Impacts of harvesting forest residues at different intensities in northern hardwood forests

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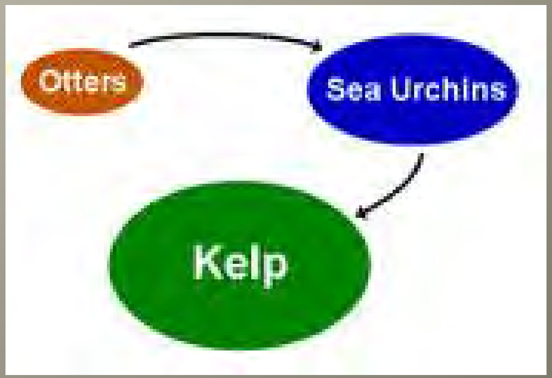
Challenge is assessing the cause-effect relationships of biomass harvest that differ from those of traditional harvest

- Identify quantifiable measures that are sensitive to showing change
- Establish baselines and thresholds of acceptable change relative to the identified measures
  - Magnitude
  - Extent
  - Duration and speed of effects
  - Spatial arrangement

Value of Biological Diversity? – generally accepted that complex systems are more resilient, stable, and productive

- Positive link between biodiversity and ecosystem functioning, but it is not fully understood
  - Large body of research has shown that loss of predator species can have impacts that cascade down a food chain to plants, altering basic ecosystem processes
    - Example: kelp - sea urchin - sea otter food chain
  - Having a range of species that respond differently to different environmental perturbations can stabilize ecosystem process rates, and help preserve range of management options



What would be the impact of residue removal on biodiversity?

What would be the impact of residue removal on biodiversity in northern hardwoods?

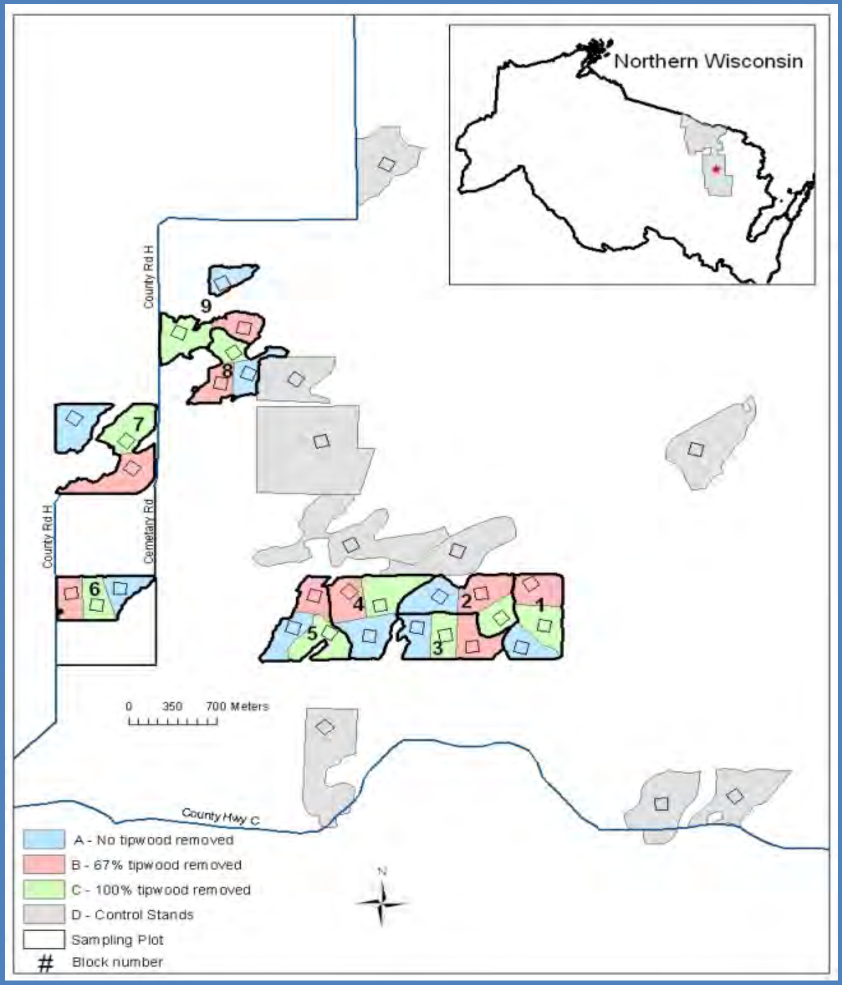
- Lack of down woody debris and structural diversity (e.g., understory shrubs)
- Disproportionate number of sensitive plant species
- Many studies on use of downed woody debris, but the impact often compared against unharvested controls, and presence of large, decaying wood
- Do not measure the impact of FWD removal compared to harvest – level effect

***Objective:* manipulate amount of logging residue left on forest floor after uneven-aged silvicultural treatments**

Compare:

- Soil nutrients: carbon, nitrogen, phosphorus, calcium, magnesium, potassium, sodium, pH levels
- Herbaceous plant community and tree regeneration
- Insect species (particularly Coleoptera: weevils, beetles)
- Amphibian species (salamanders, frogs, toads)

Applied three intensities of forest residue removal across ~900 acres



- 3 biomass removal intensities
  - 0 – 65 -100 %, control
  - ~ 20 acres
  - Similar MN harvesting guidelines
- 9 replicates of treatments
  - ~80 acres / replicate
- Treatments applied to ~ 900 acres on CNNF
- 3 year study; randomized block design

0% tipwood removed; 100% retained

current practice; all tipwood remained on site

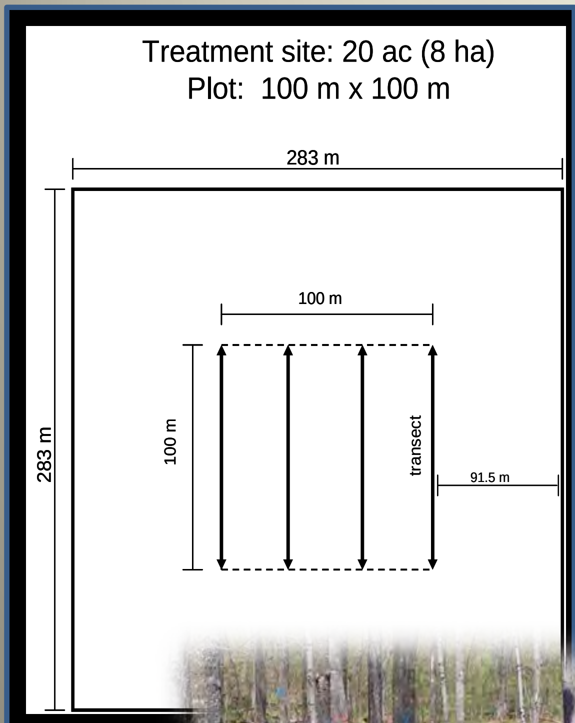
65% tipwood removed; 35% retained

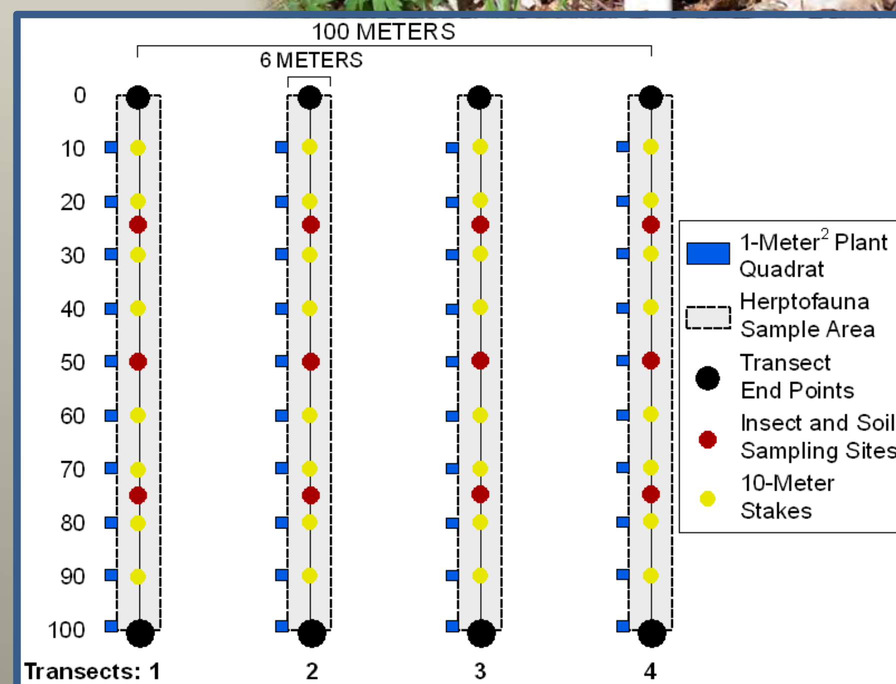
Intermediate retention; based on MN best management guidelines; 4 of every 5 trees were removed and remaining tipwood scattered

100% tipwood removed; 0% retained

All tipwood removed from site; some tipwood remained on site due to incidental breakage during skidding

Measured response variables along 4 transects within a 100 m² plot centered within treatment area





Harvest completed winter 2009-10, Nov - March

Operational Concerns

- Landing size

- Increased residual tree damage?

- Incidental loss of coarse woody debris?

We found an average 200% increase in landing size

– 1,732 tons of tipwood removed (chipped)

– 2 additional landings required; 13 to 15

– 2.4 km^2 used during removal treatment vs. historical 0.8 km^2

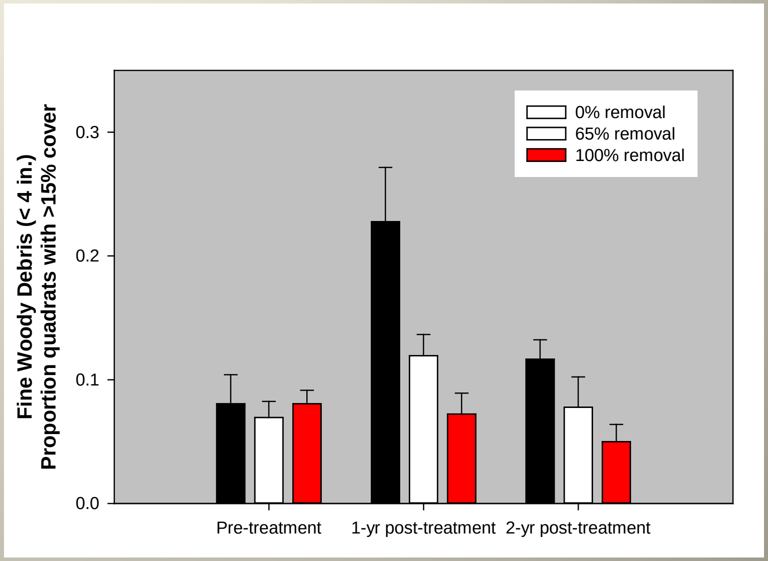
0% removal

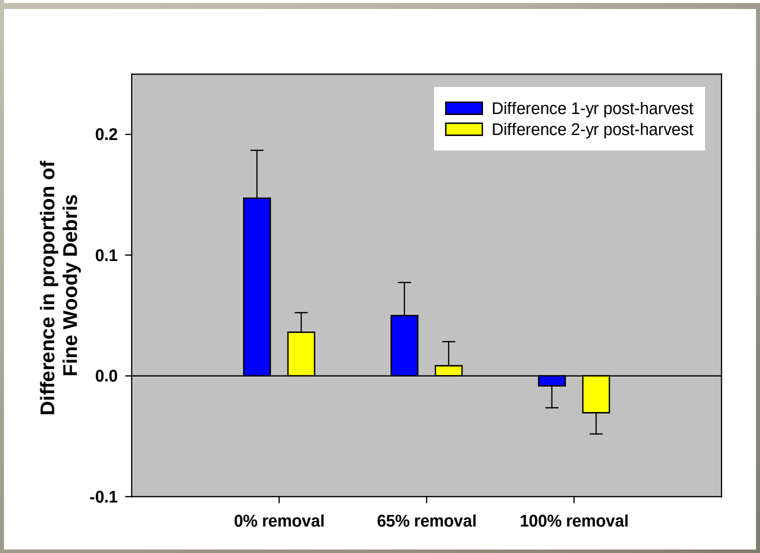
Proportion of trees with bark damage was not significantly different between harvest methods

- Processor with bunk forwarder– average 3% trees per plot showed damage
- Hand-cut with cable skidding WT – 11% trees per plot showed damage
- Damage was noticeable around landing and extra trees had to be removed

Fine woody debris remaining on forest floor followed treatment levels

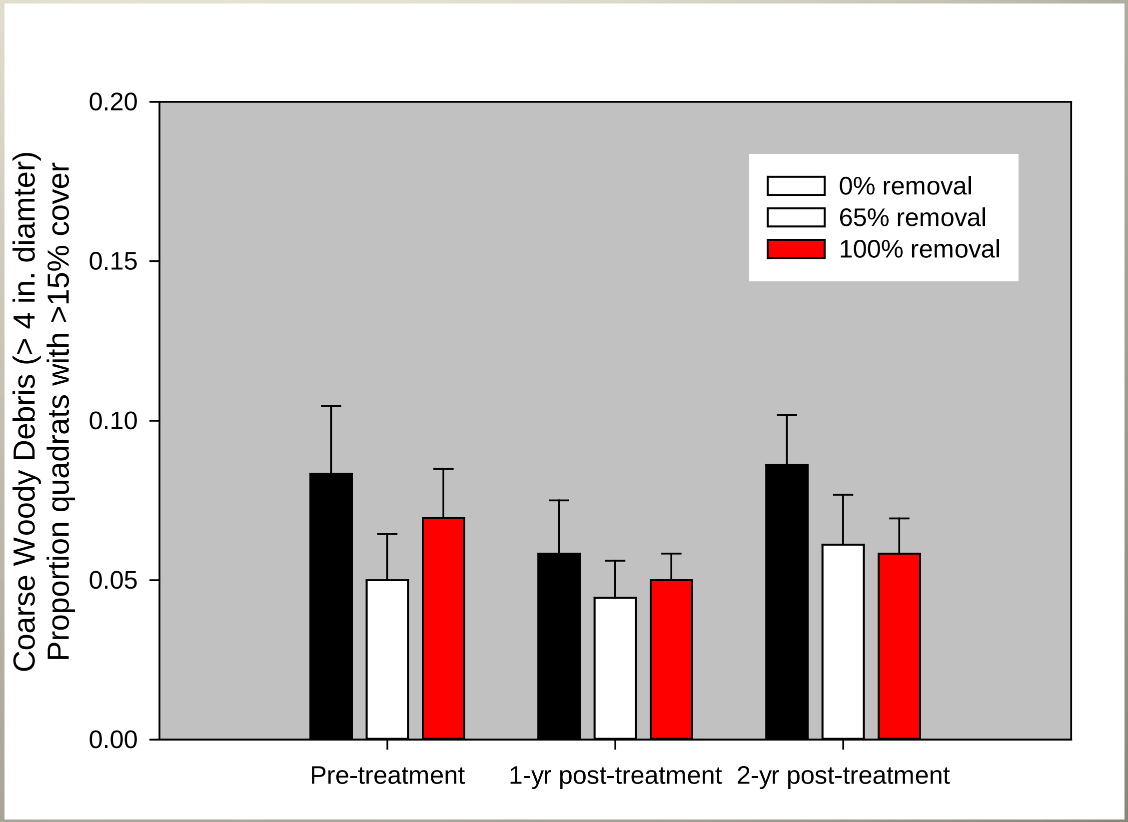
- Fine woody debris retained on-site differed significantly among treatments 1- and 2-yrs post-harvest
- Primarily between 0% and 100% removal
- Amounts declined 2 years after harvest, but pattern remained the same





Coarse woody debris remaining on forest floor was not different among removal methods

- No difference among removal intensities within each year
- No difference between pre- and 1- and 2-yrs post-harvest levels

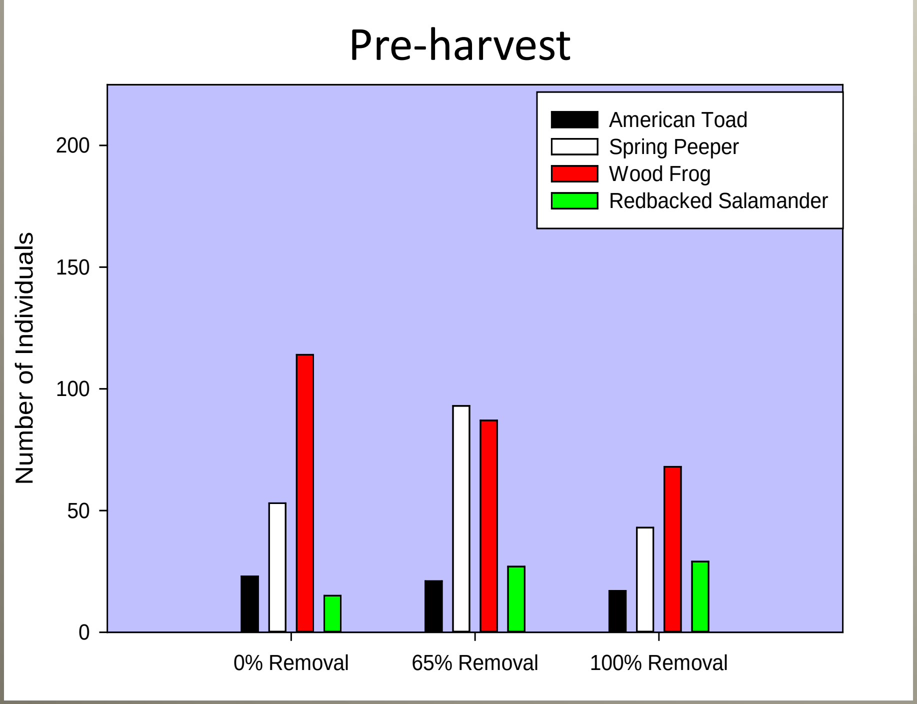


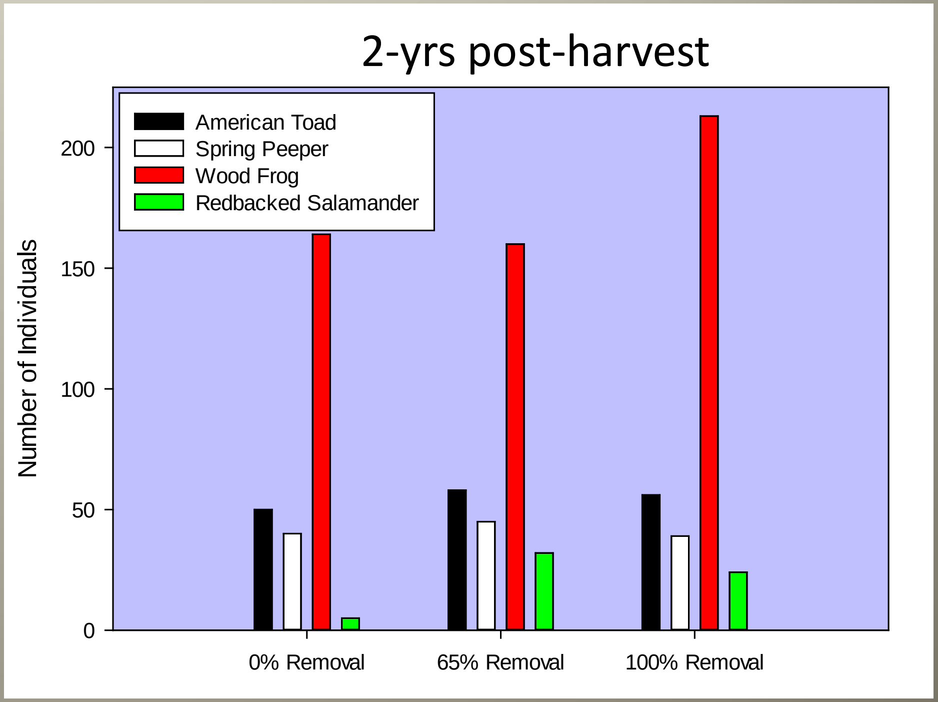
Amphibian community surveyed using time-constrained searches (180 cumulative minutes)

- Number of individuals modeled using N-mixture models ('unmarked' R package)
- Count = Site Variables + Observation (detection) variables
- Detection Variables: maximum temperature; total precipitation

Changes in amphibian population numbers were species specific

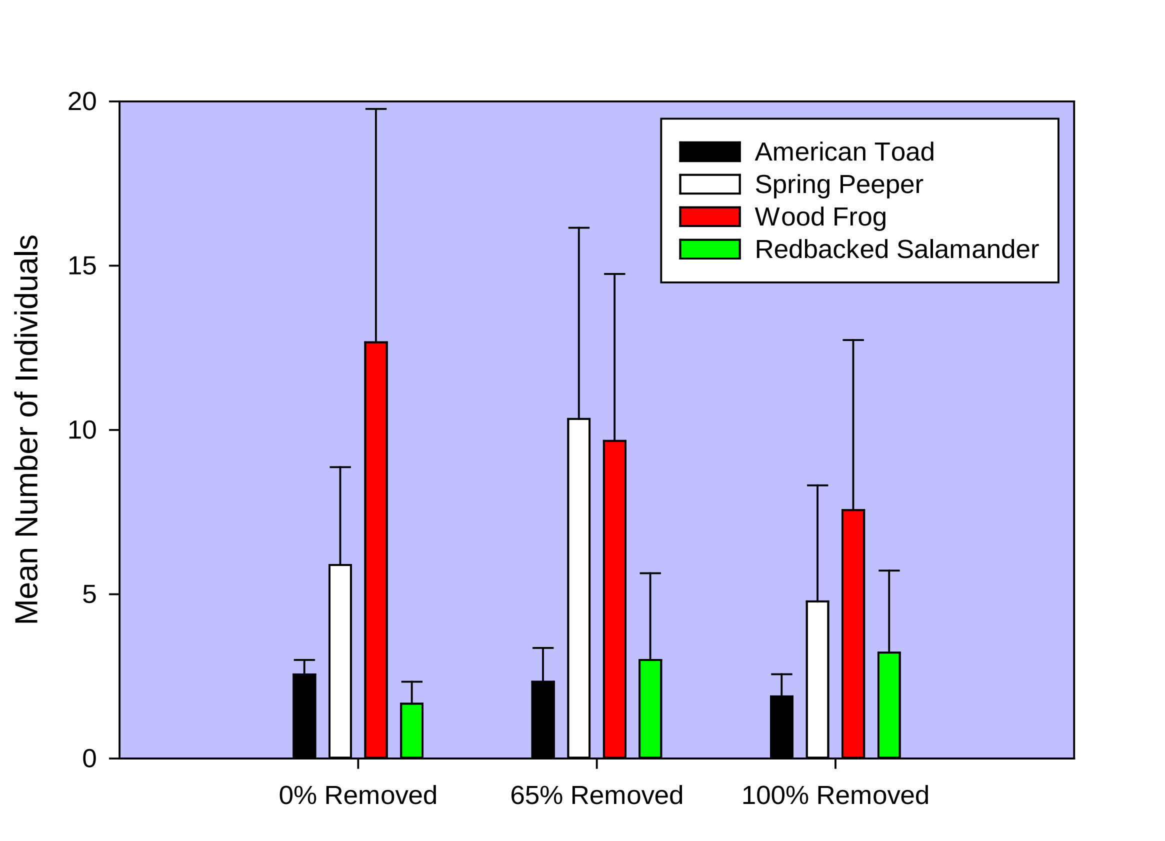
- 8 species captured; wood frog most abundant
- Spring Peepers and Red-backed Salamanders declined in numbers
- Wood frogs and American Toads increased in numbers





Amphibian population responses pre-harvest

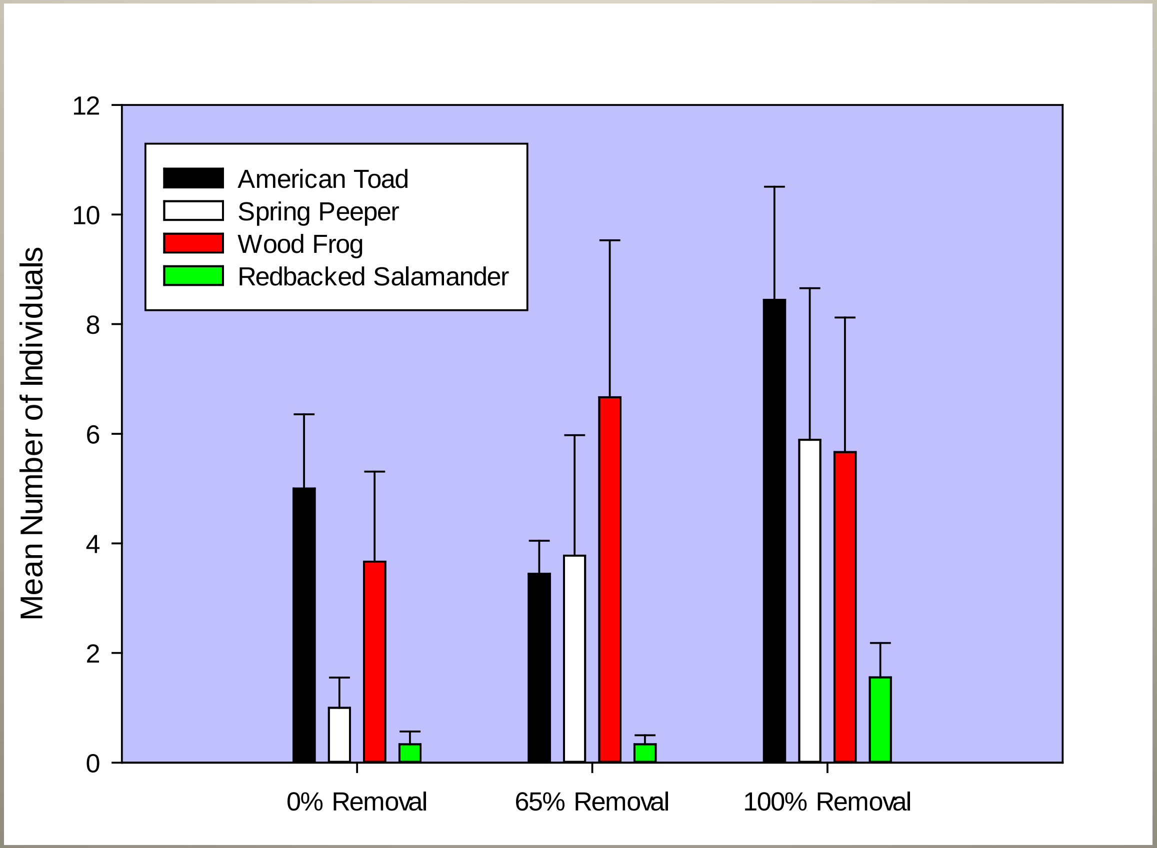
- Abundance of American toads, wood frogs, and red-backed salamanders were similar across treatments
- Spring peeper had significantly more in 65% removal treatment



Amphibian populations were greater in the FWD removal treatments than conventional 1-yr post-harvest

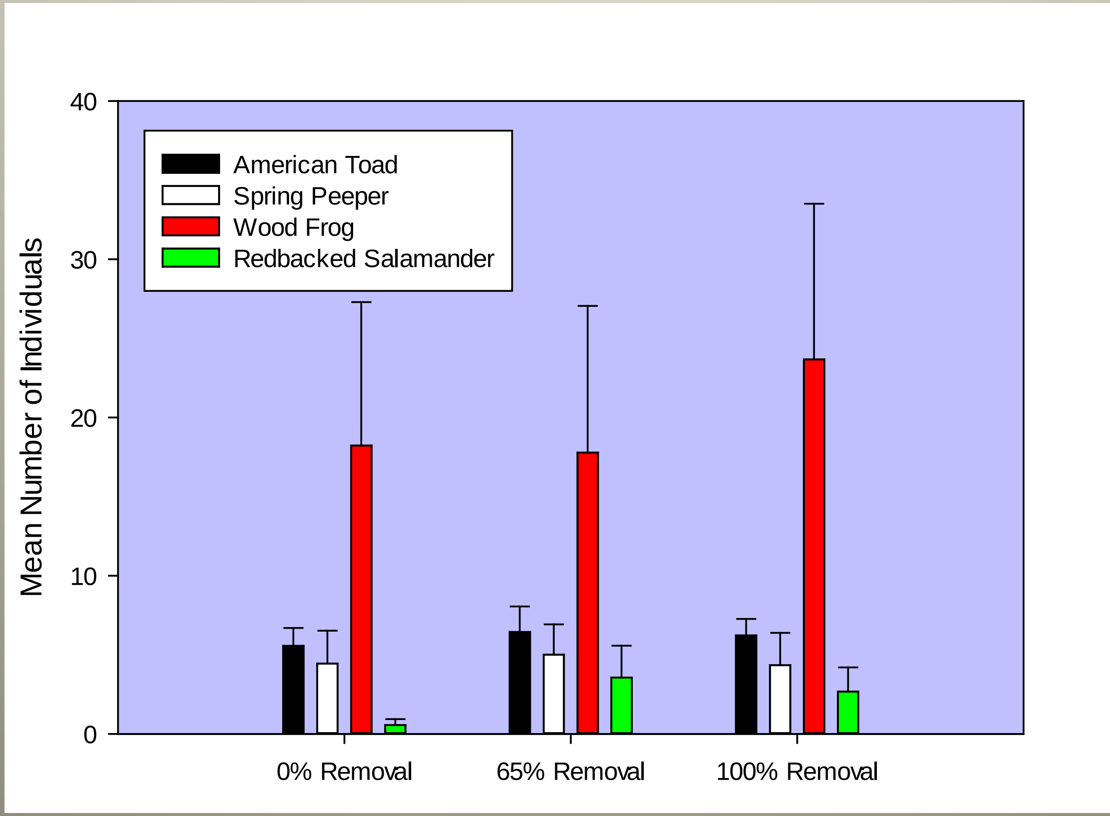
- Wood frogs and Spring Peepers - 65% and 100% removal treatments (i.e., less FWD retained on-site)

- Redbacked salamanders - 100% removal treatment



By 2-yrs post-harvest, most amphibian populations were similar among removal treatments

- Wood frogs, American toads, and Spring peepers showed no difference in abundance among treatments
- Redbacked salamanders remained higher in FWD removal treatments than conventional harvest



General amphibian community short-term responses

- Greater overall numbers 2-yrs post-harvest
  - Microclimate conditions? Herbaceous plants?
- Greatest differences immediately post-harvest, and the relationship with FWD is negative for 2 species (i.e., higher numbers in treatments with lower FWD)
- Only red-backed salamander numbers remained greater in treatments with less FWD
  - Detection?
  - Predator-prey?
  - Differences in large woody debris?

Invertebrate community surveyed using pitfall traps and sweep-netting

Number of individuals modeled using N-mixture models

No Individuals = Site Variables + Observation (detection) variables

Detection Variables: temperature and precipitation

Coleoptera (ground-dwelling beetles and weevils)

- Generally, positive relationship with slash (Gunnarsson et al. 2004)
- 18 families represented (2,854 beetles) *only half samples processed*
- Species Richness – 18 families represented (2,854 beetles)

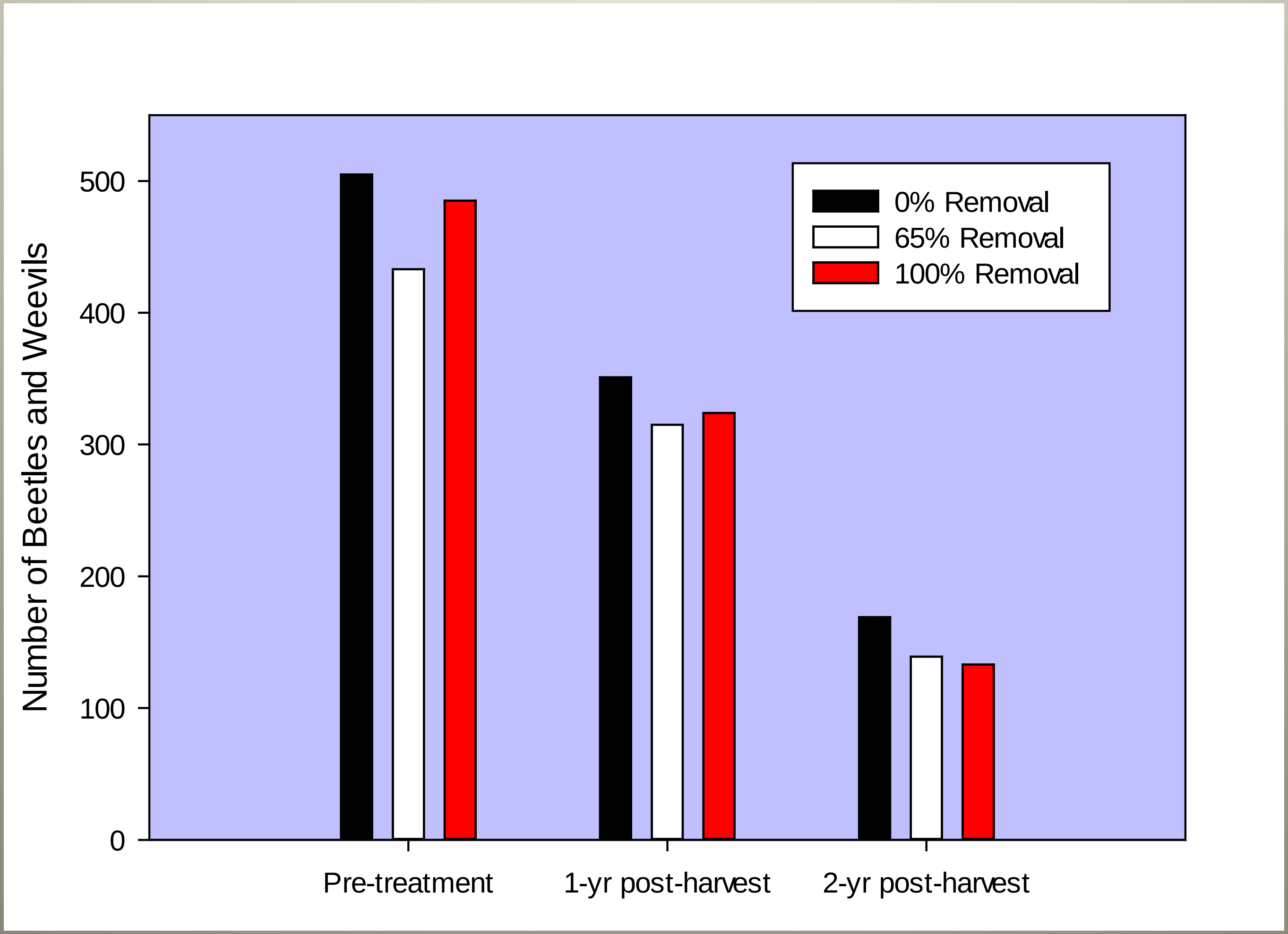
Year	0% Removal	65% Removal	100% Removal
Pre-harvest	15	15	12
1-yr post-harvest	12	11	12
2-yr post-harvest	7	9	11

  - General pattern: loss of families
  - Lost long-horned, bark, sap, leaf, and wood-boring beetles
  - Added Tiger and Soldier beetles

  - CAUTION: results at plot-level richness, may not be best scale

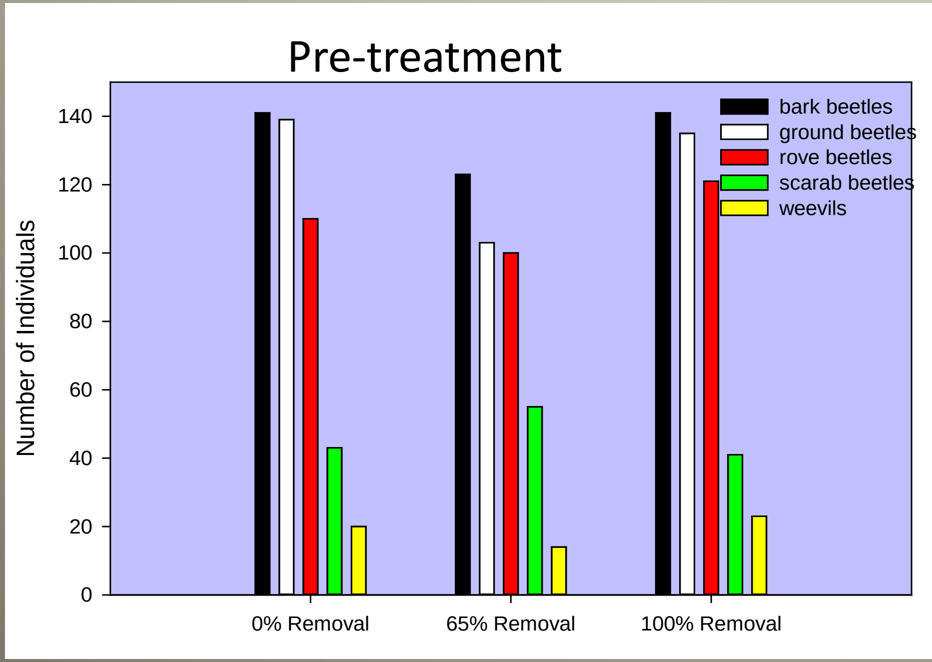
Coleoptera abundances similar across treatments all years

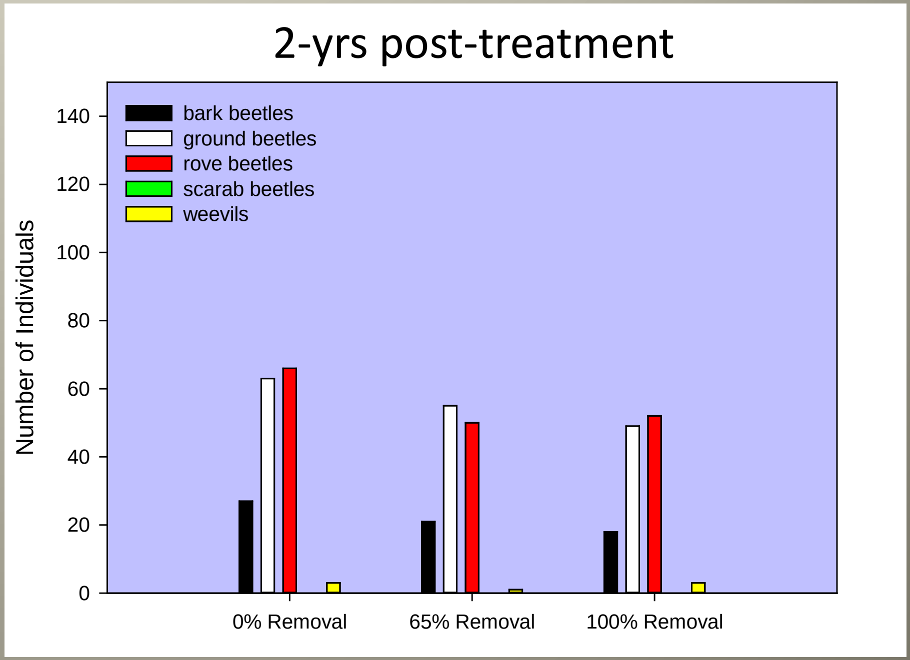
- Harvest-level effect in total abundance
- Decline in abundance 2-yrs post-harvest



More common species showed same abundance patterns

- Bark beetles most abundant pre-harvest; numbers greatly reduce post-harvest
  - Feed on wood; wood boring and long-horned beetles low numbers
- Ground and rove beetles remained next most abundant species
  - Both most easily trapped; Rove beetles feed on other insects
- Loss of Scarab beetles, and greatly reduced weevils





General insect community short-term responses

- Decline in numbers a result of increased amphibians (predators) by 2-yrs post-harvest?
- Mechanism for the lower numbers of beetles that feed on wood?
  - Bark beetles, wood-boring beetles, long-horned beetles

Regeneration impacted?

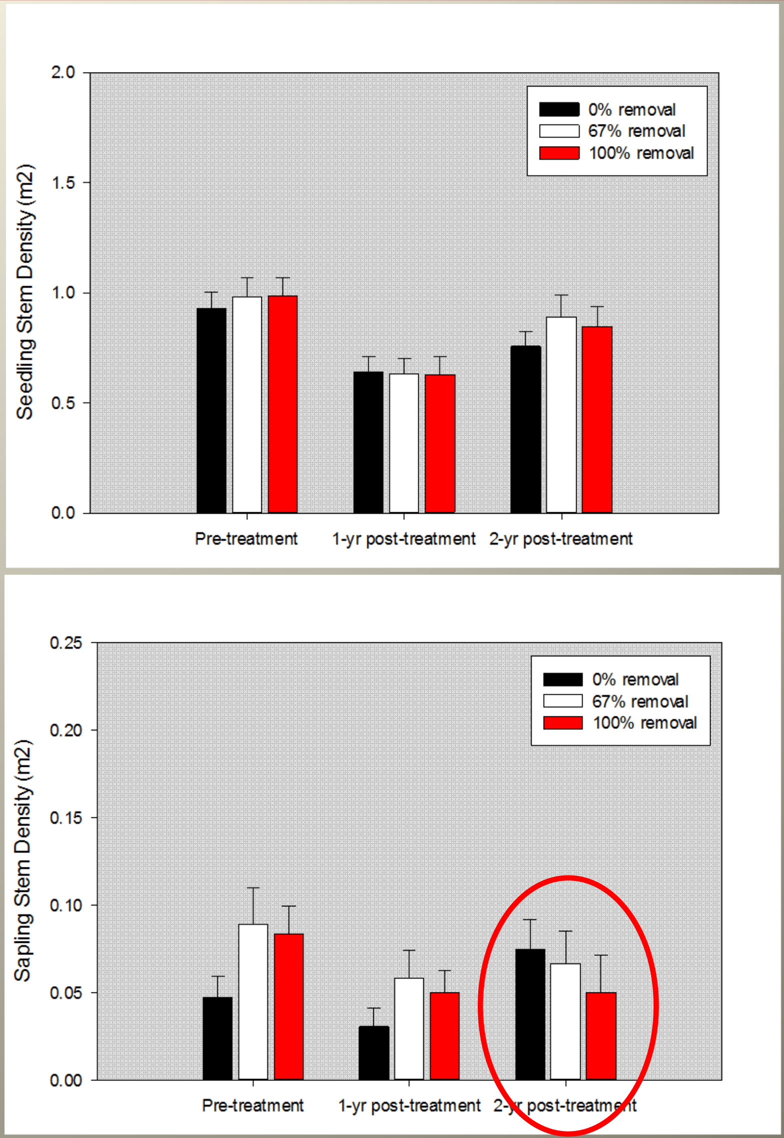
- Microhabitat conditions created by dead and down woody debris important to recruitment of species (i.e., seed establishment)

- Whole-tree harvest had positive effect on seedling survival, but negative effect on long-term growth (Thiffault et al. 2011, a review on effects of FWD harvesting on soil productivity)

- Sampling: 1 m^2 quadrats at 10 m intervals, counted seedlings and saplings

Seedling and sapling stem density was not different among removal intensities

- Sugar maple most frequent; numbers declined slightly post-harvest
- By 2-yrs post-harvest, density similar to pre-harvest levels
- Seedling density of basswood and ironwood increased 2-yrs post-harvest
- Greater increase in sapling density in 0% removal treatment, but not significantly different than other treatments



Herbaceous plant community changes

- Ground-layer plants are highly sensitive to environmental conditions
- Large woody material important to plant diversity, but unknown how FWD impacts diversity
- Loss of insulating woody material may affect sunlight and recruitment responses for the forest floor seed bank
- Potential shift to weedy and early successional species

Generally, species richness remained similar pre- and post-harvest, and among treatments

- 189 species recorded
  - 20 trees, 21 shrubs, 22 fern and fern allies, 105 forbs, 17 grasses, and 13 sedges
  - No sensitive species were recorded

- Forb and fern species richness and composition similar among treatments and years (using nonmetric multidimensional scaling – VEGAN R package)

- Shrub species richness significantly lower 1-yr post-harvest (7 species) compared to pre- and 2-yrs post-harvest (14 species)
  - Dogwood species less common post-harvest
  - *Ribes* and *Rubus* species more common post-harvest

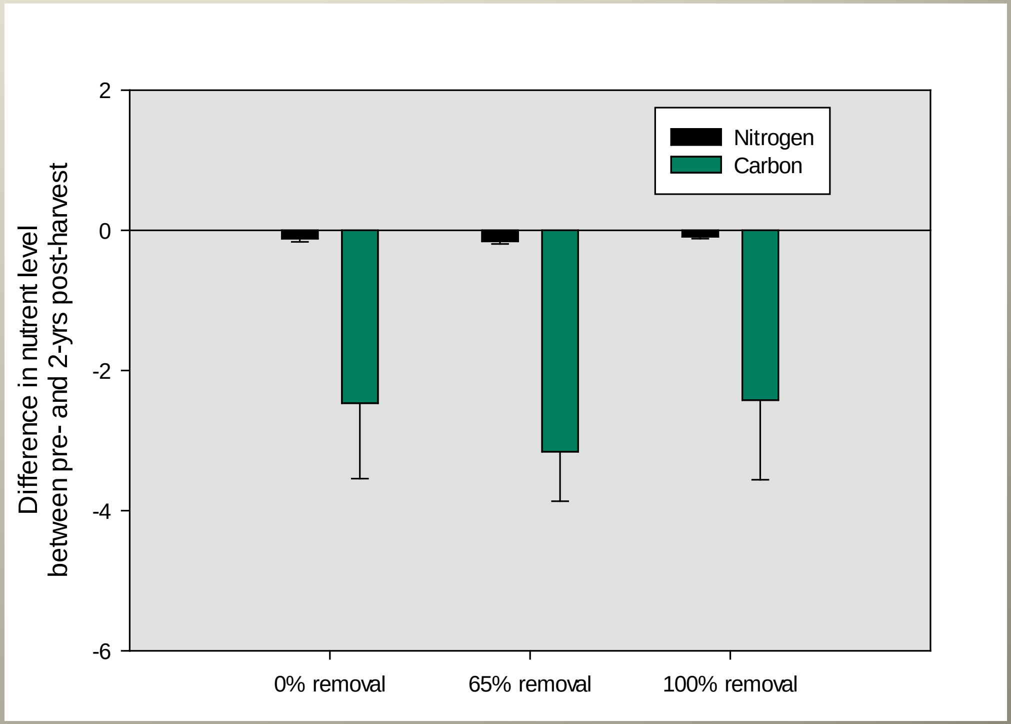
Does residue removal influence soil C and N in northern hardwood systems?

- Soil cores taken at 25 m intervals; August
- Nutrients measured in organic matter, and mineral soil at 4 depths: 0-5, 5-10, 10-20, >20 cm (2,160 samples)
- C, N (completed); Ca, K, P, Mg, Na (pending)

Carbon and Nitrogen concentration levels were similar among removal intensities

- Organic matter layer : lower 2-yrs post-harvest
- Concentrations did not change in mineral soil depths
- Lower concentrations deeper the depth

Organic Matter layer



Summary and Future Research

- In general, observed ***short-term*** harvest-level effects
- Greatest changes in community assemblage response to FWD removal was found in Coleoptera (beetles)
- Mechanism most likely combination of predator-prey relationships, response to changing microhabitat conditions, detection
- Future research will be continued 7- and 15-yrs post-treatment to gain a better understanding of long-term effects

QUESTIONS?