# Biofuel harvests, coarse woody debris, & biodiversity:
## What do we know, and what do we need to know?

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Traditional forest harvest operations often produce large amounts of woody residue consisting of tree-tops, limbs, slash, foliage, and felled non-crop trees and small-diameter trees that cannot be sold at value great enough to justify the costs of removing it from the site. However, harvesting (i.e. removing) could become economically feasible because these residues have potential to help meet increasing demand for biofuel and allow the forest industry to participate in the emerging economic market for biomass feedstocks.

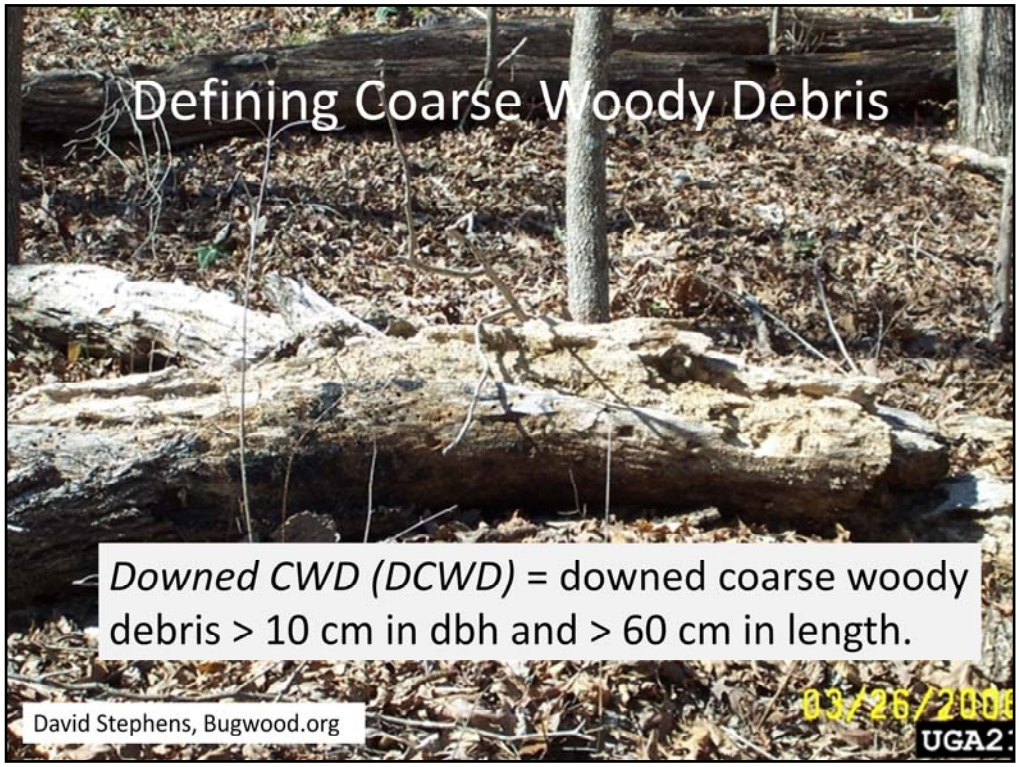

It is not clear how forest biodiversity would respond to removal of forest harvest residues during biomass operations. A primary mechanism for biodiversity response would likely occur through changes in the amount of snags, down coarse woody debris (DCWD) and fine woody debris. Harvest residues may represent a substantial input of DCWD. Thus, removal of harvest residues may impact amount of DCWD present during years following the biomass harvest.

## Defining Coarse Woody Debris

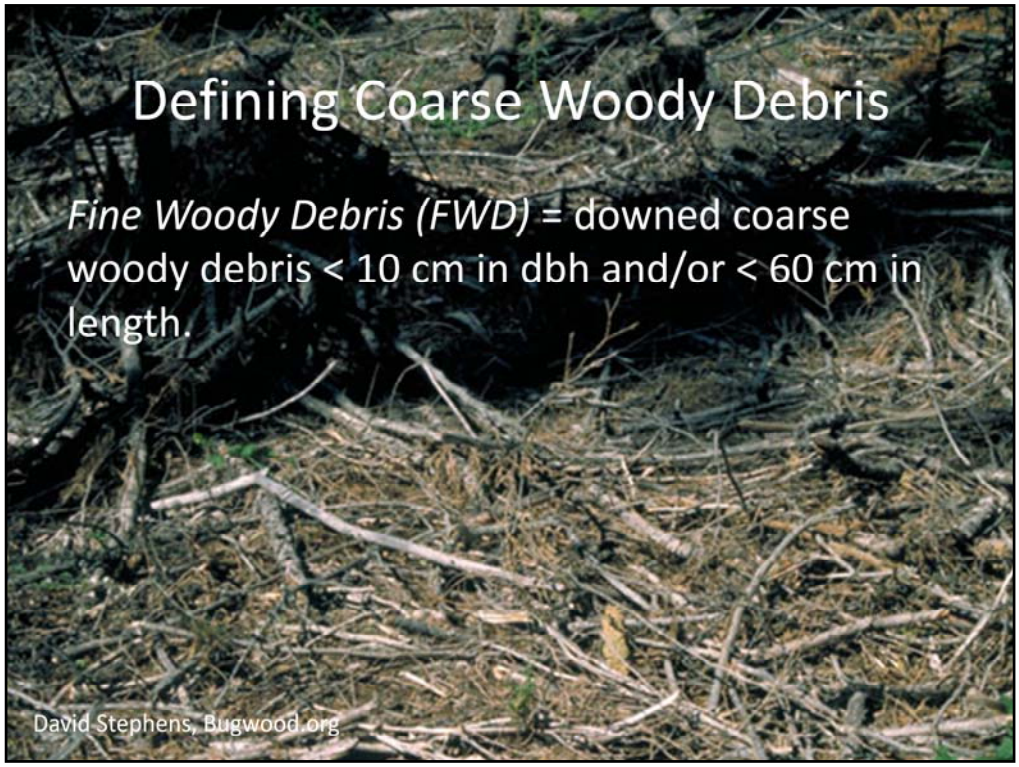

*Snags (standing CWD)* = standing dead trees ≥ 1.8 m in height & ≥ 10.2 cm diameter at breast height (dbh) following Thomas (1979).

David Cappaert, Michigan State University
Bugwood.org

***Snags*** are standing dead trees ≥ 1.8 m in height and ≥ 10.2 cm diameter at breast height (dbh) following Thomas (1979), although others may use slightly different girth and height criteria.




***Down coarse woody debris*** **(DCWD**) is downed dead wood such as logs, stumps, piles of limbs, and other woody material of a minimum size found on the forest floor. Although no universally recognized size criteria exist, most of the studies we reviewed defined CWD as > 10 cm in dbh and > 60 cm in length.



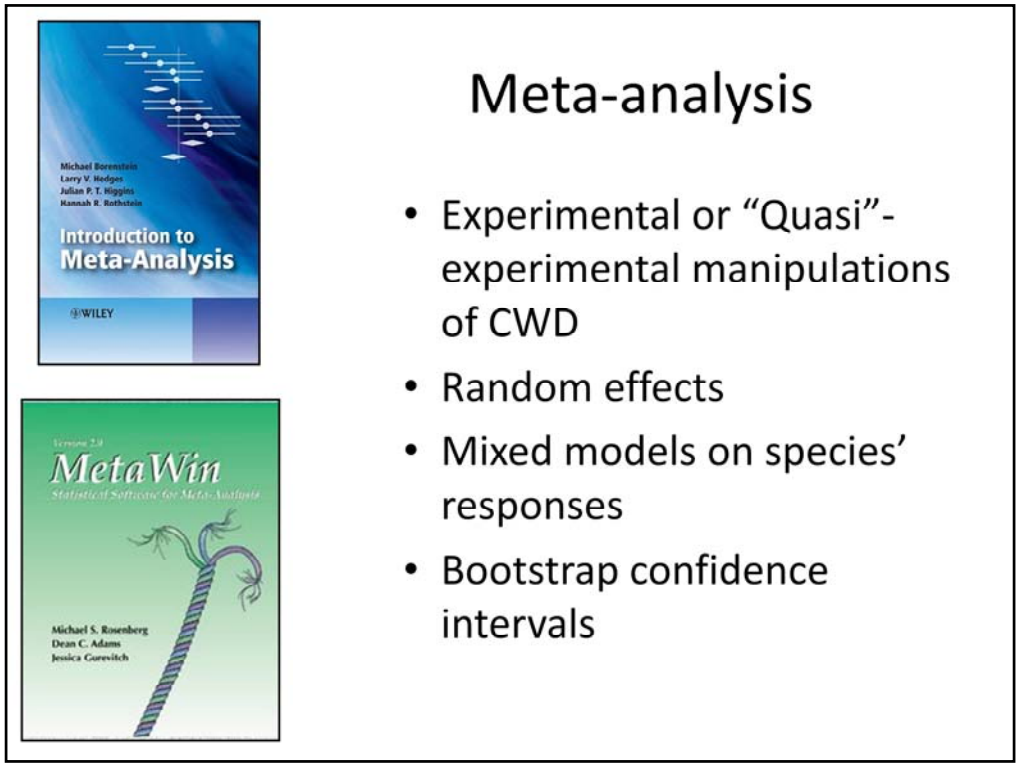

***Fine woody debris*** (FWD) as down, dead woody material smaller < 10 cm in dbh and/or < 60 cm in length.


In addition to breeding sites for cavity-nesting animals, woody debris provides habitat structure for foraging, resting, thermoregulation, and escape from predators for a variety of animals including birds, mammals, and herptofauna. Animals may use woody debris to cache food, movement corridors, and display & communication.

# Literature Search

Wildlife & Ecology Worldwide, USDA Forest Service TreeSearch, & Google Scholar

coarse woody debris, fine woody debris, snags, harvest residue, slash, salvage logging, biodiversity, diversity, richness, wildlife, birds, avian, amphibians, reptiles, invertebrates, insects, and mammals




We reviewed the literature for papers that compared biodiversity responses to experimental manipulations of downed coarse woody debris and/or snags. We included both manipulative experiments and management experiments where harvested areas were compared to appropriate unharvested controls. We included studies of salvage logging – harvest of merchantable residues after large forest fires to recover economic value of wood – because it is a common practice in forests in western North America. Additionally , demand for woody biomass may increase the frequency (and intensity) of salvage logging. Also, salvage logging mimics – to a certain extent – CWD manipulations likely to occur in biomass harvests, especially post-disturbance. Salvage logging experiments reduce standing dead biomass similar to what might occur when non-crop trees are removed at harvest and potentially reduce the future stock of snags.

## Response Ratios

$$\ln R = \left(\overline{X}_E / \overline{X}_C\right)$$

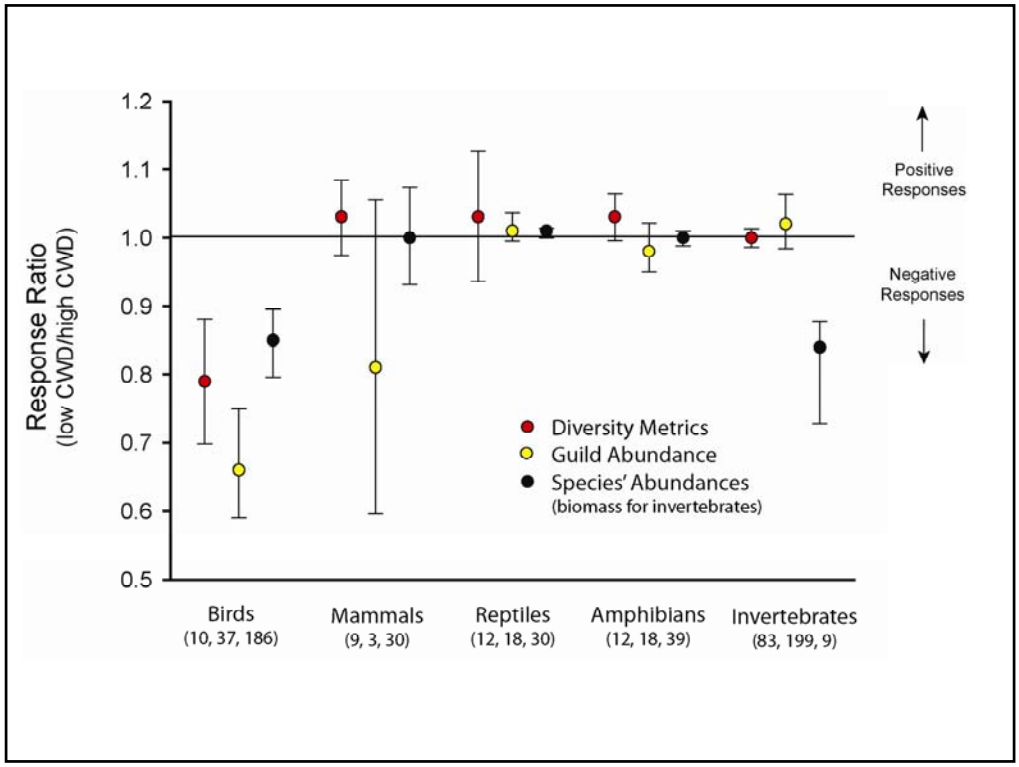
- Low CWD = control group
- RR > 1.0 = positive response to lower CWD
- RR < 1.0 = negative response to lower CWD

Diversity responses included diversity metrics (i.e., species richness, diversity, or evenness), abundance of taxa or groups of species (guilds), and abundance of individual species. We included responses of birds, mammals, reptiles, amphibians, and invertebrates. We calculated a response ratio which is the ratio of the experimental to control groups. For each response, we coded the low CWD treatment as the control so that response ratios could be consistently interpreted. For example, when DCWD was experimentally removed, we coded the removal group as the "control" group for meta-analysis. Response ratios < 1.00 indicate a negative response to lower CWD levels, and ratios > 1.00 indicate a positive response to lower CWD. Because some means were zero, we added 1 to all means before calculating effect sizes. We used bootstrap confidence intervals and considered a combined effect to be significant if the confidence interval did not include 1.00.

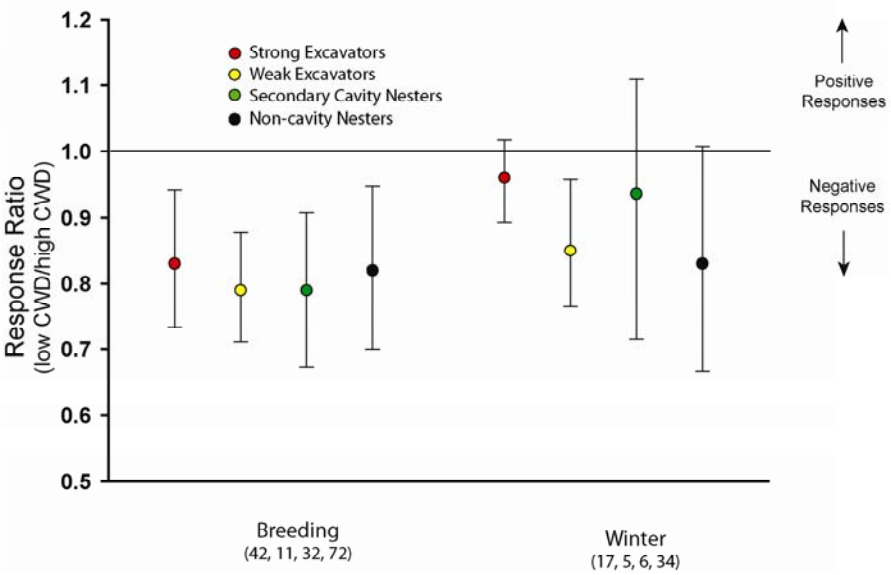
## 25 Papers / 723 Effect Sizes

- Removal of DCWD
- Addition of DCWD
- Snag removal (including salvage logging)
- Snag addition
- Removal of both snags and DCWD

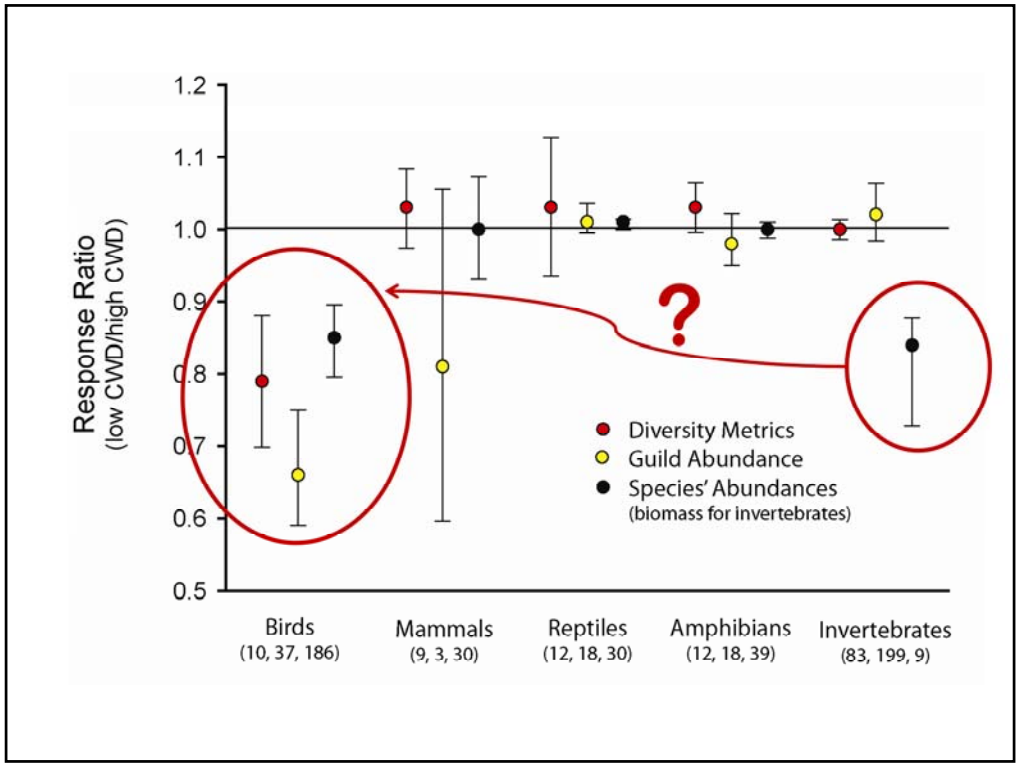
We found 25 papers that met our criteria, and these studies provided 723 effect sizes. Experimental treatments included 5 different manipulations.



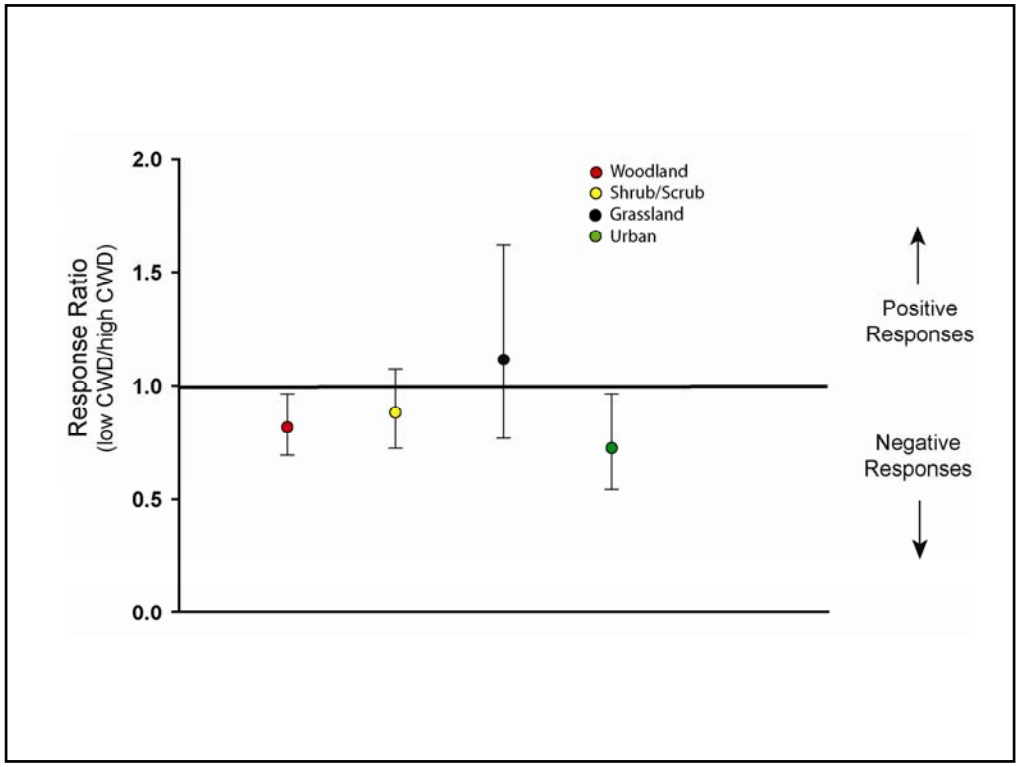

Summary effect sizes for birds, mammals, reptiles, amphibians and invertebrates across all manipulations. Circles are mean effect sizes and bars are 95% bootstrap confidence intervals. Bird diversity and invertebrate biomass were consistently lower on low CWD treatments. Confidence intervals for all other taxa included zero, indicating little effect of CWD removal.



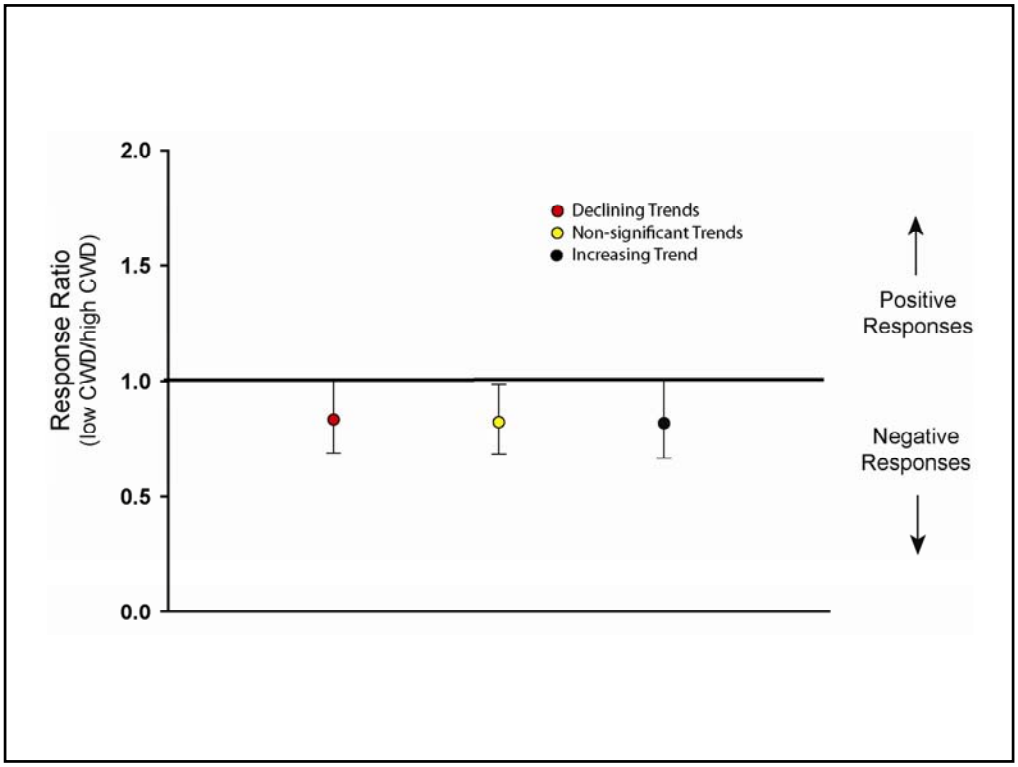

During the breeding season, strong excavators, weak excavators, secondary cavity nesters and non-cavity nesters all responded negatively to fewer snags and less DCWD, indicating that birds that do not actually nest in snags (or DCWD) may respond negatively to reductions in snags and DCWD. During the winter season, effect sizes were smaller and/or more variable. Only the effect size for weak excavators did not include zero.




A possible explanation is that reduced invertebrate biomass reduces food availability (and hence habitat quality) for all birds, regardless of nesting strategy. However, the effect for invertebrate biomass is based on 9 effect sizes from 1 study. More research is need to establish this link.




Because birds had the most effect sizes and demonstrated responses to CWD manipulations, we further investigated effects on birds. Woodland and urban associated birds were negatively affected by removal of CWD, but shrub/scrub and grassland birds were not. CWD reductions may facilitate habitat conditions more similar to grassland habitat types these species prefer.




Birds that were declining (regional Breeding Bird Survey trends), increasing and un-changing were all equally affected by CWD manipulations. Thus, CWD removal would not likely disproportionately affect species of conservation concern. There were no differences in response to CWD among other factors like nesting strategy, nest height, migratory status, habitat specialization and diet specialization (graphs not shown).

## What do we know?

- Birds are likely to respond negatively.
- Responses by other taxa were small or variable.

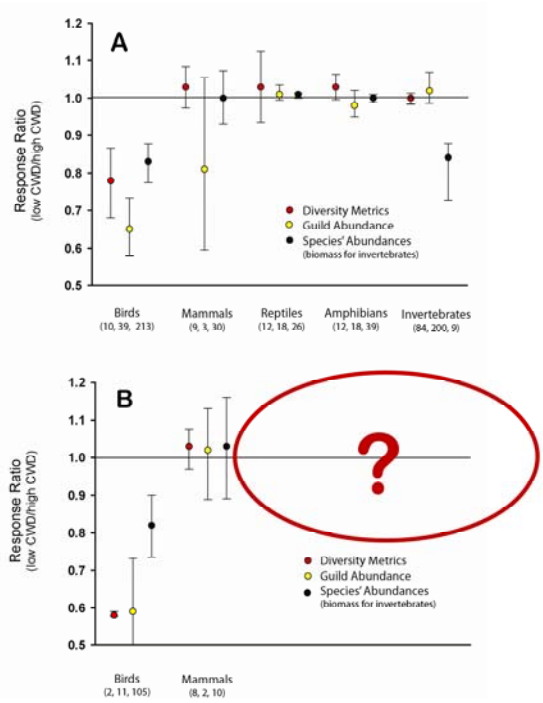
The summary of what we know is that birds are likely to respond negatively to reductions in CWD, and responses by other taxa were small or variable.

## What do we ***need*** to know?

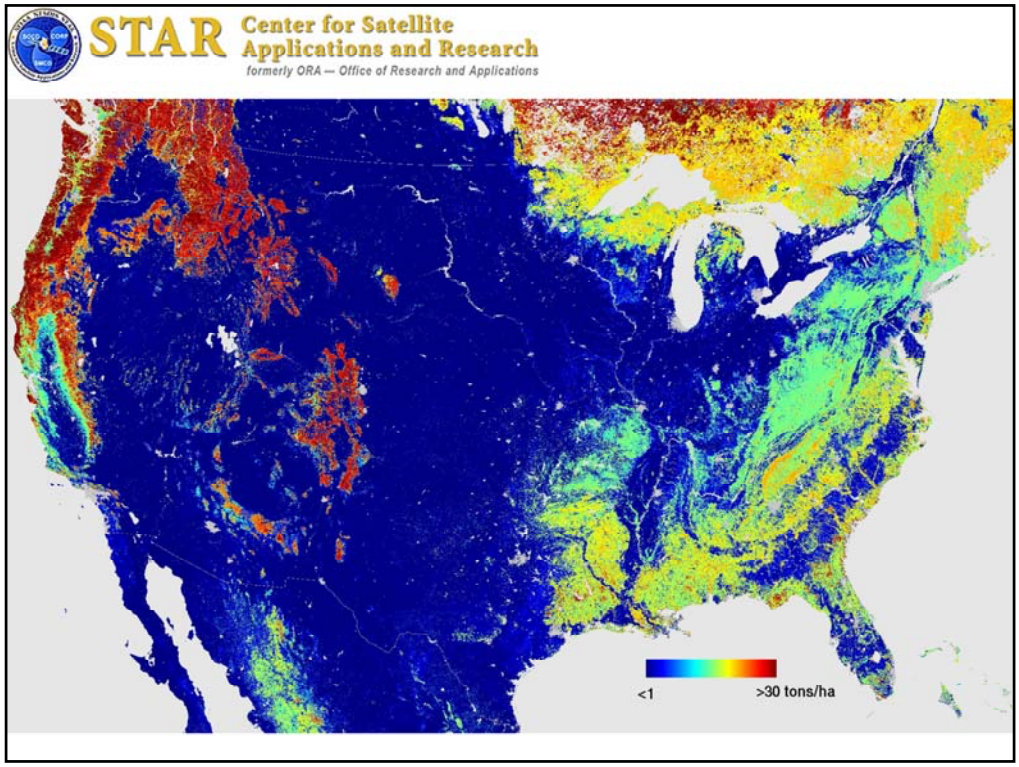
- ? Animal-FWD relations
- ? Non-avian taxa
- ? Animal-CWD relations in other regions
- ? How much CWD left after biomass harvests?
- ? Do small-scale experiments scale up to operational (i.e. landscape) extents?
- ? Effects of landscape context

Knowledge gaps are large and numerous. We found only one study about FWD-animal relations.


Geographical coverage was poor. Approximately 80% of the effect sizes came from the southeastern United States.




Omitting effect sizes from the Southeastern United States produced similar mean effect sizes for bird and mammal metrics. That increases our confidence that our current knowledge represents that true relationships between CWD and animals. However, we found no effect sizes for other taxa (reptiles, amphibians and invertebrates) outside the Southeastern US. More research on these taxa in other regions is sorely needed.



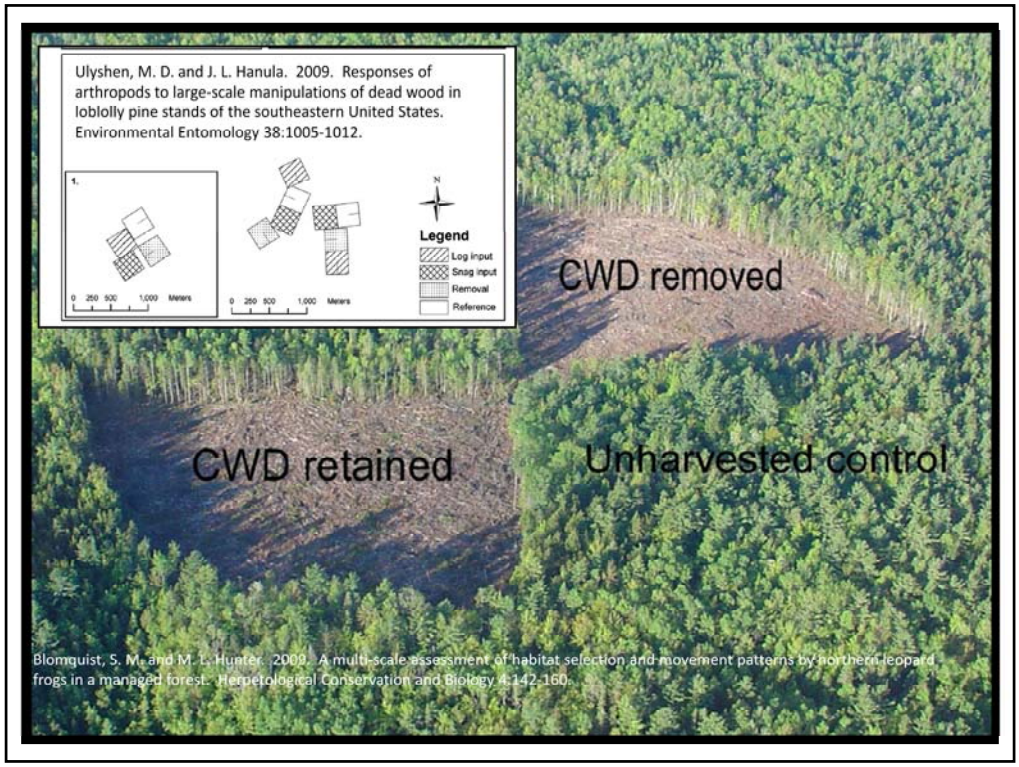

Fortunately, all our effect sizes were from areas with high stocks of forest residues (see image of forest residue biomass above) – including southeastern and northwestern North America. However, more research about CWD/harvest residues in the Great Lakes and northeastern regions are needed.

## How much is left after biomass harvests?

| Harvest Regime | CWD_Total | CWD_Large |
|---|---|---|
| 50% sub / Remove all dead & down | + 5 % | +41 % |
| Thin sub / Remove 80% dead & down | - 14 % | - 60 % |
| Thin sub / Remove 80% dead & down | + 1 % | - 1 % |
| Thin sub / Crush dead < 6 in | + 19 % | + 222 % |
| Thin sub / Crush dead < 6 in | + 13 % | + 9 % |
| Remove fir / Crush dead < 6 in | -11 % | - 100 % |
| Remove sub fir & spruce / Leave dead & down | + 5 % | - 35 % |
| 35% thin sub / Leave dead & down | - 38 % | - 82 % |
| 55 – 75% thin sub / Leave dead & down | - 8 % | + 57 % |

Arnosti, D., D. Abbas, D. Current, and M. Dernchik. 2008. Harvesting fuel: cutting costs and reducing forest fire hazards through biomass harvest. Institute for Agriculture and Trade Policy, Minneapolis, MN.

How much CWD is left after actual biomass harvests is another knowledge gap. Some pilot projects report that post-harvest reductions in woody debris may be small or non-existent. In the table above for example, change in CWD range from – 38% to + 19% after biomass harvest operations. Even the largest of these reductions are very small reductions compared to the manipulative studies we reviewed (≥ 90% reductions in some studies, e.g. Todd and Andrews 2008). Considering that impacts on diversity and abundance were not large in the manipulative experiments we reviewed (with the exception of birds), it is possible that biofuel harvests may not substantially alter biodiversity in managed forests, esp. when following guidelines that provide for retention of minimum levels of woody debris. It will be impossible to accurately predict impacts of forest harvest residue removal on biodiversity until such information has been gathered.




Most manipulative studies have used relatively small experimental units embedded in an unharvested matrix (e.g., Ulyshen & Hanula – 9.3 ha plots; Blomquist & Hunter – 2.1 ha plots; see image above). Quite possibly, if CWD was removed over larger areas (as would happen if harvest residue removal became common), these large, CWD-poor areas might be less readily colonized from surrounding areas compared to the smaller plots used in experiments. If so, small-scale experiments may underestimate the extent and magnitude of biodiversity response to biomass harvests. Conversely, small-scale experiments may overestimate biodiversity response over large areas if biomass harvests occur only in a small percent of stands in a landscape.

## Contact Information for Questions & Inquiries

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