Hammond, H.L. 1984a. Evaluation of logging soil disturbance and
logging efficiency FL A20192 of block 3 Springer Creek.
Contract report submitted to Forestry Division, Nelson Region,

Hammond, H.L. 1984b. Soil disturbance levels in ground skidded

Hammond, H.L. 1985. Technical evaluation of forest management
practices in the Nass River Valley. Silva Ecosystem

Hammond, H.L. 1986a. A practical forest resources planning
system. In: Degradation of forested lands - forest soils at
risk; Proc. Tenth B.C Soil Science Workshop. J.D. Lousier and
G. Still (eds). Land Management Report. B.C. Ministry of

Hammond, H.L. 1986b. Soil degradation: costs of rehabilitation
versus costs of prevention. In: Degradation of forested lands
- forest soils at risk; Proc. Tenth B.C Soil Science Workshop.
J.D. Lousier and G. Still (eds). Land Management Report. B.C.

Hart, J.S. 1974. Clastic sediment sources and suspended sediment
yield in a coast mountain watershed, British Columbia.
University of British Columbia. 75p.

disturbances in logging. J. For. 68: 772-775.

Hazard, J.W. and J.M. Geist. 1984. Sampling forest soil
conditions to assess impacts of management activities. Notes
from workshop - Forest Soils and Treatment Impacts pp. 422-
430.

Helms, J.A. and C. Hipkin. 1986. Effects of soil compaction on
tree volume in a California Ponderosa pine plantation. West.

nutrient losses by soil erosion and mass movement after

burning on the water repellency of forest soils at Vancouver,


Pomeroy, K.B. 1949 The germination and initial establishment of loblolly pine under various surface soil conditions. J. For. 47:541-543.


APPENDIX I
QUESTIONNAIRE FORM AND RESPONSES
QUESTIONNAIRE

EVALUATION OF SOIL DEGRADATION AS A FACTOR EFFECTING N.S.R. BACKLOG IN B.C.

Name of Respondent

Position/Agency

Address

Phone Number

1. Please list any existing or ongoing studies and/or data that you are aware of regarding soil degradation in your Region.

   We are interested in any and all information related to causes and effects as well as methods of rehabilitation and prevention.

   1. 

   2. 

   3. 

   4. 

2. Please list any studies or data regarding soil degradation that you feel are applicable to your area but were undertaken outside of B.C. For example, the U.S., Alberta, Ontario, Quebec or Europe.
3. Given that the major factors of soil degradation are:

<table>
<thead>
<tr>
<th>Factor</th>
<th>% reduction or increase in productivity (min-max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. soil density increase</td>
<td></td>
</tr>
<tr>
<td>2. soil moisture decrease/increase</td>
<td></td>
</tr>
<tr>
<td>3. soil nutrient decrease</td>
<td></td>
</tr>
<tr>
<td>4. loss of surface organic matter</td>
<td></td>
</tr>
<tr>
<td>5. soil acidity increase/decrease</td>
<td></td>
</tr>
<tr>
<td>6. soil erosion and mass movement</td>
<td></td>
</tr>
<tr>
<td>7. increase/decrease in soil bacteria/actinomycetes</td>
<td></td>
</tr>
<tr>
<td>8. increase in frost depth and/or frost heaving</td>
<td></td>
</tr>
</tbody>
</table>

From your best guess based on personal experience, or knowledge acquired from the literature, please indicate what you feel is the effect in your Region on conifer productivity for each soil degradation factor (assuming there has been a significant change in soil properties for that factor). This is best given as a % reduction (or increase) in conifer productivity for each factor.

4.1 Please indicate what you feel are the most significant soil degradation processes in your region in decreasing order of importance (please feel free to add any factors which you may feel we have missed).
4.2 Do you feel that there is a significant link between soil degradation and backlog NSR in your Region. If so, what are they?


4.3 Do you feel soil degradation on re-stocked lands (ie. non NSR) is having a significant effect on soil productivity? If so, should it be reflected in the calculations of AAC.?


5. Based on your knowledge and experience could you please provide us with your opinion as to the amount and type of soil/site degradation caused by various treatments, as applied in your Region.

<table>
<thead>
<tr>
<th>Type of Treatment</th>
<th>Types of Degradation</th>
<th>% of treated area affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ground Skidding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Cable Logging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Broadcast Burning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Windrowing/Bunching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Scarification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Related to #5 above, please indicate to the best of your knowledge, the methods and costs for prevention of soil/site degradation and for site soil rehabilitation on a hectare basis.

<table>
<thead>
<tr>
<th>Type of Degradation</th>
<th>Means of Prevention</th>
<th>Costs of Prevention ($/ha)</th>
<th>Rehabilitation Method</th>
<th>Costs of Rehabilitation ($/ha)</th>
</tr>
</thead>
</table>
7. Could you please provide us with a list of contacts (government and industry) in B.C., Canada, and/or the U.S. Pacific Northwest who you feel may have information regarding soil/site degradation.


8. Other comments


DISCUSSIONS OF RESPONSES TO QUESTIONNAIRE

1. The questionnaire was sent to 26 individuals; 19 government and 7 industry.

2. A total of 18 responses were received.

3. Of the 18 responses, 8 were from the coast and 10 from the interior.

4. The following list ranks soil degradation factors according to questionnaire respondents from most severe to least severe and provides the range of productivity reduction as a percentage:

   - Soil density increase: 5-25%
   - Soil erosion/mass movement: 1-30%
   - Loss of organic matter: 5-20%
   - Soil moisture increase/decrease: 0-15%
   - Soil biota changes: 0-14%
   - Soil acidity changes: 0-10%
   - Increase in frost depth: 0-5%

5. Respondents from industry tended to estimate lower productivity losses than government respondents; respondents from the coast tended to record lower values for productivity losses in comparison to respondents from the interior.

6. 75% of respondents felt that there is no direct link between soil degradation and backlog NSR; 25% felt that there is some connection.

7. 92% of all respondents felt that soil degradation is having a significant effect on conifer productivity; 8% said there wasn't or that more information is required.
APPENDIX II
ALTERNATIVE PRODUCTIVITY - LOSS CALCULATION
APPENDIX II: ALTERNATIVE PRODUCTIVITY-LOSS CALCULATION

The calculations of decreased forest productivity presented in this appendix are based on the same methods used in Chapters 5 and 6. The differences are in the assumptions of percentages of degraded soil area and yield reductions resulting from that degradation (see tables II.1, II.2 and II.3). The calculations presented previously were conservative interpretations of the available data. The assumptions made here are equally plausible interpretations of the existing data, but not conservatively biased.

Modifications to assumptions employed in Chapters 5 and 6 are summarized as follows:

* estimates of harvested area degraded by ground skidding are increased by 3%.
* the percent growth reduction due to soil degradation resulting from harvesting is increased to 60% on the coast and 75% in the interior.
* an additional 10% of the broadcast burned areas are included as having a 20% reduction in growth.
* 5% of the areas receiving "Other Mechanical Site Preparation" are included as having degraded soils.

These alternative assumptions include consideration of factors felt to be likely, but not proven with existing data. For example, the percent area severely disturbed by ground skidding, reported from studies in B.C., ranges from 14 to 58 percent (see table 5.1), with the majority between 20 and 40%. The percentages chosen here are still within that range.
The percent growth changes on skidroads presented in table 6.1 range from -26 to -95% for the impacted area. The studies indicated that in most cases there is a decrease in the size of individual trees, as well as a decrease due to stocking reductions. For the estimates presented here, it is assumed that the decreased size of trees results in further yield losses because many trees on the skidroads are of unmerchantable size when the cutblock has reached rotation age (alternatively the rotation age could be extended also resulting in further long-term yield reductions). For the coast where trees are generally larger, the growth reduction is set at 60%, as opposed to 75% for the interior.

The addition of another loss category for slashburning is to account for long-term site productivity losses of a minor nature from reductions in organic matter and nitrogen. The "other mechanical site preparation" losses likely result from compaction and/or scalping from some types of machinery or operations on moist soils.

These minor adjustments in assumptions have increased the estimated area degraded by forestry practices between 1976 and 1985/86 by 18%, the annual yield losses by 55%, and the current annual loss to the provincial economy to $126 million (see tables II.4 and II.5). Assuming similar forestry practices and levels of soil degradation, the annual loss to the provincial economy could exceed $200 million by the year 1991. Given the limited nature of the data available at present, the losses due to forest soil degradation could very well be of this magnitude.
### Table II.1: Percentage of harvested area degraded by various harvesting systems* on specified slope classes (assumptions by the authors based on available literature).

<table>
<thead>
<tr>
<th></th>
<th>HELI &gt;50%</th>
<th>HELI &lt;35%</th>
<th>CABLE 35-50%</th>
<th>CABLE &gt;50%</th>
<th>LT FLOT &lt;35%</th>
<th>LT FLOT 35-50%</th>
<th>GR WIN &lt;35%</th>
<th>GR WIN 35-50%</th>
<th>GR WIN &gt;50%</th>
<th>GR SUM &lt;35%</th>
<th>GR SUM 35-50%</th>
<th>GR SUM &gt;50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPACT &amp; DEEP DIST</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>23</td>
<td>25</td>
<td>28</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>ERODED</td>
<td>0.5</td>
<td>0.1</td>
<td>0.5</td>
<td>1.0</td>
<td>0.1</td>
<td>0.5</td>
<td>0.5</td>
<td>1.5</td>
<td>0.2</td>
<td>1.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>TOTAL DEGR</td>
<td>3.5</td>
<td>10.1</td>
<td>10.5</td>
<td>11</td>
<td>18.1</td>
<td>20.5</td>
<td>20.5</td>
<td>24.5</td>
<td>25.2</td>
<td>29</td>
<td>30.5</td>
<td></td>
</tr>
</tbody>
</table>

*HELI=helicopter, CABLE=cable yarding, LT=light flotation, GR=ground skidding, WIN=winter, SUM=summer.

### Table II.2: Percentage of treated area degraded by specified silvicultural practices (assumptions by the authors based on available literature).

<table>
<thead>
<tr>
<th>AREA DEGR</th>
<th>BURN HEAVY</th>
<th>BURN LIGHT</th>
<th>WINDROW</th>
<th>BUNCH</th>
<th>BLADE SCARIFY</th>
<th>DRAG SCARIFY</th>
<th>OTHER MECH</th>
<th>CHEMICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA DEGR</td>
<td>10</td>
<td>10</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table II.3: Percentage reduction in growth applied to degraded areas of each degradation class (assumptions by the authors based on available literature).

<table>
<thead>
<tr>
<th>HARV DEGR</th>
<th>EROSN DEGR</th>
<th>BURN HEAVY</th>
<th>BURN LIGHT</th>
<th>WINROW DEGR</th>
<th>BUNCH DEGR</th>
<th>5L SCAR DEGR</th>
<th>OTH MEC DEGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>COAST</td>
<td>60</td>
<td>100</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>INTERIOR</td>
<td>75</td>
<td>100</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>FOREST</td>
<td>TOTAL DEGR AREA (ha)</td>
<td>MAI m3/ha/yr</td>
<td>HARV DEGR</td>
<td>EROSN DEGR</td>
<td>BURN DEGR</td>
<td>WINDRW DEGR</td>
<td>BUNCH DEGR</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------</td>
<td>--------------</td>
<td>-----------</td>
<td>------------</td>
<td>-----------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>VANC CST</td>
<td>43148</td>
<td>4.3</td>
<td>87392</td>
<td>5585</td>
<td>11128</td>
<td>127</td>
<td>741</td>
</tr>
<tr>
<td>P RUP CST</td>
<td>7744</td>
<td>2.6</td>
<td>11830</td>
<td>418</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>VANC INT</td>
<td>1965</td>
<td>2.8</td>
<td>4044</td>
<td>110</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>P RUP INT</td>
<td>53945</td>
<td>1.5</td>
<td>44841</td>
<td>528</td>
<td>14076</td>
<td>522</td>
<td>1652</td>
</tr>
<tr>
<td>PR GEORGE</td>
<td>159573</td>
<td>1.7</td>
<td>140142</td>
<td>1645</td>
<td>18443</td>
<td>6354</td>
<td>10995</td>
</tr>
<tr>
<td>CARIBOO</td>
<td>76703</td>
<td>1.4</td>
<td>68022</td>
<td>880</td>
<td>4906</td>
<td>104</td>
<td>3833</td>
</tr>
<tr>
<td>KAMLOOPS</td>
<td>78939</td>
<td>2.0</td>
<td>87909</td>
<td>1350</td>
<td>3166</td>
<td>1139</td>
<td>10211</td>
</tr>
<tr>
<td>NELSON</td>
<td>54565</td>
<td>2.1</td>
<td>70291</td>
<td>1756</td>
<td>1809</td>
<td>290</td>
<td>4027</td>
</tr>
<tr>
<td>TOTAL</td>
<td>475582</td>
<td></td>
<td>514482</td>
<td>12271</td>
<td>53528</td>
<td>8516</td>
<td>31459</td>
</tr>
</tbody>
</table>

Table II.4: Estimate of the current annual growth losses (m3/yr) occurring on degraded soils as a result of forestry practices during 1976-1985/86 (derived from tables 5.4, 5.6, II.1, II.2, II.3 and MOF 1980).

<table>
<thead>
<tr>
<th>FOREST</th>
<th>TOTAL DEGR AREA (ha)</th>
<th>MAI m3/ha/yr</th>
<th>HARV DEGR</th>
<th>EROSN DEGR</th>
<th>BURN DEGR</th>
<th>WINDRW DEGR</th>
<th>BUNCH DEGR</th>
<th>BL SCAR DEGR</th>
<th>OTH MEC DEGR</th>
<th>TOTAL LOSS (m3/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VANC CST</td>
<td>5383</td>
<td>4.3</td>
<td>11468</td>
<td>733</td>
<td>1100</td>
<td>22</td>
<td>11</td>
<td>8</td>
<td>37</td>
<td>13379</td>
</tr>
<tr>
<td>P RUP CST</td>
<td>143</td>
<td>2.6</td>
<td>218</td>
<td>8</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>226</td>
</tr>
<tr>
<td>VANC INT</td>
<td>351</td>
<td>2.8</td>
<td>723</td>
<td>20</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>743</td>
</tr>
<tr>
<td>P RUP INT</td>
<td>7276</td>
<td>1.5</td>
<td>5065</td>
<td>60</td>
<td>913</td>
<td>395</td>
<td>209</td>
<td>26</td>
<td>116</td>
<td>6784</td>
</tr>
<tr>
<td>PR GEORGE</td>
<td>21480</td>
<td>1.7</td>
<td>15484</td>
<td>182</td>
<td>2796</td>
<td>1994</td>
<td>1084</td>
<td>642</td>
<td>129</td>
<td>22312</td>
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<tr>
<td>CARIBOO</td>
<td>9790</td>
<td>1.4</td>
<td>9313</td>
<td>120</td>
<td>161</td>
<td>65</td>
<td>166</td>
<td>1</td>
<td>122</td>
<td>9949</td>
</tr>
<tr>
<td>KAMLOOPS</td>
<td>8603</td>
<td>2.0</td>
<td>10979</td>
<td>163</td>
<td>382</td>
<td>85</td>
<td>525</td>
<td>259</td>
<td>42</td>
<td>12053</td>
</tr>
<tr>
<td>NELSON</td>
<td>6318</td>
<td>2.1</td>
<td>7630</td>
<td>191</td>
<td>356</td>
<td>139</td>
<td>676</td>
<td>111</td>
<td>17</td>
<td>9120</td>
</tr>
<tr>
<td>TOTAL</td>
<td>59344</td>
<td></td>
<td>60498</td>
<td>1475</td>
<td>5708</td>
<td>2700</td>
<td>2671</td>
<td>1048</td>
<td>465</td>
<td>74565</td>
</tr>
</tbody>
</table>

Table II.5: Estimate of the current annual growth losses (m3/yr) occurring on degraded soils as a result of forestry practices during 1985/86 (derived from MOFLAR, tables 5.3, II.1, II.2, II.3 and MOF 1980).
This report was produced for the Canada-British Columbia Forest Resource Development Agreement under contract to the Canadian Forestry Service