EMEND





ECOSYSTEM MANAGEMENT EMULATING NATURAL DISTURBANCE

EMEND Insights #3

HIGHLIGHTS

Ecological Messages:

- Species recovery was delayed at least by five years on clear-cut sites as compared to sites with green-tree retention.
- Higher levels of retention may be required on coniferous and mixedwood sites to achieve the same level of recovery as deciduous sites.
- Despite intensive efforts to survey biodiversity our knowledge about responses to forest harvesting is still imperfect. Thus, we should focus on maintaining habitat structural heterogeneity on sites and promoting ecological recovery.

Management Implications:

- Green-tree retention harvesting resulted in a significant increase in rate of species recovery when compared to clear-cut harvesting.
- Managing for a range of retention levels (heterogeneity) is more important than focusing on retaining a specific threshold level of retention.
- The application of both dispersed retention and aggregated retention patches is the best science based recommendation for sustainable forest management.

Spider responses to variable retention harvesting: Biodiversity lessons learned from the EMEND project

By Jaime Pinzon and John Spence

Fifteen years into the project, what is EMEND telling us about sustainable forest management, and the application of green-tree retention? Turns out, a lot! In fact, many of our most important insights about retention harvesting are only possible because of the long-term data collection at EMEND. This unique data set enables us to look at how the forest is changing over time, in response to green-tree retention harvesting.

In this study, we looked at the response of spider assemblages to green-tree retention during the first 10 years at EMEND. We found that green-tree retention is a valuable alternative to clear-cut harvesting. Not only can retention harvesting help to maintain some forest specialist species, but it also promotes faster recovery of the forest. We found that clear-cut treatments took 10 years to recover to an equivalent level of species diversity as retention treatments reached in five years.

We also found that aiming to identify a single retention threshold is a naïve approach, as different species respond very differently to forest disturbance. Instead, our results suggest that maintaining variability in retention levels across the landscape provides the best ecological benefit. Our data also suggest that higher levels of retention may be required on coniferous and mixedwood sites as harvesting tends to have a greater impact on the species characteristic of these later successional forests. READ ON TO FIND OUT MORE.

AN AERIAL VIEW OF EMEND 15 YEARS POST-HARVEST. CREDIT: J. PINZON.

RENEWABLE RESOURCES

Alberta School of Forest Science & Management

EMEND: Supporting progress in forest management

Worldwide, the Natural Disturbance paradigm and the idea of "new forestry" have emerged as an alternative to conventional clear-cutting, developing and implementing novel harvesting practices rooted in an ecological perspective. Therefore, development of management practices that emulate natural disturbances within an adaptive management framework has guided Canadian thinking about sustainable forest management.

Practices developed under this umbrella seek to recreate elements lost in traditional harvest prescriptions to preserve more natural structural complexity, so as to protect biodiversity and maintain ecological processes. A main guiding approach under this model is to manage the forest from an ecosystem perspective using natural disturbances to inspire design of harvesting practices. Hence, structural features and legacies similar to those remaining after natural disturbances (e.g., aggregated and dispersed retention of living trees, standing and downed dead trees) are left in cut-blocks at harvest. These so-called 'legacy' elements are thought to maintain biodiversity on managed landscapes, assuming that species which have evolved alongside natural disturbances are more likely to persist and be maintained.

A FEMALE CRAB SPIDER IN A 'SIT AND WAIT' POSITION WAITING FOR FOOD TO FLY BY. CREDIT: J. PINZON.

About EMEND:

The Ecosystem-based Management Emulating Natural Disturbance (EMEND) Project is a multi-partner, collaborative forest research program. The EMEND project documents the response of ecological processes to experimentally-delivered variable retention and fire treatments. The research site is located in the western boreal forest near Peace River, Alberta, Canada, with monitoring and research scheduled for an entire forest rotation (i.e. 80 years).

However, such management must not be seen as the end, signifying the arrival at sustainable forest management; this model is a hypothesis that remains largely untested, as harvested stands have yet to reach maturity. In order to respond to this scientific challenge, the Ecosystem Management Emulating Natural Disturbance (EMEND) project was initiated more than a decade ago as an experimental test of this hypothesis. EMEND seeks to track trajectories of recovery after variable retention harvest to assess resilience of forest systems managed under the new paradigm, using biodiversity as the main indicator of overall system condition.

Why Spiders?

Much research and public attention has been focused on conservation of mammals and plant species and their roles in ecosystem processes. However, invertebrates are also demonstrably threatened and ecologically important. Not only do invertebrates account for a far greater share of terrestrial biodiversity than vertebrates (estimates indicate that they account for more than 80% of global diversity), but also they are probably more important in terms of ecosystem processes. Indeed, E. O. Wilson referred to invertebrates as *"the little things that run the world".*

Given their huge diversity, invertebrate assemblages provide an integrated and multi-facetted assessment of forest health and ecosystem function.

Spiders are among the most ubiquitous and diverse groups of terrestrial arthropods, playing important functional roles in many terrestrial ecosystems. For example, they contribute to habitat and ecosystem stability by predating on other invertebrates and constitute an important food source for mammals and birds that tend to be more valued by the general public. Many studies have shown the usefulness of spiders for environmental assessments, and responses of spiders to disturbances are well documented. Thus, by evaluating the effects of post-harvest habitat change on little known boreal spider assemblages, we may start to understand and suggest useful inferences about how biodiversity is maintained and affected in managed landscapes. Such knowledge will provide the intellectual underpinnings required to adjust forestry practices and promote sustainable forest management that conserves biodiversity.

SPIDERS ARE INCREDIBLY DIVERSE WITH MORE THAN 1400 SPECIES RECORDED IN CANADA AND ALASKA AND ABOUT 600 SPECIES OBSERVED IN ALBERTA. AT EMEND WE HAVE FOUND AT LEAST 300 SPECIES.

Green-tree retention: An effective way to maintain spider biodiversity

EMEND was designed to include a combination of retention prescriptions (clear-cut, 10%, 20%, 50% and 75% retention of the original pre-harvest stand volume) and different forest cover-types (representing the natural successional chronosequence in the mixedwood boreal). The experiment also incorporates a temporal effect, that is, how the forest responds and recovers over time to each prescription.

EMEND is already providing exceptional and useful results. Results from the experiment-wide sampling carried out five and ten years post-harvest are showing some interesting patterns in the way ground-dwelling spider assemblages respond to harvest intensity. For example, the number of species (species richness) increase as harvest intensity decreases, especially in the 75% retention, and no large differences are observed in the lower retention levels (Figure 1a). This suggests that these prescriptions have a modest but evident positive effect in maintaining species compared to a clear-cut. In addition, a much larger number of individuals are collected from highly disturbed areas (Figure 1b).

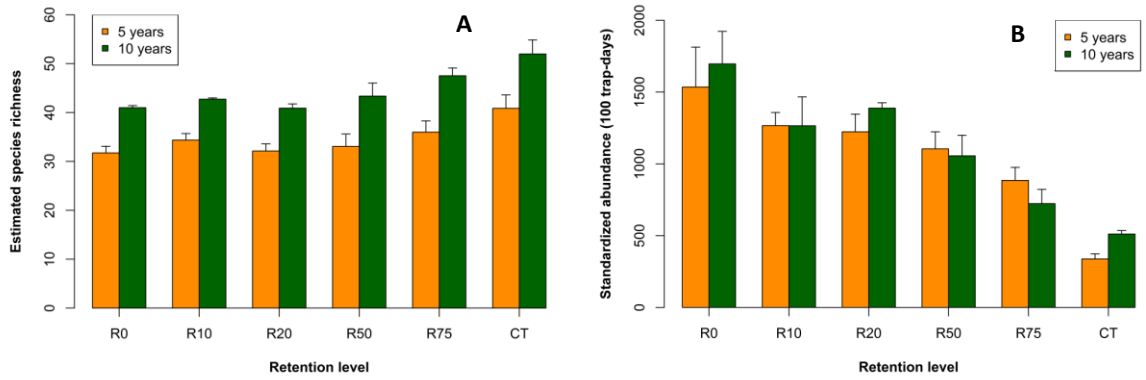

FIGURE 1. CHANGES IN SPIDER RICHNESS AND ABUNDANCE FIVE AND TEN YEARS AFTER VARIABLE RETENTION. A. ESTIMATED SPECIES RICHNESS; B. MEAN SPIDER CATCH (R0-R75: CLEAR-CUT TO 75% RETENTION, CT: UNHARVESTED CONTROL).

Most of these individuals belong to a few open-habitat species, such as the wolf spider *Pardosa moesta* that dominates assemblages in the range of clear-cut to 50% retention (Figure 2a). Interestingly, despite the retention of living trees, catches of this species increased rather dramatically in 10-50% retention between the five and ten years after harvesting.

This suggests that the effects of canopy removal remain evident 10 years after harvesting in all practical retention prescriptions.

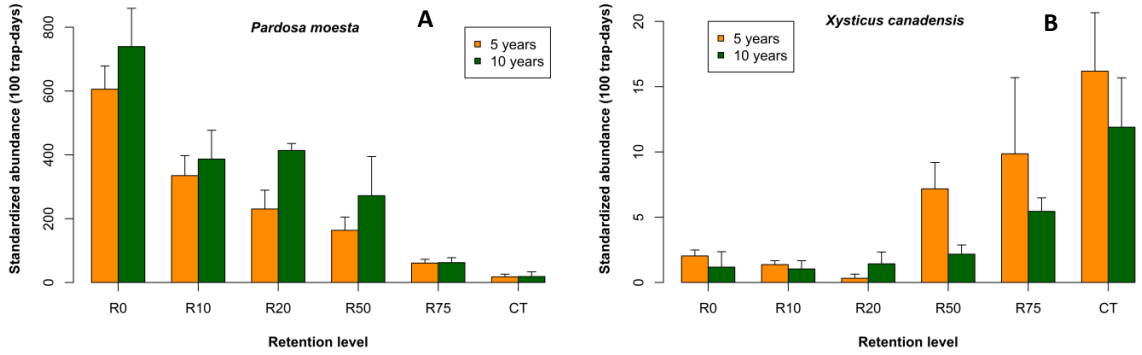

FIGURE 2. CHANGES IN SPIDER RICHNESS AND ABUNDANCE FIVE AND TEN YEARS AFTER VARIABLE RETENTION. A. MEAN CATCH FOR THE WOLF SPIDER *PARDOSA MOESTA*; B. MEAN CATCH FOR THE CRAB SPIDER *XYSTICUS CANADENSIS* (R0-R75: CLEAR-CUT TO 75% RETENTION, CT: UNHARVESTED CONTROL).

Nonetheless, diversity and evenness (how well represented a species is relative to the other species in an assemblage) are much higher in all retention levels compared to clear-cuts (Figure 3). **This shows that in fact green-tree retention has positive effects and helps to maintain species assemblages that are otherwise lost if all trees are removed (i.e., conventional clear-cutting).** This relationship also suggests that even though there are signs of recovery in clear-cuts, it will take much longer for assemblages in these areas to recover than when trees are retained within the harvested block: **It takes about ten years for spider assemblages in clear-cuts to reach an equivalent diversity level as that observed during the first five years in 10-75 % retention treatments**.

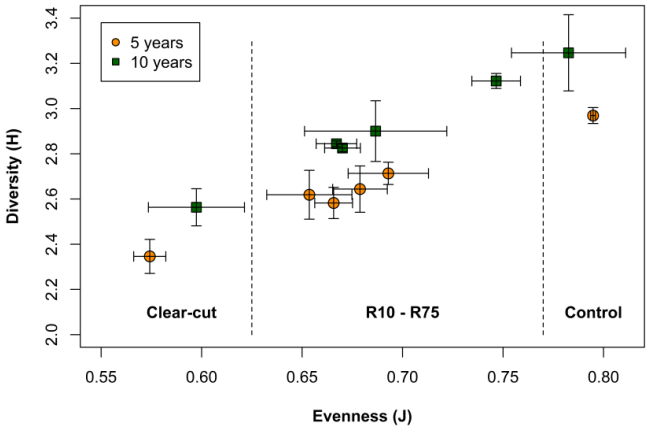

FIGURE 3. SPIDER DIVERSITY (SHANNON INDEX) AND EVENNESS (PIELOU INDEX) FIVE AND TEN YEARS AFTER VARIABLE RETENTION HARVESTING (R10-R75: 10% TO 75% RETENTION).

Is there a retention threshold that minimizes the effects of harvesting on biodiversity?

It is quite expected, as shown above, that retaining living trees in a cut-block has beneficial effects for many species when compared to a clear-cut (for example the crab spider *Xysticus canadensis* as in Figure 2b). However, how much is enough? Perhaps, this is one of the most pertinent questions being asked by both researchers and forest managers. Despite its relevance, this is a difficult question to answer given the extreme complexity of the boreal forest.

The mixedwood boreal forest is a highly dynamic disturbance-driven ecosystem that hosts a high level of biological diversity, which we understand quite imperfectly. **Consequently, it is far from simple to provide a definite number, and at present the safest approach is to use a range of retention levels.**

From past work, we know that more homogeneous and less diverse species assemblages are found in blocks harvested to lower retention levels. For instance, it has been suggested that at least a 50% retention level is required to maintain ground beetle (Carabidae) assemblages similar to those in undisturbed and late successional stages of the forest. **Because such levels are impractical given the economics of the forest industry, we must focus on system recovery.**

In the case of ground-dwelling spiders, figure 4 shows how different each retention level is from the unharvested controls in terms of species composition (*i.e.*, higher values mean higher difference). A decreasing pattern is observed from clear-cuts to higher retention, and it is not surprising that clear-cuts differ most from the controls. Conversely, differences in the 10-50% retention are minimal, suggesting that within this range the overall effect is similar. Although assemblages have recovered from 5 to 10 years post-harvest (all points have lower values), the pattern remains relatively unchanged. **Nonetheless, recovery is evident and it is faster, given higher levels of retention, *and* any level of retention is better than on clear-cuts.**

Although the 50% prescription will be impractical for large-scale implementation by the forest industry, lower retention levels are being employed, and clearly these are effective for biodiversity maintenance. **Results from work at EMEND on other organisms (*e.g.*, vascular plants, bryophytes, snails) had suggested that an overall retention level of 20% would be an effective prescription to maintain forest-specialist species on harvested landscapes.**

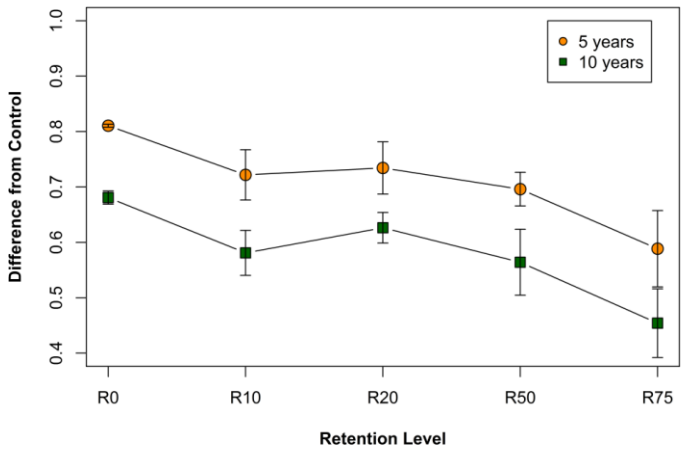

FIGURE 4: COMPARISON OF SPIDER ASSEMBLAGES IN UNHARVESTED CONTROLS TO EACH PRESCRIPTION FIVE AND TEN YEARS AFTER VARIABLE RETENTION HARVESTING (R0-R75: CLEAR-CUT TO 75% RETENTION).

However, we cannot evade complexity. Variable retention has different impacts on species depending on the forest-cover type prior to harvest. That is, it is not the same to harvest a deciduous, mixed or conifer stand. In the case of spiders, as seen in figure 5, **assemblages are much more similar to unharvested controls in all retention levels for deciduous stands than mixed and conifer stands.** Consequently, in this case 10% retention in deciduous dominated stands might be sufficient, while a higher prescription (20-50%) could be much more effective in late successional forests.

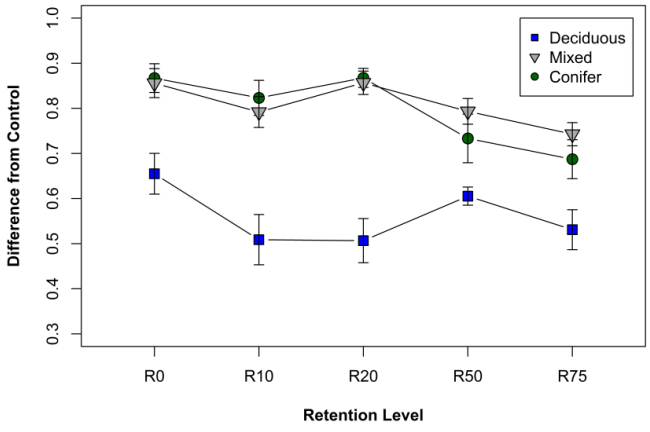

FIGURE 5. COMPARISON OF SPIDER ASSEMBLAGES BY FOREST COVER-TYPE IN UNHARVESTED CONTROLS TO EACH PRESCRIPTION FIVE AND TEN YEARS AFTER VARIABLE RETENTION HARVESTING (R0-R75: CLEAR-CUT TO 75% RETENTION).

Management Implications

Compared to conventional clear-cutting, variable retention harvesting clearly preserves structural features required for species to maintain viable populations as the forest recovers from harvesting. However, it becomes evident that aiming at a single retention threshold is a naïve approach, given that different species respond differently to disturbance. **Instead, our findings and those suggested by other studies from EMEND and elsewhere, point toward diversity as the solution; in other words, maintaining heterogeneity is the key.**

From a general point of view, the application of different retention levels over a managed landscape provides habitat heterogeneity and a template of conditions seemingly required to maintain a wider suite of species on landscapes managed for timber extraction. However, in addition to varying retention levels over the landscape, the type of retention is also important, as suggested by other studies. It has been shown that legacies, such as patches of unharvested forest, are critical for the maintenance of forest specialist species. **Therefore, the application of both dispersed and aggregated retention is the best present science-based recommendation for a more sustainable approach to forest harvesting.**

Further Reading

Macdonald SE & Fenniak TE. 2007. Understory plant communities of boreal mixedwood forests in western Canada: Natural patterns and response to variable-retention harvesting. Forest Ecology and Management, 242: 34-48.

Pinzon J. 2011. Composition and structure of spider assemblages in layers of the mixedwood boreal forest after variable retention harvest. PhD dissertation, Department of Renewable Resources, University of Alberta, Edmonton, Canada.

Pinzon J, Spence JR & Langor DW. 2012. Responses of ground-dwelling spiders (Araneae) to variable retention harvesting practices in the boreal forest. Forest Ecology and Management, 266: 42-53.

Pyper MP. 2009. Retention patch characteristics and ground dwelling beetle diversity: Implications for natural disturbance-based management. MSc Thesis, Department of Renewable Resources, University of Alberta, Edmonton, Canada.

Spence JR. 2001. The new boreal forestry: adjusting timber management to accommodate biodiversity. Trends in Ecology and Evolution, 16(11): 591-593.

Work T, Jacobs J, Spence JR & Volney WJ. 2010. High levels of green-tree retention are required to preserve ground beetle biodiversity in boreal mixedwood forests. Ecological

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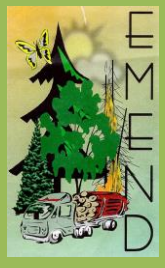

A PARTNERSHIP COMMITTED TO A LONG LOOK AT BOREAL ECOSYSTEMS

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