# Quantifying Emissions Reductions for Ecosystem Restoration Projects in the BC Rocky Mountain Trench: Is Biomass Harvesting and Utilization the Answer?

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# Project Team and Funders

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- Sarah Sinclair – GSI Inc.

Rocky Mountain TRENCH SOCIETY NATURAL RESOURCES

Rocky Mountain Trench Ecosystem Restoration Program

Restoring Nature's Balance.

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SCR Management Inc.

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# 2013 Research Objectives

- ER dbase development
- Literature review
- Mastication data collection
- Cost benefit mastication vs. traditional ER
- Model emissions
- Evaluate non-market benefits and costs

# 2014 Research Objectives

- Estimate biomass volumes for the ER planning area (81,000+ Ha)
- Compare mastication emissions vs. biomass harvesting
- Estimate biomass harvest costs

# Traditional ER Methods

# Smoke Issues

# ER Program Objectives

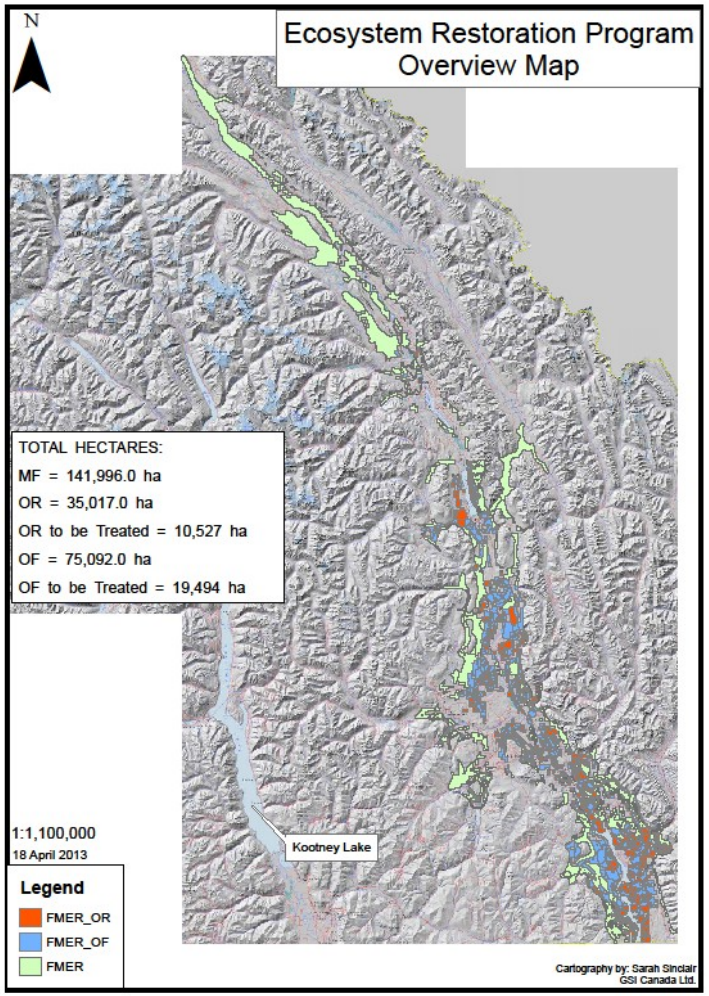
| Ecosystem Component | Tree Stocking Range/Stems/ha | 1997 Distribution | 2004 Distribution | 2030 Target Ha *(%)* |
|---|---|---|---|---|
| **Shrubland** | • 0 sph<br>• no target | 5% | 1% | 5,000 *(5%)* |
| **Open Range** | • <75 sph<br>• target 20 sph | 10% | 12% | 43,500 *(17%)* |
| **Open Forest** | • <400 sph<br>• target 150 sph | 85%* | 26% | 75,000 *(30%)* |
| **Managed Forest** | • varied<br>• Target 500-4000 sph | 85%* | 61% | 119,000 *(48%)* |

** Open and Managed forests were not disaggregated **into each of their individual components in 1997.***

# ER Treatment Area

**NDT 4**
**250,000+ ha in Trench**

Open Forest <150 SPH
Open Range <75 SPH
Managed Forest <400 SPH

# ER Treatments by Type

**Hectares treated over the 1999-2013 period**

| Type of Treatment | Total Hectares |
|---|---|
| **Logging** | 11,135 |
| **Thinning** | 869 |
| **Slash and pile** | 16,120 |
| **Prescribed burn** | 14,731 |
| **Grass seed** | 1,775 |
| **Total** | 48,172 |

# Mastication

Mastication is a mechanical means of small diameter tree removal whereby the wood is chopped/ground into a woody mulch cover; chips/chopped material is mostly less than 15” long and less than 3” diameter



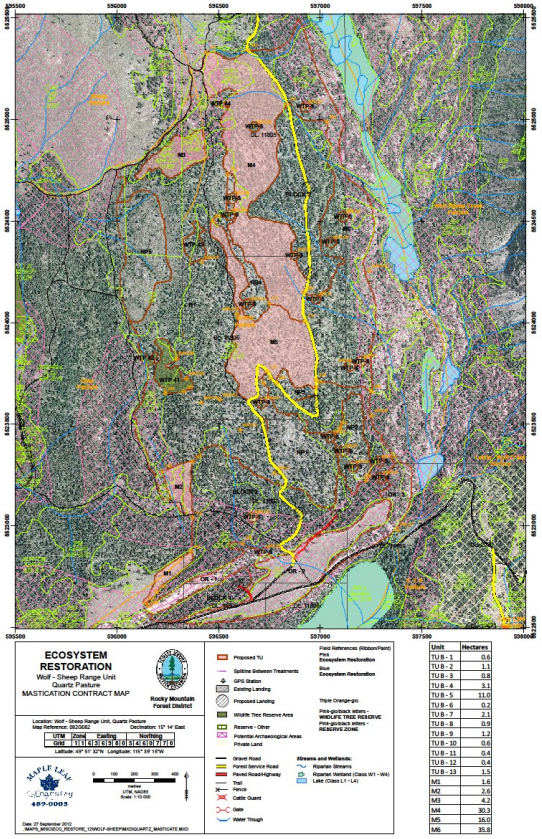
# Mastication

## Before

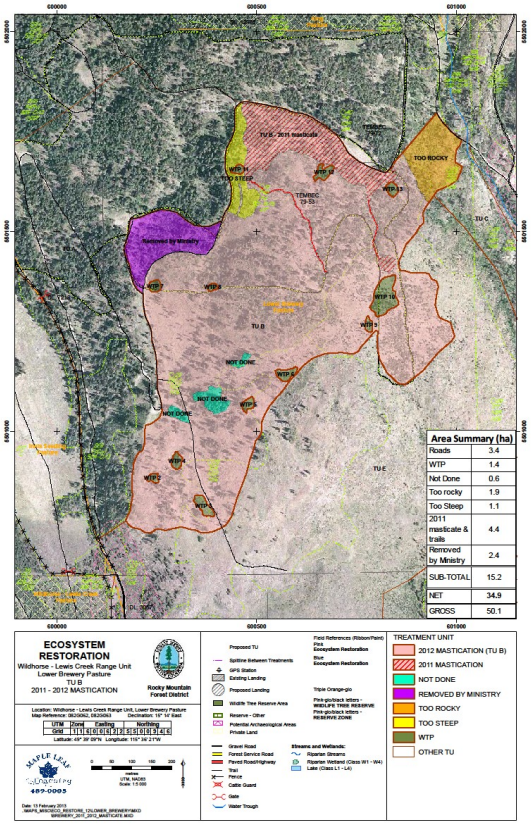
## After

# Mastication Treatment Areas

## Premier Ridge



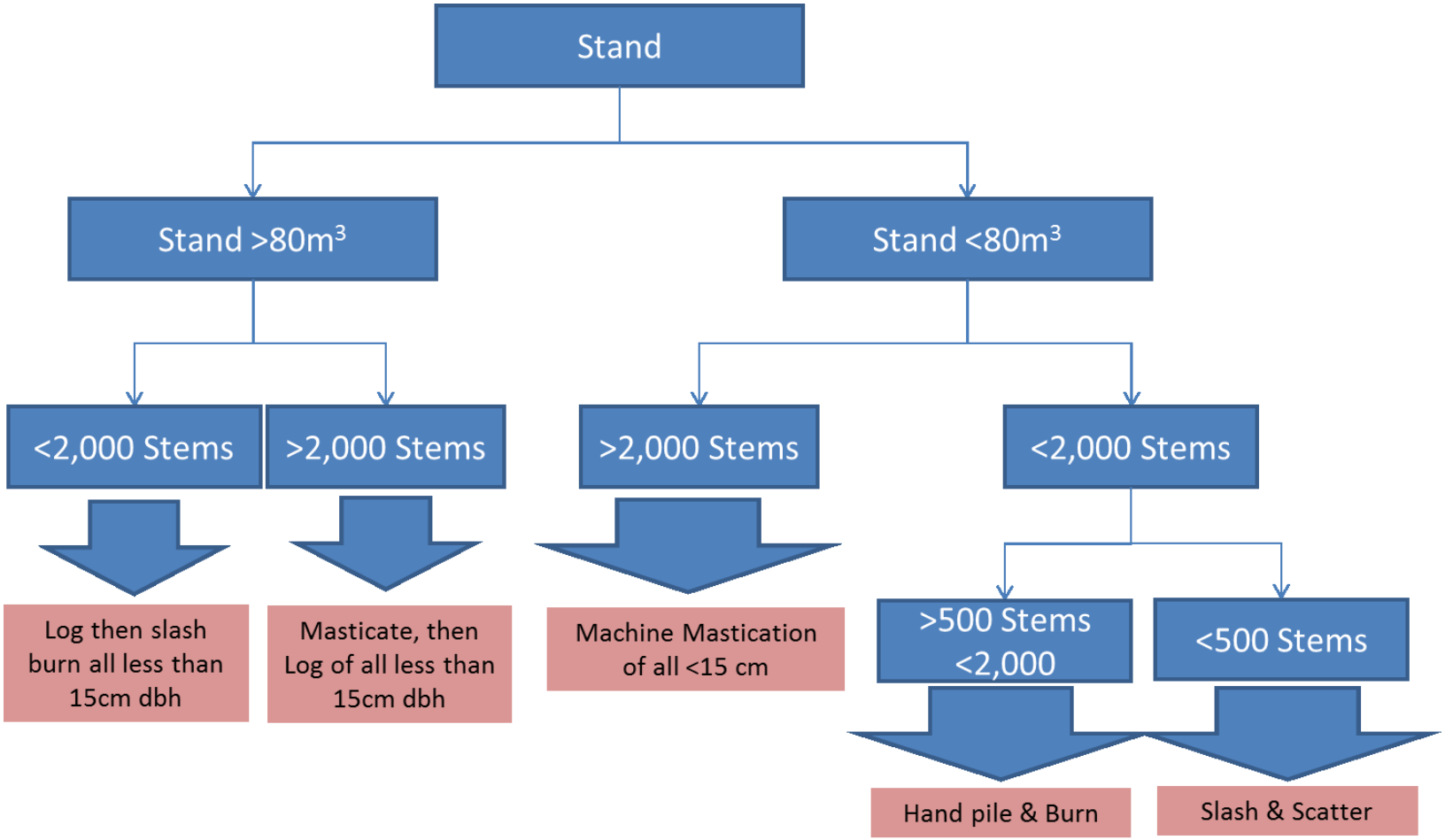

## Brewery Ridge



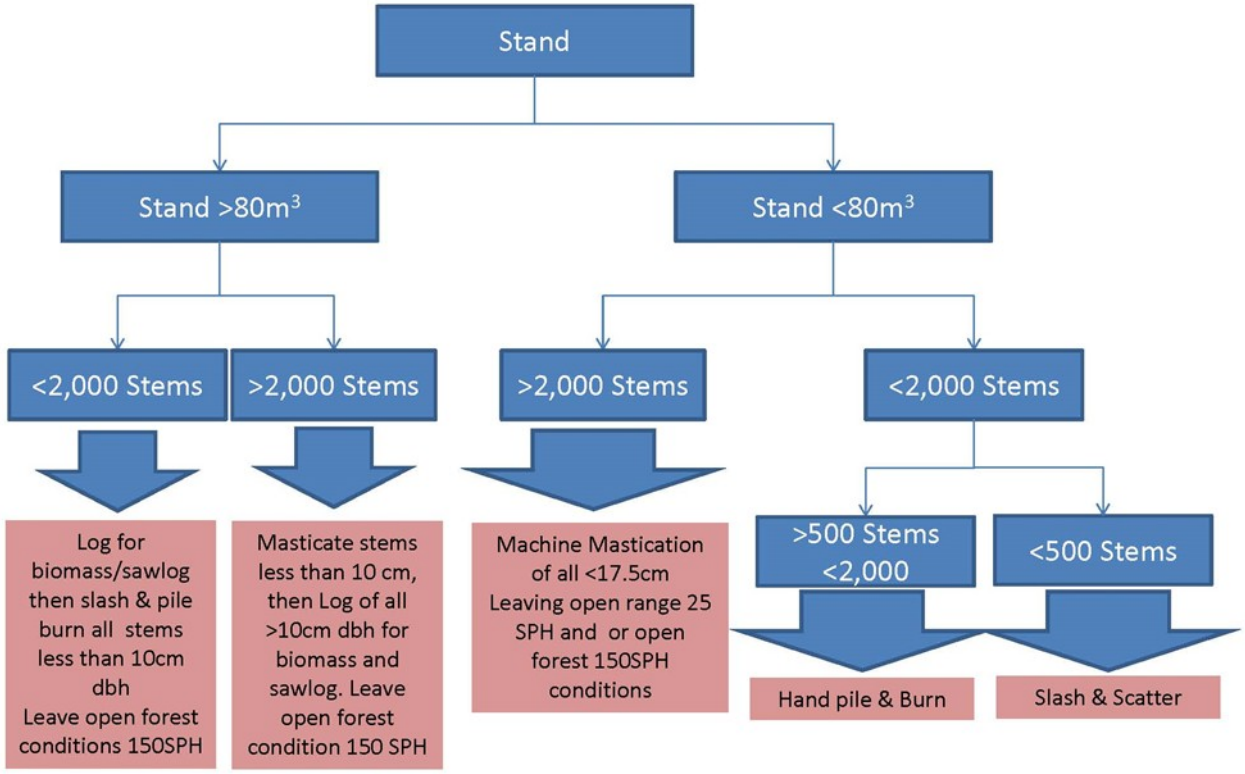
# Data Collection

- Tree – fixed radius plots
- Mulch depth- transects
- Slash pile measurements
- ER treatment costs
- Mastication treatment cost
- Mastication machine hours
- Forest Vegetation Resource Inventory

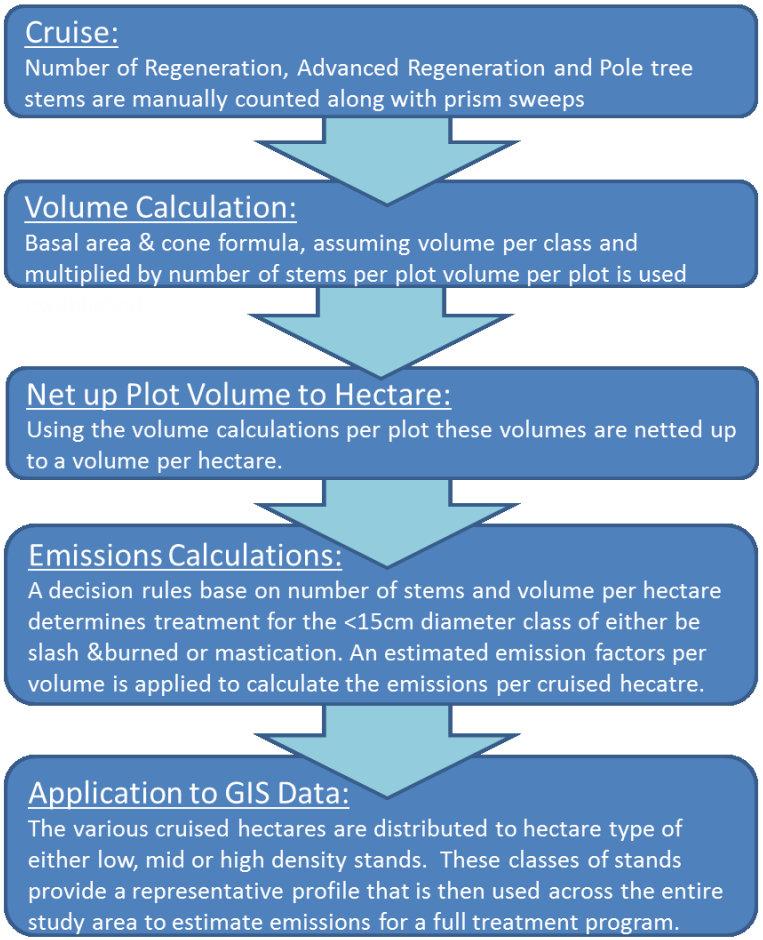
# Methods - Mastication only



# Methods - Biomass Utilization



# Emissions Estimation Methods

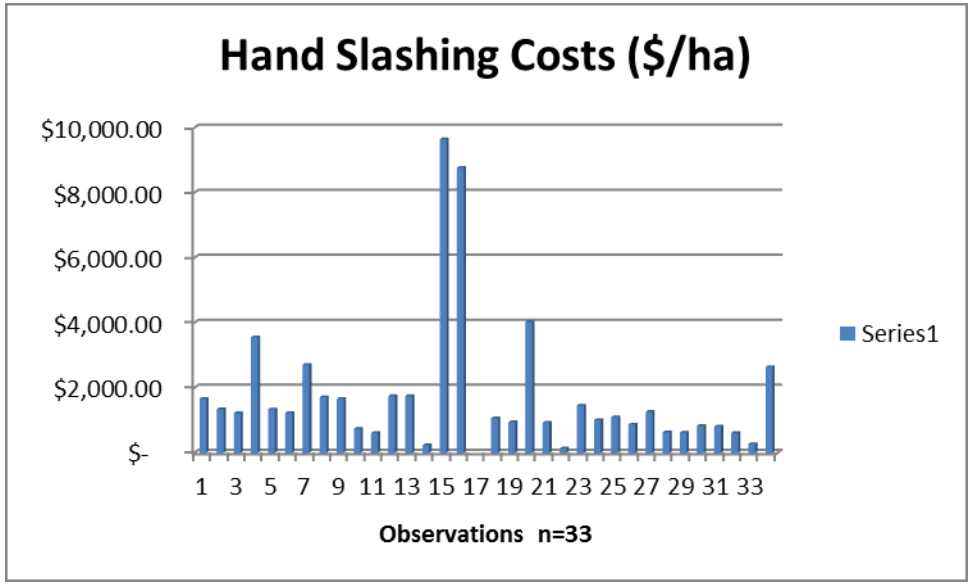


# ER Cost Results – Slashing

2009-2010

$1,791/ha Ave. slashing costs

Cost Range $300-9,500/ ha

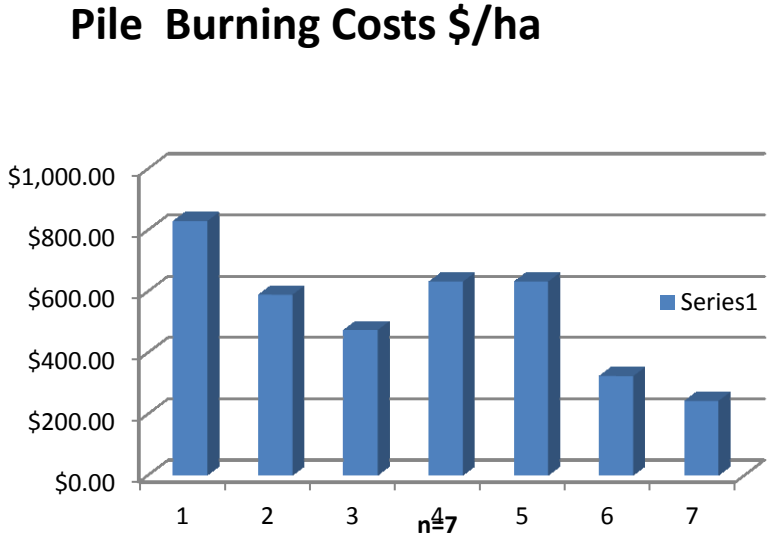


# ER Cost Results- Pile Burning

2009-2010

- Ave $532/ha
- Range $243-830/ha

- Seeding Ave $77/ha
- Range $40-120/ha



# ER Cost Results – Mastication Trials

| E/R Treatment Unit | Year | Hectares Treated | Cost/Ha | Notes |
|---|---|---|---|---|
| **Brewery Ridge TUB** | 2011-2012 | 34.9 | 1,560 | Very rocky and difficult for front mounted masticator. Fair results |
| **Brewery Ridge TU F** | 2011 | *4.4* | $4,000+ | Very dense 20,000 stems per/ha and too dense of mulch |
| **Premier Ridge All Treatment units** | 2012 | *80+* | $1,800 | Some rocky sections making mastication difficult, but cost effective |
| **Lackit Ridge** | 2013 | *13.7* | $1,759 | Cost effective using excavator head |
| **Fussie Pasture** | 2013 | 14.1 | $1,800 | Same as Lackit Ridge |
| **Totals** | | *147.1* | Range $1,560-4,000 | |

** Open and Managed forests were not disaggregated **into each of their individual components in 1997.***

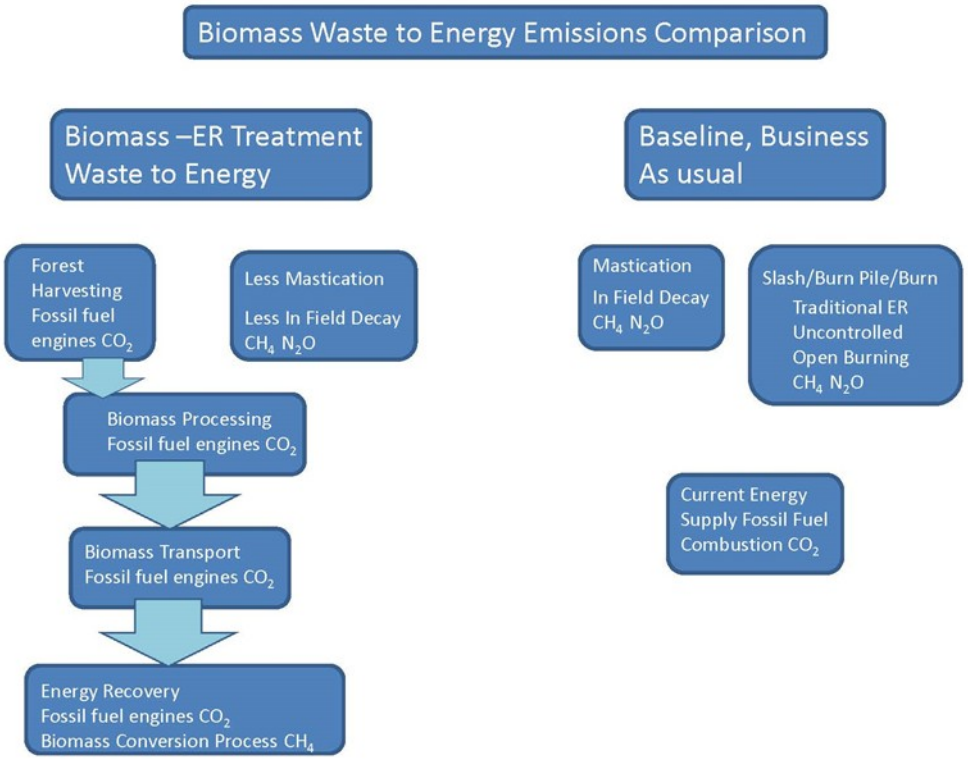
# Aggregate Sawlog & Biomass Volume Estimates

derived from ER Prescription plots and linked with VRI dbase

| SUMMARIZE CLASSES | |
|---|---|
| TREAMENT CLASS | VOL (M3) <12.5CM |
| HAND_PILE | 807,382 |
| SLASH&SCATTER | 24,257 |
| HI_LOG | 3,571,766 |
| LO_MAST | - |
| MI_MAST | 90 |
| TOTAL SAWLOG | 4,403,496 |

| SUMMARIZE CLASSES | |
|---|---|
| TREAMENT CLASS | VOL (M3)Pole |
| HAND_PILE | 82,540 |
| SLASH&SCATTER | 48,261 |
| HI_LOG | 228,684 |
| LO_MAST | 21,215 |
| MI_MAST | 26 |
| TOTAL POLES | 380,726 |

# Biomass Emissions Model



# Emissions Results

| BIOMASS UTILIZATION - USING POLES FROM ER TREATMENTS THAT WOULD BE OPEN BURNED | | | | |
|---|---|---|---|---|
| **Biomass Utilization -Emissions Reduction Calculations** | | | | |
| Green tons | $BM_{T,W}$ | 207,500 | tonne | |
| Moisture Content | M | 40% | % | |
| **Pre-project Biomass End-use** | | | | |
| Fraction Open Burned (slash) | $X_{OB}$ | 90% | % | |
| Fraction left to decay | $X_{DD}$ | 10% | % | |
| **Energy Production** | | | | |
| Higher Heating Value | $HHV_{BM}$ | 12.0000 | MMbtu/dry tonne | |
| Energy production efficiency | f | 50% | % | |
| Natural Gas Equivalent | $E_{BM}$ | 747,000 | MMbtu | assumes same energy production efficiency |
| Natural Gas Equivalent | $E_{BM}$ | 788,085 | Gl | assumes same energy production efficiency |
| Base Case (BAU) Total Emissions | $GHG_{Base}$ | 218,569 | tCO2e | |
| GHG Emission from Combustion | $GHG_{proj}$ | - 118,538 | tCO2e | |
| **TOTAL GHG EMISSION REDUCTIONS** | $GHG_{offsets}$ | **337,108** | tCO2e | |

# Transport Emissions

| Transport Emissions CO2e | $CO_2$ | $CH_4$ | $CH_4$ ($CO_2e$) | $N_2O$ | $N_2O$ ($CO_2e$) | Total $CO_2e$ | Units |
|---|---|---|---|---|---|---|---|
| Cycle distance (ave 80 km/50 miles) | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.00 |
| Fuel usage - Litres per km | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.80 |
| Diesel – On Road Vehicles[3] | 2,663.0 | 0.1 | 2.5 | 0.1 | 25.4 | 2,690.9 | g/L |
| Total emissions ( g) per load - 19 tonnes/load | 170,432.0 | 7.7 | 161.3 | 5.2 | 1,626.9 | 172,217.6 | |
| Total emissions ( g) Bdtonne | 8,970.1 | 0.4 | 8.5 | 0.3 | 85.6 | 9,064.1 | |
| Total Bone dry tonnes hauled | 186,750.0 | 186,750.0 | 186,750.0 | 186,750.0 | 186,750.0 | 186,750.0 | |
| Total emissions tonnes | 1,675.17 | 0.08 | 1.59 | 0.05 | 15.99 | 1,692.72 | |

# Harvesting Costs

**Tree-To-Truck Harvest Costs**

| Average Tree Volume(m3/tree) | Slope (%) 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.11 | $23.83 | $24.13 | $24.44 | $24.74 | $25.05 | $25.36 | $25.66 | $25.97 | $26.28 | $26.58 |
| 0.13 | $23.40 | $23.70 | $24.01 | $24.31 | $24.62 | $24.93 | $25.23 | $25.54 | $25.85 | $26.15 |
| 0.15 | $22.96 | $23.27 | $23.58 | $23.88 | $24.19 | $24.50 | $24.80 | $25.11 | $25.42 | $25.72 |
| 0.17 | $22.53 | $22.84 | $23.15 | $23.45 | $23.76 | $24.07 | $24.37 | $24.68 | $24.99 | $25.29 |
| 0.19 | $22.10 | $22.41 | $22.72 | $23.02 | $23.33 | $23.64 | $23.94 | $24.25 | $24.56 | $24.86 |
| 0.21 | $21.67 | $21.98 | $22.29 | $22.59 | $22.90 | $23.21 | $23.51 | $23.82 | $24.13 | $24.43 |
| 0.23 | $21.24 | $21.55 | $21.86 | $22.16 | $22.47 | $22.78 | $23.08 | $23.39 | $23.70 | $24.00 |
| 0.25 | $20.81 | $21.12 | $21.43 | $21.73 | $22.04 | $22.35 | $22.65 | $22.96 | $23.26 | $23.57 |
| 0.27 | $20.38 | $20.69 | $21.00 | $21.30 | $21.61 | $21.91 | $22.22 | $22.53 | $22.83 | $23.14 |
| 0.29 | $19.95 | $20.26 | $20.56 | $20.87 | $21.18 | $21.48 | $21.79 | $22.10 | $22.40 | $22.71 |
| 0.31 | $19.52 | $19.83 | $20.13 | $20.44 | $20.75 | $21.05 | $21.36 | $21.67 | $21.97 | $22.28 |
| 0.33 | $19.09 | $19.40 | $19.70 | $20.01 | $20.32 | $20.62 | $20.93 | $21.24 | $21.54 | $21.85 |
| 0.35 | $18.74 | $19.05 | $19.36 | $19.66 | $19.97 | $20.28 | $20.58 | $20.89 | $21.19 | $21.50 |
| 0.4 | $18.74 | $19.05 | $19.36 | $19.66 | $19.97 | $20.28 | $20.58 | $20.89 | $21.19 | $21.50 |

# Delivered Wood Cost Estimates

**Total Delivered Cost - Green Wood** Green Tons $/tonne

| Volume/ha | Slope 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| 60 | $44.35 | $45.97 | $47.78 | $49.59 | $51.40 | $53.21 | $55.02 | $56.83 | $58.64 | $60.45 |
| 80 | $44.27 | $45.89 | $47.69 | $49.50 | $51.31 | $53.12 | $54.93 | $56.74 | $58.55 | $60.36 |
| 100 | $44.18 | $45.80 | $47.61 | $49.42 | $51.23 | $53.04 | $54.85 | $56.66 | $58.47 | $60.28 |
| 120 | $44.10 | $45.71 | $47.52 | $49.33 | $51.14 | $52.95 | $54.76 | $56.57 | $58.38 | $60.19 |
| 140 | $44.01 | $45.63 | $47.44 | $49.25 | $51.06 | $52.87 | $54.68 | $56.49 | $58.30 | $60.10 |
| 160 | $43.92 | $45.54 | $47.35 | $49.16 | $50.97 | $52.78 | $54.59 | $56.40 | $58.21 | $60.02 |
| 180 | $43.84 | $45.46 | $47.27 | $49.08 | $50.89 | $52.70 | $54.50 | $56.31 | $58.12 | $59.93 |
| 200 | $43.75 | $45.37 | $47.18 | $48.99 | $50.80 | $52.61 | $54.42 | $56.23 | $58.04 | $59.85 |
| 220 | $43.67 | $45.29 | $47.10 | $48.90 | $50.71 | $52.52 | $54.33 | $56.14 | $57.95 | $59.76 |
| 240 | $43.58 | $45.20 | $47.01 | $48.82 | $50.63 | $52.44 | $54.25 | $56.06 | $57.87 | $59.68 |
| 260 | $43.50 | $45.11 | $46.92 | $48.73 | $50.54 | $52.35 | $54.16 | $55.97 | $57.78 | $59.59 |
| 280 | $43.41 | $45.03 | $46.84 | $48.65 | $50.46 | $52.27 | $54.08 | $55.89 | $57.70 | $59.51 |
| 300 | $43.32 | $44.94 | $46.75 | $48.56 | $50.37 | $52.18 | $53.99 | $55.80 | $57.61 | $59.42 |
| 320 | $43.24 | $44.86 | $46.67 | $48.48 | $50.29 | $52.10 | $53.91 | $55.71 | $57.52 | $59.33 |
| 340 | $43.15 | $44.77 | $46.58 | $48.39 | $50.20 | $52.01 | $53.82 | $55.63 | $57.44 | $59.25 |

# Delivered Wood Cost Estimates with Biomass Top-up

**Total Delivered Cost - Green Wood** Green Tons $/tonne

| Volume/ha | Slope 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| 60 | $37.35 | $38.97 | $40.78 | $42.59 | $44.40 | $46.21 | $48.02 | $49.83 | $51.64 | $53.45 |
| 80 | $37.27 | $38.89 | $40.69 | $42.50 | $44.31 | $46.12 | $47.93 | $49.74 | $51.55 | $53.36 |
| 100 | $37.18 | $38.80 | $40.61 | $42.42 | $44.23 | $46.04 | $47.85 | $49.66 | $51.47 | $53.28 |
| 120 | $37.10 | $38.71 | $40.52 | $42.33 | $44.14 | $45.95 | $47.76 | $49.57 | $51.38 | $53.19 |
| 140 | $37.01 | $38.63 | $40.44 | $42.25 | $44.06 | $45.87 | $47.68 | $49.49 | $51.30 | $53.10 |
| 160 | $36.92 | $38.54 | $40.35 | $42.16 | $43.97 | $45.78 | $47.59 | $49.40 | $51.21 | $53.02 |
| 180 | $36.84 | $38.46 | $40.27 | $42.08 | $43.89 | $45.70 | $47.50 | $49.31 | $51.12 | $52.93 |
| 200 | $36.75 | $38.37 | $40.18 | $41.99 | $43.80 | $45.61 | $47.42 | $49.23 | $51.04 | $52.85 |
| 220 | $36.67 | $38.29 | $40.10 | $41.90 | $43.71 | $45.52 | $47.33 | $49.14 | $50.95 | $52.76 |
| 240 | $36.58 | $38.20 | $40.01 | $41.82 | $43.63 | $45.44 | $47.25 | $49.06 | $50.87 | $52.68 |
| 260 | $36.50 | $38.11 | $39.92 | $41.73 | $43.54 | $45.35 | $47.16 | $48.97 | $50.78 | $52.59 |
| 280 | $36.41 | $38.03 | $39.84 | $41.65 | $43.46 | $45.27 | $47.08 | $48.89 | $50.70 | $52.51 |
| 300 | $36.32 | $37.94 | $39.75 | $41.56 | $43.37 | $45.18 | $46.99 | $48.80 | $50.61 | $52.42 |

@ 40% MC the ave Bdtonne = $67

# Conclusions

- Mastication benefits
  - Low volume  treatments will contribute less
    - CO2e,
    - Particulate matter
    - Public issues related to smoke
  - Improves many market and non-market values
  - Competitive as an ER treatment method

# Conclusions

## ER Biomass Utilization Benefits

- Biomass  Utilization + mastication could lower overall treatment costs
- Lowers C02e and PM
- Provides  an economical biomass supply for energy use

# Future Research

## Mastication

- Develop ERPro dbase  to support knowledge and decision making
- Develop better stand volume estimates for developing an ER mastication/biomass harvesting analysis
- Continue to develop  better carbon and emissions models that  quantify  the $CO2^{e}$ impacts of mastication and biomass utilization
- Develop Carbon offset protocol for ER biomass utilization

# Thank you

for more information
or to review reports go to
www.scrmanagement.com

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