EMEND





ECOSYSTEM-BASED MANAGEMENT EMULATING NATURAL DISTURBANCE

EMEND Insights #1

Ecological Messages:

- Natural regeneration of white spruce following logging resulted in a mean stocking rate of 44.5% for deciduous, mixed and conifer sites.
- Natural regeneration of spruce was strongly influenced by proximity to seed trees. However, high densities of aspen and balsam poplar were also regenerated in the deciduous and mixed stand types.
- Passive soil disturbance was a stronger predictor of natural regeneration of spruce than the amount of understory vegetation, including amount of hardwoods.

Management Implications:

- Clear-cutting paired with soil disturbance from skidding promoted white spruce regeneration, provided that ≥ 5 seed trees/ha were retained within 60 m of survey transects.
- Machine corridors, which had soil disturbance from skidding, showed a six-fold increase in regeneration compared to undisturbed retention strips.
- The protection of understory spruce at harvest paired with the establishment of seedlings on the machine corridors resulted in a multi-aged and a multi-layered spruce forest.

The intersect between retention harvests and natural regeneration

By Kevin Solarik, Vic Lieffers, and Jan Volney

There have been many small-scale experiments that have shown natural regeneration of white spruce is influenced by: 1) a seed source for spruce, 2) a receptive seedbed, 3) a suitable microclimate, and 4) limited competition from vegetation. Few studies, however, have assessed the success of natural regeneration at an industrial scale (8-10 Hectares).

We investigated how natural regeneration might be improved under variable retention harvesting regimes by looking at the influence of: post-harvest overstory composition; level of overstory retention (clear-cut (2% retention), 10%, 20%, 50%, 75% and 100% (uncut)); passive soil disturbance within machine corridors compared to retention strips; density of seed trees within 60m of plots; and presence of grasses and shrubs. We established eight 10 m^2 plots within each of 432 permanent survey transects in order to assess natural regeneration of spruce 10 years after harvest.

We found that retaining as few as five seed trees within 60 metres of our survey transects produced an average stocking rate of 49.6%. Retention levels higher than 10-20%, however, began to impede natural regeneration as the higher density of overstory trees inhibited germination and establishment. We also found that the passive soil disturbance created by whole-tree winter skidding at EMEND proved a critical factor in promoting natural regeneration. Finally, understory protection cuts were found to promote regeneration of white spruce, resulting in multi-cohort stands with enhanced vertical structure.

It is important to recognize that a range of outcomes are possible using natural regeneration, depending upon a variety of stochastic factors. If managers retain seed trees, disturb the substrates and ensure that there is sufficient removal of overstory trees, the probability of successful regeneration of white spruce is increased. ***Read on to find out more. . .***

Strip-cut retention harvests at EMEND.

The Context

Variable retention harvesting has evolved over the past few decades as a way to maintain biodiversity across harvested landscapes. This technique seeks to emulate patterns of natural disturbance so as to promote a variety of 'legacy' elements across forested landscapes. Retaining living and dead trees is one technique that is believed to minimize the impact of harvesting on forest ecosystem function. However, leaving living trees in a variable retention cutting system may initially require managerial planning prior to implementation, especially when attempting to maximize natural regeneration of white spruce. As a result, there are still important questions which must be addressed in order to promote effective planning and natural regeneration within managed forests.

In this note, we summarize the natural regeneration of white spruce 10 years after variable retention harvesting of boreal forest stands at the EMEND (Ecosystem-based Management Emulating Natural Disturbance) study area in north-western Alberta. We discuss how managers can improve the probability of successful natural regeneration of white spruce by investigating five key topics:

- How many seed trees should be retained to promote regeneration? Is it possible to retain too many mature trees?
- Is soil disturbance needed to maximize natural regeneration?
- What cutting pattern should be used, i.e. clear-cut vs. strip cutting?
- How important is vegetation competition for natural regeneration compared to other factors?
- Can we expect natural regeneration of spruce in understory protection harvesting?

We defined stocking as the presence of at least one spruce seedling $\geq$ 10 cm in height within a 10 m^2 plot.

About EMEND:

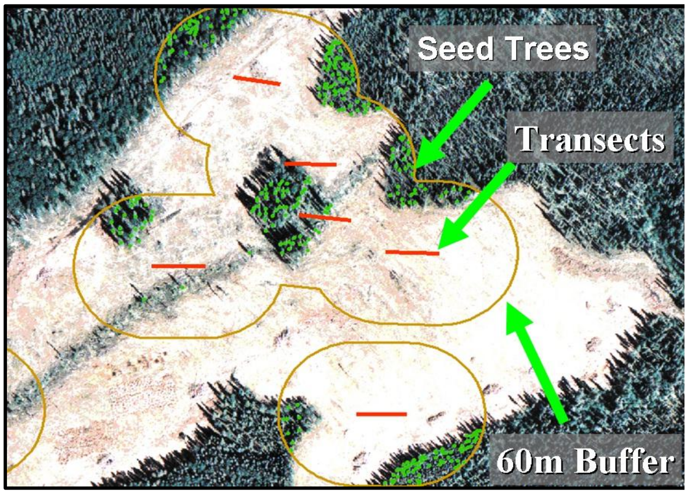
The Ecosystem-based Management Emulating Natural Disturbance (EMEND) Project is a multi-partner, collaborative forest research program. The EMEND project documents the response of ecological processes to experimentally-delivered variable retention and fire treatments. The research site is located in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

Photos showing the machine corridor of the 20% retention (top) compared to the 75% retention treatments (bottom). Both sites were dominated by conifers prior to cutting. Note the difference in local density of seed trees retained.

Research Findings

How many seed trees should be retained in order to maximize regeneration of white spruce?

It is well known that two key factors which influence natural regeneration are: the presence of a suitable seed bed, and the presence of a seed source. The clear-cuts at EMEND provided a moderately-high quality seed bed because skidding created a mild soil disturbance over the majority of the clear-cut blocks. We found regeneration on these clear-cut sites with as few as five seed trees within 60 metres of the survey transects (Figure 1).



A digital analysis procedure was used to identify potential seed trees within 60 m of regeneration transects (clear-cut shown here).

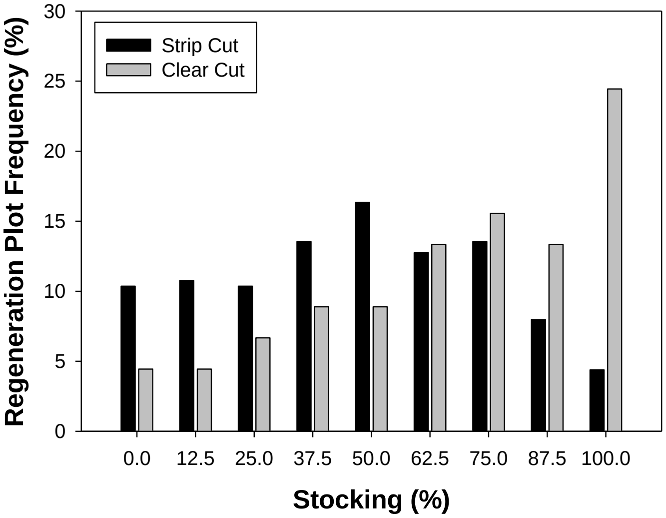


***Figure 1**: Frequency distribution of stocking of white spruce from natural regeneration. Data were from 244 transects in partially-harvested strip cuts and 45 transects in clear-cuts where there were ≥ 5 seed trees within 60 m of the survey transect. Stocking level for each transect is defined as the percentage of plots (10 m^2) on the transect with at least one white spruce seedling >10 cm tall.*

Is it possible to leave too many seed trees?

Yes. We found when moving from 10% retention to 20%, 50% and 75% retention there was a decline in natural regeneration (Figure 2). This is because dense white spruce canopies can absorb much of the incoming light. This in turn prevents soil warming which slows spruce growth rates and inhibits successful regeneration. **Depending on stocking objectives for spruce, there appears to be a threshold between 10-20% retention** at which point the number of residual trees begins to impede the success of natural regeneration.

Is soil disturbance needed to maximize natural regeneration?

Yes. We found that passive site preparation from whole-tree skidding down machine corridors produced a 6-fold increase in natural spruce regeneration compared to the adjacent undisturbed retention strips. Skidding temporarily removed vegetation and passively disturbed the forest floor, sometimes exposing mineral soil which is a good seed bed for white spruce. Thus, soil disturbance, such as that occurring during whole-tree skidding, is important in promoting natural regeneration. The scientific literature suggests mechanical site preparation that scalps the litter layers would produce even more regeneration.

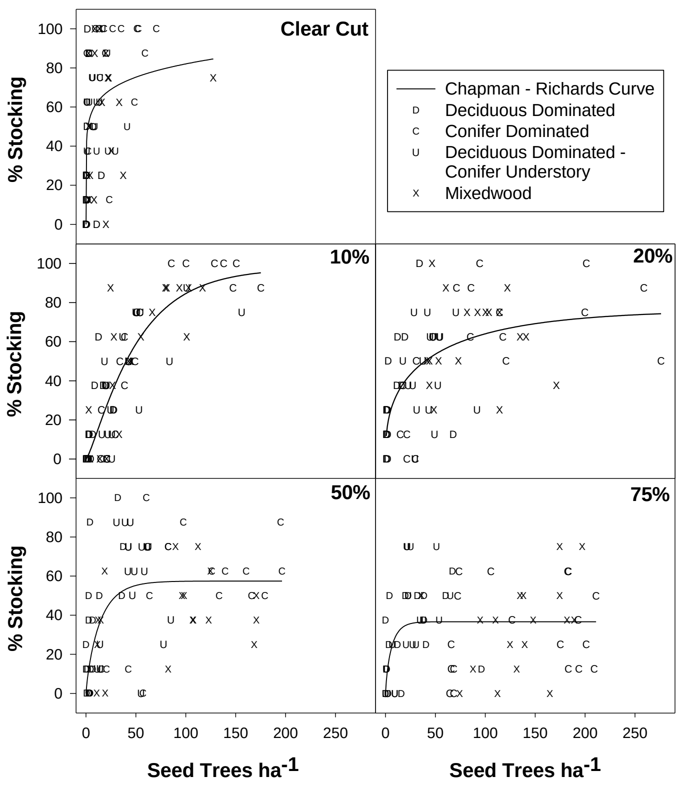


Figure 2*: Percent stocking in relation to density of seed trees, for clear-cuts (2%), 10%, 20%, 50% and 75% retention harvests (data fit with a Chapman-Richard's function).*

How important is vegetation competition for natural regeneration?

In our study, the greatest regeneration within the retention treatments (i.e. excluding clear-cuts) was on machine corridors. These sites also tended to have the highest level of grasses, herbs and shrubs by year 10. Because the corridors had greater levels of soil disturbance (in comparison to the retention interiors), we interpret this to mean that the benefits of forest floor disturbance via skidding outweighed any negative effects of vegetation competition for establishment of seedlings.

What are the effects of cutting pattern on regeneration?

Although the strip cutting at EMEND was useful for retaining high levels of residual trees, this technique disturbed only 25% of the soil surface. Clear-cuts had a higher frequency of stocked plots when compared with the strip cuts (Figure 1) even though there were fewer seed trees; this was likely related to more of the area with disturbed soils in the clear-cuts. **It appears that harvesting systems that minimize passive soil disturbance (such as strip cutting systems) are not conducive to natural regeneration.** Also, in the strip cuts with high retention levels there was lower light transmission which may have reduced the amount of regeneration (Figure 3).

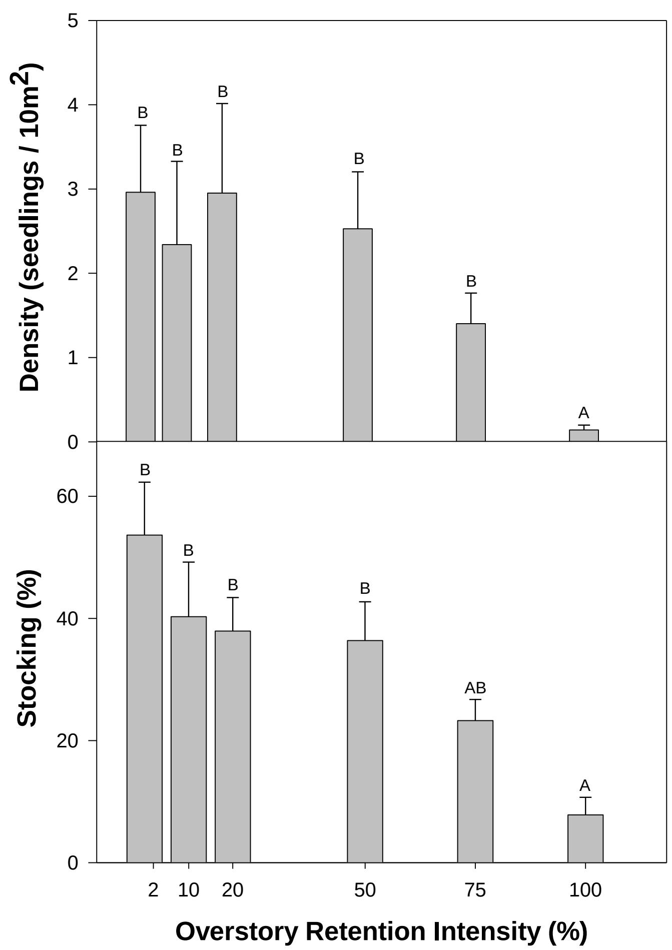


Figure 3*: The effect of overstory retention intensity on seedling density and overall seedling stocking rates of the 8 plots of each transect. Bars with the same letter were not significantly different.*

Can we expect natural regeneration in understory protection harvesting?

Yes. In addition to the advanced regeneration protected during harvesting, there was another crop of seedlings that established on machine corridors. **Thus, understory protection harvesting paired with natural white spruce**

regeneration can result in a multi-cohort, multi-layered stand composition. We found that when protecting advanced regeneration of spruce in deciduous-dominated with conifer understory stands, regeneration was comparable to the regeneration in the mixedwood stand types, and better than the deciduous-dominated stand (Figure 4).

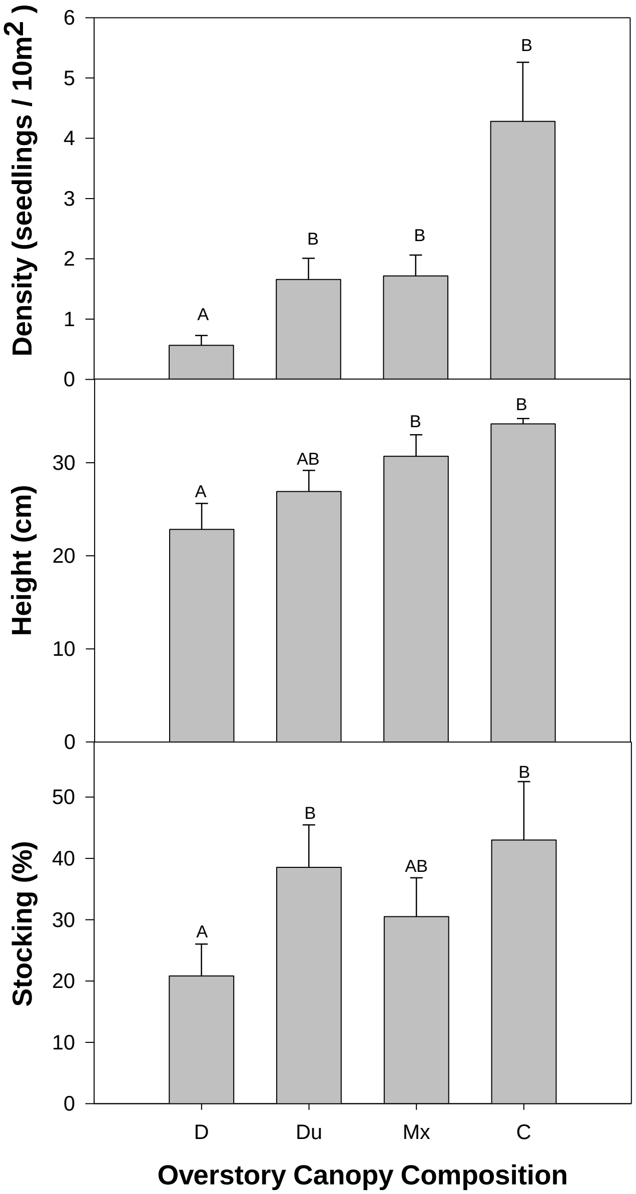


***Figure 4**: The effect of post-harvest overstory composition (D – deciduous dominated, Du- deciduous dominated with conifer understory, Mx – mixedwood, and C – coniferous dominated) on seedling density, seedling maximum height (cm) and stocking rates for EMEND. Bars with the same letter were not significantly different.*

Management Implications

There are many uncontrolled factors influencing natural regeneration. As a result, a range of outcomes might occur on a particular site – depending upon yearly precipitation, animal browsing, frosts and other uncontrolled factors which determine regeneration stocking (see the frequency distribution of stocking in Figure 2). **The distribution of outcomes, however, can be shifted toward the side of success by making sure that there are seed trees and that there is mild soil disturbance over much of the area**; see the shift towards higher stocking in the clear-cuts when more of the area was disturbed from skidding (Figure 1). Nonetheless, because of the inherent variability in natural regeneration, managers cannot expect high levels of regeneration on all sites but instead must use forest-level summaries of regeneration success to predict outcomes for natural regeneration in their forest.

- Clear-cutting and passive site preparation from skidding can provide adequate seedbeds for white spruce regeneration.
- Five seed trees/ha within 60 m of a site is likely sufficient to expect stocking success, and then other factors such as seedbed condition become more important for regeneration success (i.e. increased densities).
- Managers must be aware of the importance of a receptive seedbed; passive site preparation can increase white spruce regeneration 6-fold – other literature suggests that active site preparation can increase regeneration even more.
- Depending on stocking objectives, there appears to be a threshold between 10-20% retention at which point the number of seed trees begins to impede the success of natural regeneration.
- Managers should recognize that a range of outcomes are possible using natural regeneration, depending upon a variety of stochastic factors. If managers retain seed trees, disturb the substrates and ensure that there is sufficient removal of overstory trees, the probability of successful regeneration is increased.

Further Reading

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WRITTEN BY:

KEVIN SOLARIK[1]

AND

VIC LIEFFERS[1]

AND

JAN VOLNEY[2]

[1] DEPARTMENT OF RENEWABLE RESOURCES, UNIVERSITY OF ALBERTA, EDMONTON, CANADA

[2] CANADIAN FOREST SERVICE, NORTHERN FORESTRY CENTRE, EDMONTON, CANADA

COORDINATING EDITOR: M. PYPER
GRAPHICS & LAYOUT: M. PYPER

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