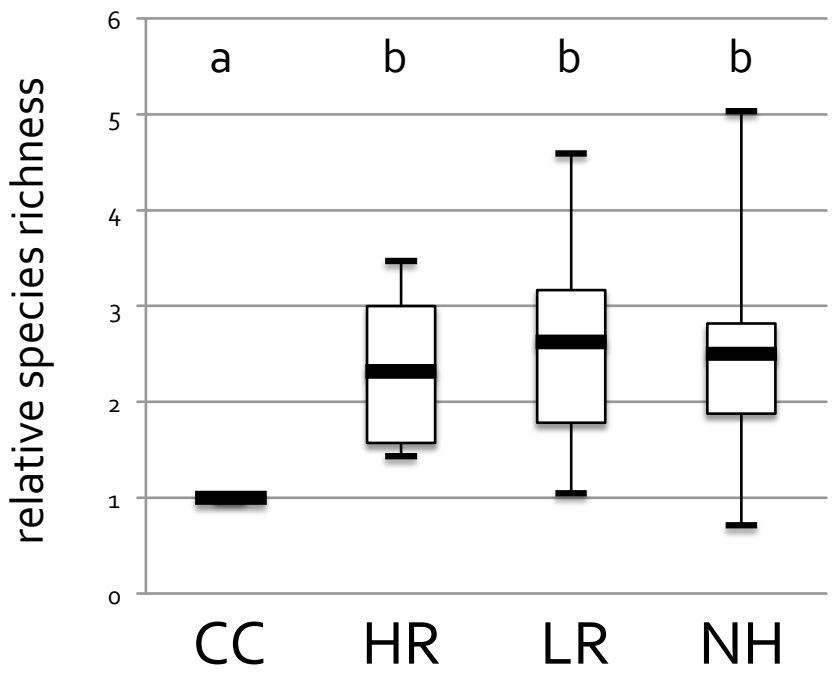
Sicamous Creek:



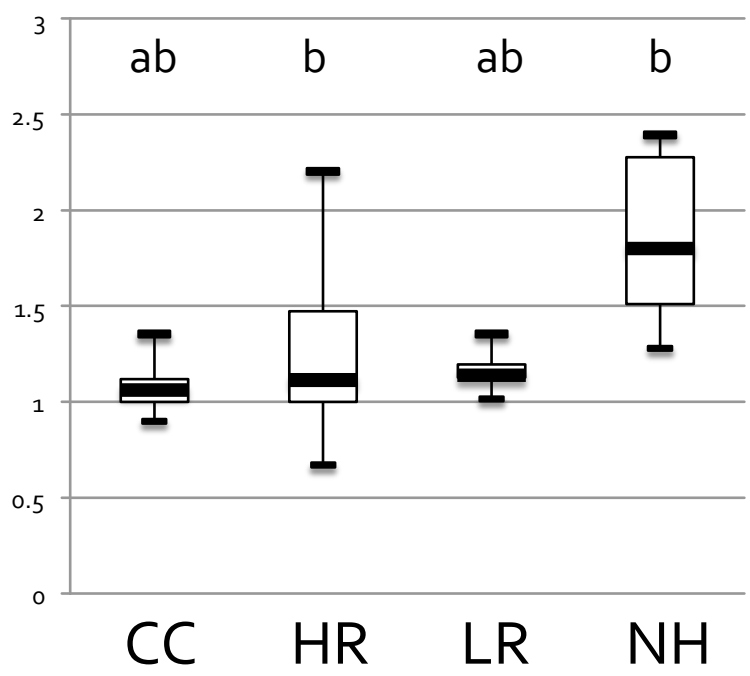
- rarified species richness per treatment

Results: relative comparisons

Date Creek:



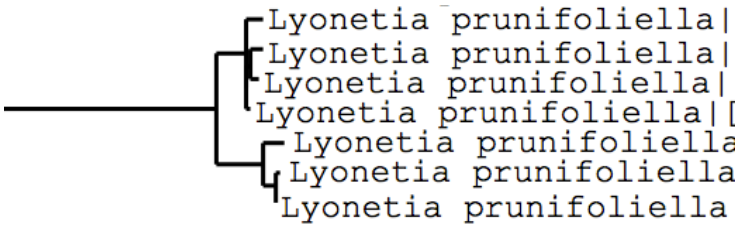
Sicamous Creek:



- relative species richness (same collection event)

Additional levels of diversity

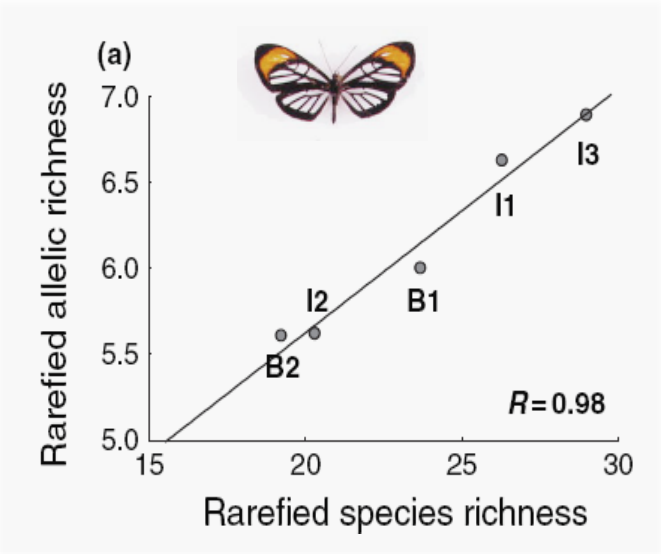
- genetic diversity (GD)
  - e.g. haplotype diversity
  - Stanley Park Leps – mean of 3.4 haplotypes/spp., or one new haplotype every 3.9 individuals
- phylogenetic diversity (PD)
  - variation in evolutionary history
  - can add phylogeny backbone to primary barcode, or not (see Faith 2007)



Lyonetia prunifoliella (Lyonetiidae) contributes highly to both GD and PD

More to do…

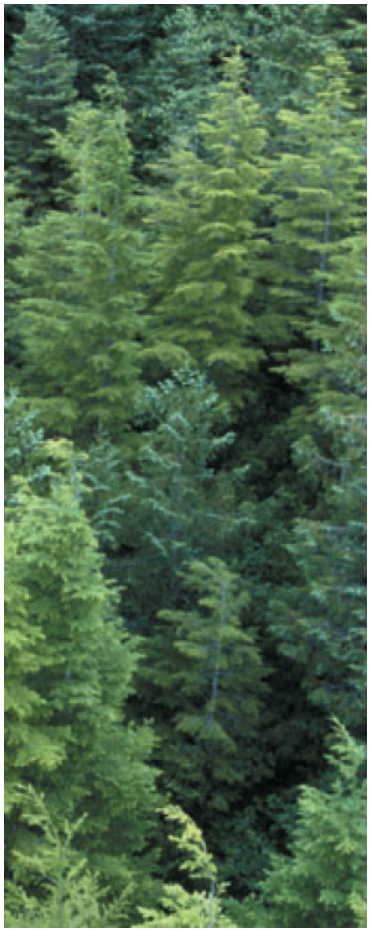
- interplay between 3 levels of diversity
  - can 1 or 2 be a proxy for all?
- family and feeding guild responses
- interesting hypotheses to address
  - e.g. species/genetic diversity correlation (SGDC) (Vellend 2003)



Post-disturbance SGDC in butterflies (Cleary et al 2006).

Conclusions

- DNA barcoding has proven valuable for forest inventory work and looks promising for post-disturbance assessments
- DNA barcoding provides informed sorting, reduction of specialist time, enhanced sensitivity at low density, and estimates of multiple levels of diversity



Acknowledgements

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  - Forest Investment Account – FSP

Thank you.

Hup Holland Hup!