Introduction

Tropical storm Fiona caused widespread wind disturbance damage across central and eastern regions of Nova Scotia. This has led to requests from private woodland owners for salvage guidelines that allow for removal of blown down trees while still considering nutrient sustainability, soil health, and biodiversity concerns. The guidelines presented below are derived from recent publications and research related to ecological forest management by the Department of Natural Resources and Renewables (Department). This includes the *Nova Scotia Silviculture Guide for the Ecological Matrix* (SGEM) (McGrath et al., 2021), the *Forest Ecosystem Classification* (FEC) guide (Neily et al., 2013), *A Field Guide to Forest Biodiversity Stewardship* (Neily and Parsons, 2017), soon-to-be published guidelines on nutrient sustainability using the Department's nutrient budget model (Keys et al., 2016), and ongoing research on ground disturbance guidelines related to soil damage and potential site productivity.

Use of the guidelines presented below assumes woodland owners have stand level data on FEC vegetation type (VT) and soil type (ST), merchantable volume, and recent harvest levels (if any).

Definitions

Coarse Woody Material (CWM): Dead wood of 10 cm diameter class (≥ 9.1 cm) or larger and lying horizontally at 45 degrees or less.

Snag: Dead or dying standing tree, or the standing bole of a broken off tree, within the 10 cm dbh class (≥ 9.1 cm) or larger.

Advanced Regeneration: Regenerating trees in the understorey that are in their development stage (seedling/sapling).

SusMAI: Sustainable mean annual increment – an estimate of the sustainable growth rate of a stand (m^3/ha/yr) based on the calculated nutrient demand of the vegetation type found and the estimated nutrient supply rate of the soil/site.

General Retention Levels

Based on interpretation of natural disturbance regimes associated with different FEC forest groups in Nova Scotia, minimum recommended retention levels after harvesting are shown in Table 1. Where no nutrient concerns exist and operability windows allow for removals with minimal soil damage from machine traffic, these values can be used as a conservative basis for maximum salvage removal.

Table 1. Minimum post-harvest retention levels by FEC forest group derived from the *Silviculture Guide for the Ecological Matrix* (McGrath et al., 2021).

Forest Group	Minimum % Retention
Spruce Hemlock (SH)	33%
Mixedwood (MW)	33%
Tolerant Hardwood (TH)	50%
Spruce Pine (SP)	20%
Intolerant Hardwood (IH)	33%
Old Field (OF)	20%
Coastal (CO)*	20%

*** The CO forest group is not listed in the SGEM but is similar to SP with respect to disturbance regime patterns**

The approach would be to take pre-treatment/pre-disturbance stand volumes and apply applicable forest group retention values from Table 1 to calculate maximum salvage volumes (see Appendix A for sample calculations).

Note: *Where applicable, recent harvest removals before tropical storm Fiona should be considered in salvage volume calculations*.

For biodiversity reasons, other forest groups found in Crown land matrix forests are currently not eligible for any harvesting. Therefore, it is recommended that salvage operations in these groups be avoided or kept to a minimum: Floodplain (FP), Open Woodland (OW), Karst (KA), Cedar (CE), and all wet forests (WC and WD).

Coarse Woody Material (CWM)

Coarse woody material (previously referred to as coarse wood debris – CWD) contributes to both long-term site productivity and biodiversity objectives. No specific targets for CWM in Nova Scotia have been determined, but biomass modelling analysis using extensive data from Nova Scotia's permanent sample plot (PSP) network has been used to estimate average CWM volumes in mature stands by FEC forest group (Table 2).

Except for the Coastal (CO) forest group, percent values in Table 2 (column 3) are all below the levels in Table 1 suggesting that adhering to SGEM retention levels during salvage harvesting in Acadian ecosites will result in post-salvage CWM volumes that reflect average mature stand levels plus some additional volume that would be expected after a wind disturbance event.

Table 2. Average coarse woody material (CWM) volumes found in mature stands across Nova Scotia (by forest group) with corresponding percent of merchantable standing volume.

Forest Group	Average CWM Volume (m^3/ha)	Average % of Standing Merchantable Volume
Spruce Hemlock (SH)	28	13
Mixedwood (MW)	33	20
Tolerant Hardwood (TH)	23	16
Spruce Pine (SP)	15	17
Intolerant Hardwood (IH)	22	12
Old Field (OF)	11	15
Coastal (CO)	16	30

It should be noted that windthrow is a natural disturbance agent that historically would have resulted in large CWM inputs without any removal. Therefore, woodland owners are encouraged to leave as much CWM as possible (especially larger diameter pieces > 20 cm) while meeting their management objectives. In addition, a more uniform distribution of material is preferred to patch distribution. Lastly, biodiversity and soil health benefits of CWM are not related to stem quality, so salvage removal can target the best quality trees within each size class. Fig. 2 shows a quick way to estimate CWM (CWD) volumes based on piece size and transect counts.

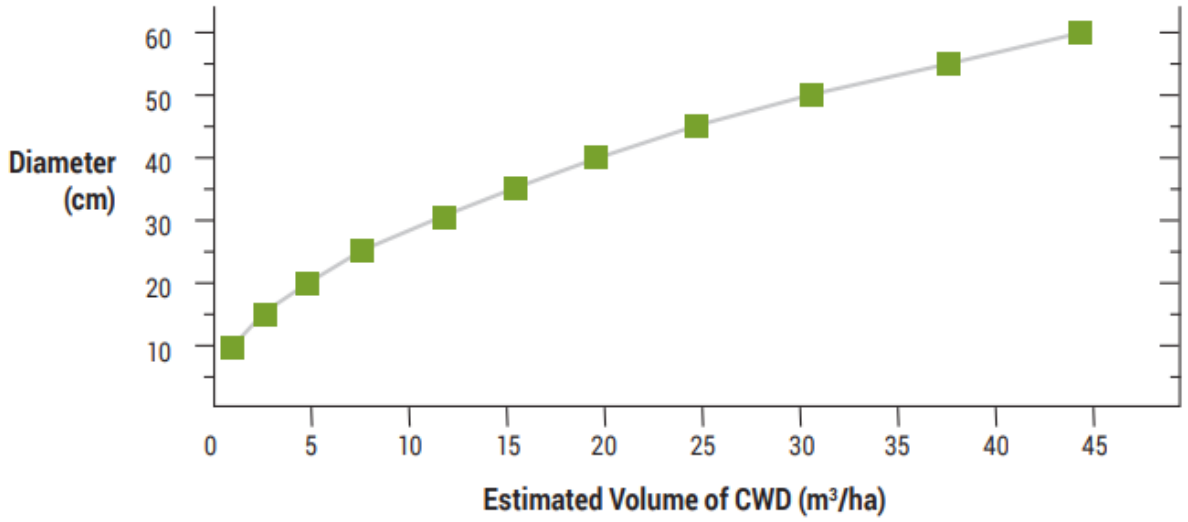

Fig. 2. Estimated volume per hectare for each piece of coarse woody debris (CWD) crossed by a 100 m transect – by diameter class at transect point (from *A Field Guide to Forest Biodiversity Stewardship* and derived from McCurdy and Stewart, 2005).

Nutrient Sustainability

Using the forest nutrient budget model for Nova Scotia (NBM-NS), the Department has recently generated estimates of nutrient sustainable mean annual increment (SusMAI) values (m^3/ha/yr) that can be used to assess the sustainability of proposed harvest (and salvage) removals. These SusMAI values are related to different FEC vegetation type (VT) and soil type (ST) combinations found in all ecodistricts across the province (see accompanying spreadsheet).

For many VT/ST combinations, the SGEM retention levels shown in Table 1 are sufficient to meet nutrient sustainability objectives. However, VT/ST combinations with SusMAI values below 2.2 m^3/ha/yr may require increased retention levels to be nutrient sustainable (Table 3). Recent harvest removals before tropical storm Fiona should also be considered in salvage volume calculations (see Appendix A for sample calculations).

Table 3. Minimum recommended stand-level retention levels based on SusMAI values for associated VT/ST combinations.

SusMAI value (m^3/ha/yr)	Minimum % Retention
< 1.0	No salvage recommended
1.0-1.3	Retain minimum 67% of original stand volume
1.4-1.7	Retain minimum 50% of original stand volume
1.8-2.1	Retain minimum 33% of original stand volume
2.2-2.7	Retain minimum 20% of original stand volume
≥ 2.8	Retention limit based on other factors

In addition, it is recommended that no salvage take place on sites with shallow soils (ST15, ST16, ST17, ST18) or with coarse, stony soils (ST1-S, ST1-GS) as these soils are nutrient poor and/or highly susceptible to damage from harvest or salvage operations.

Best Management Practices for Biodiversity Values and Soil Health

Other recommended practices to promote biodiversity and maintenance of soil health during salvage operations include:

- Adhere to *Wildlife Habitat and Watercourse Protection* (WHWP) regulations with respect to establishment and/or maintenance of wildlife clumps and protection of watercourses.

- As much as possible, protect existing biodiversity features as identified in *A Field Guide to Forest Biodiversity Stewardship* (for example, cavity trees and legacy trees).

- As much as possible, standing live trees, damaged trees, and snags should be retained wherever safe to do so as seed stock, vertical structure diversity, and future CWM sources.

- As much as possible, avoid crushing downed CWM and maintain existing angles above the ground.

- To emulate natural disturbance patterns and for safety during future silviculture operations, exposed root mats should not be forced back to the horizontal position. Once the stem is removed, if the root mat naturally remains in the vertical position, it should be left in that position. If it naturally wants to return to the horizontal position, do not prevent this from occurring.

- As much as possible, protect advanced regeneration during salvage operations.

- As much as possible, minimize additional mineral soil exposure and maintain forest floor cover during salvage operations.

- Avoid salvage operations that will result in excessive compaction and/or rutting damage. Increased seasonal precipitation and reduced evapotranspiration mean that most soils will be in a moist or wet condition during fall and winter months and prone to increased damage (despite their normal drainage condition). Under these conditions, some soils can be damaged in as few as one or two machine passes. Therefore, minimize the amount of area travelled by machines (target <10 % of treated area), avoid travelling through low areas and depressions, and use slash and/or corduroy to maximize the utility of main and secondary haul trails (see the soil *Management Interpretations* and *Soil Hazard Mitigation* sections of the FEC guide for more information).

Conclusion

These guidelines are intended to help woodland owners decide on how much volume to salvage from tropical storm Fiona damaged stands. For each stand assessed, it is suggested that the highest estimated retention volume needed to meet all assessment criteria be chosen as the minimum post-salvage retention level.

- Minimum SGEM harvest retention levels by forest group as shown in Table 1., or if maximum salvage is desired, minimum CWM volumes shown in Table 2 column 2 (must also meet nutrient sustainability criteria).

- Nutrient sustainability objectives based on site-specific SusMAI values and previous harvest levels (Table 3 and spreadsheet supplement).

- Avoidance of excessive soil damage associated with poor operating conditions (target less than 10% of treated area with machine traffic).

References

Keys, K., J.D. Noseworthy, J. Ogilvie, D.L. Burton, and P.A. Arp. 2016. A simple geospatial nutrient budget model for assessing forest harvest sustainability across Nova Scotia, Canada. *Open Journal of Forestry* 6: 420-444.

McCurdy, D and B. Stewart. 2005. *Changes in dead wood structure following clearcut harvesting in Nova Scotia softwood forests*. Forest Research Report No. 76. Nova Scotia Department of Natural Resources.

McGrath, T., M. Pulsifer, R. Seymour, L. Doucette, G. Forbes, R. McIntyre, R. Milton, L. Cogan, M. Retallack, and T. Crewe. 2021. *Nova Scotia silviculture guide for the ecological matrix* (SGEM). Nova Scotia Department of Lands and Forestry.

Neily, P. and G.J. Parsons. 2017. *A field guide to forest biodiversity stewardship*. Report FOR 2017-1. Renewable Resources Branch, Nova Scotia Department of Natural Resources.

Neily, P., K. Keys, E. Quigley, S. Basquill, and B. Stewart. 2013. *Forest ecosystem classification for Nova Scotia (2010)*. Report FOR 2013-1. Renewable Resources Branch, Nova Scotia Department of Natural Resources.

Appendix A Sample Calculations

General Retention Calculations:

Where stand SusMAI values are ≥ 2.8 m^3/ha/yr

Stand is an SH5 vegetation type with pre-treatment/pre-disturbance volume of 180 m^3/ha.
Post-Fiona standing volume is 20 m^3/ha.
Minimum retention for SH group stands (Table 1) = 33% of 180 m^3/ha = 60 m^3/ha.

Maximum salvage = 180 m^3/ha – 60 m^3/ha = 120 m^3/ha,

or

Minimum windfall retention = 60 m^3/ha – 20 m^3/ha still standing = 40 m^3/ha

If the same stand had a recent partial harvest of 40 m^3/ha:

Maximum salvage = 120 m^3/ha – 40 m^3/ha = 80 m^3/ha

or

Minimum windfall retention = 60 m^3/ha – 20 m^3/ha still standing = 40 m^3/ha

Nutrient Sustainable Salvage Calculations:

1. Where stand SusMAI values are < 2.8 m^3/ha/yr

Use the following calculation to determine sustainable salvage removal:

100% – A – B = C

Where:
A = SusMAI minimum % retention requirement per Table 3 above
B = Previous recent % volume harvested (if applicable)
C = Allowable salvage %

Example 1 **Stand X:** **IH5 on ST6-S** **Ecodistrict 340**

Stand X has a SusMAI of 1.5 m^3/ha/yr with a pre-treatment/pre-disturbance volume of about 160 m^3/ha. There were no recent harvests of significance from this stand.

Maximum salvage = 100% - 50% - 0% = 50% of original stand volume = 80 m^3/ha

or

Minimum windfall retention = 50% of 160 m^3/ha = 80 m^3/ha

Interpretation: To maintain site nutrient sustainability, a maximum of 50% of the original stand volume may be salvaged (Table 3). This equates to a minimum of 50% windfall retention which supercedes the minimum 33% retention value listed in Table 1. Best management practices for biodiversity values and soil health should also be followed.

Example 2 **Stand Y:** **MW2 on ST2-G** **Ecodistrict 430**

Stand Y has a SusMAI of 1.8 m^3/ha/yr with a pre-treatment/pre-disturbance volume of about 140 m^3/ha. A recent partial harvest already removed 30% basal area (volume) = 42 m^3/ha.

Maximum salvage = 100% - 33% - 30% = 37% of original stand volume = 52 m^3/ha

or

Minimum windfall retention = 33% of 140 m^3/ha = 46 m^3/ha

Interpretation: With the earlier partial harvest, only a maximum of 37% of the original stand volume can be salvaged to maintain site nutrient sustainability. Best management practices for biodiversity values and soil health should also be followed.

Minimum CWM Considerations:

Where stand SusMAI values are ≥ 2.8 m^3/ha/yr and maximum salvage is desired

Stand is an SH5 vegetation type with pre-treatment/pre-disturbance volume of 180 m^3/ha. No trees were left standing, and no recent partial harvest was conducted.

Minimum CWM retention for SH group stands = 28 m^3/ha (Table 2)

This minimum retention can be assured by planning to leave this amount post-salvage.

Maximum salvage = 180 m^3/ha – 28 m^3/ha = 152 m^3/ha

or

Minimum windfall retention = 28 m^3/ha