Appendix

Forest Fertilization and Management Objectives

Note: Workshop participants are encouraged to explore the information presented in this appendix to further their background knowledge of forest fertilization planning.

The opinions of a person outside of our country can sometimes provide a different and unique perspective of the situation, particularly when that country (Sweden) has significant experience with this forest management tool and its effects. The three postulates of Stig Hagner, Professor of Silviculture and Director of Forestry Operations, Svenska Cellulosa Ab., provide an opportunity to discuss if the conditions are suitable for forest fertilization in BC.

The following is a synopsis of a paper given by Professor Stig Hagner at the March, 1988 Forest Fertilization Workshop entitled “Improving Forest Fertilization Decision-making in British Columbia.” His talk gave an overview of Sweden’s fertilization experience and role in forest management. He suggested three postulates (prerequisites or fundamental conditions) regarding the basic conditions that forest fertilization must satisfy to be considered a suitable silviculture management treatment. The postulates are:

- The agency benefiting from the increased wood availability should fund its production.
- Forest fertilization should be integrated into an overall plan for long-term utilization of forest resoures, requiring that the agency planning to benefit has long-term security of tenure.
- Forest fertilization can be justified on economic grounds if, for forest owners who sell timber, the increased value of the selling price of the wood is greater than the cost to produce it. For forest owners also operating wood-processing facilities, the forest fertilization can be justified if it improves the industry’s raw material supply position at a cost that permits profitable production, or allows for obtaining harvested timber from less expensive sources.

Think about these three postulates and put them in the perspective of British Columbia and its current state of forest management.

- Do you agree or disagree with Stig Hagner?
- With the high level of privately owned forest in Sweden (by small land owners and by the forest industry), how would a fertilization program in Sweden differ from that in British Columbia?

- What are the limiting factors to an expanded forest fertilization program in BC?
- How could BC's factors be modified to allow for an expanded program and the resulting benefits?
- In light of recent land use plans and zoning in BC through higher level plans, how could fertilization be used more beneficially?

Foliar Analysis

Interpretation and Diagnosis Exercises

Consider each of the following scenarios and make interpretations on the possibility of the stand being affected by nutrient deficiencies. Identify possible deficiencies and explain which factor may be contributing to the occurrence of the foliar nutrient levels found.

Scenario 1

A young (7 to 10 year old) hemlock plantation in the Campbell River forest district is showing obvious signs of "checked height growth." The initial height growth following burning and plantation establishment was good (40–60 cm/year) and has now declined to less than 15 cm per year. The trees are growing on an old cedar-hemlock site with a surface organic horizon approximately 55 cm thick of decaying wood. Soil samples of this organic soil type (Folisolic Humoferric Podzol) show high C:N ratio, low mineralization rates and high probability of immobilization. The site has a fresh to moist SMR and poor SNR. Annual rainfall is approximately 2600 mm/year.

Foliage samples were collected as a composite sample of 15 trees during the dormant season of 1987. The following foliar nutrient levels were found:

	%		ppm
N	0.61	SO_4-S	214
P	0.13	Cu	4.3
K	0.78	Zn	26
Ca	0.52	Mn	957
Mg	0.08	Active Fe	66
S	0.07	B	18

What are the site factors likely contributing to the poor growth performance of this plantation? Is nitrogen fertilization likely to result in improved growth performance? What other nutrient(s) would you prescribe and would you expect to get a long-term growth response?

Answer:

Scenario 2

A 32 year old white spruce stand is growing in the Bowron River area of the Prince George Forest District. The site is very productive, the actual soil moisture regime is fresh to moist, and the actual soil nutrient regime is medium to rich. The understory vegetation is in the *Gymnocarpium–Oplopanax* plant association. The site is located at the toe of a long slope with the forest classified as a Mormoder and the mineral soil as an Orthic Eutric Brunisol approximately 1.5 m deep and moderately well drained. The annual height increment is 75–100 cm.

	%		**ppm**
N	1.22	SO_4-S	55
P	0.145	Cu	2.3
K	0.62	Zn	16
Ca	0.29	Mn	125
Mg	0.085	Active Fe	44
S	0.116	B	9

Is this stand likely to respond to fertilization? What nutrients are likely to be most deficient, if any? Are any site or stand factors important when considering the nutrient status of this stand?

Answer:

Scenario 3

A 22 year old lodgepole pine stand is located in the Anahim Lake area of the Chilcotin Plateau. The stand has developed on an outwash terrace, and the parent material mineralogy is acid igneous, primarily granodiorites and quartz-diorites. The forest floor is a thin Hemimor while the mineral soil is a well-drained coarse-textured gravelly loamy-sand. Annual precipitation is approximately 740 mm with a prolonged summer drought. This stand has been already spaced and fertilized with 225 kg N/ha as urea. These are the post-treatment foliar analysis results.

	%		**ppm**
N	1.29	SO_4-S	235
P	0.182	Cu	4.2
K	0.57	Zn	13
Ca	0.40	Mn	565
Mg	0.115	Active Fe	34
S	0.116	B	5.2

Is this stand likely to have responded to the nitrogen fertilization? If not, what factors are likely to have contributed to the lack of response? Are any visual symptoms of nutrient deficiency likely to be present?

Answer:

Example of Calculating Fertilizer Application Rate

The most common application rate for nitrogen on the coast is 200–225 kg N/ha and slightly less for the interior at 175–200 kg N/ha. Note that the *application rate* is properly stated in terms of an amount of nutrient element applied. The actual amount of fertilizer material (prill) applied depends on the concentration of the element in the material.

For example, the fertilizer material – urea [$(NH_2)_2CO$] – is only 46% nitrogen by weight. Therefore, the amount of urea to apply to achieve the target rate of application of 200 kg N/ha is:

$$\frac{200\text{ kg N/ha}}{0.46\text{ N}} = 435\text{ kg/ha}$$

For the interior, where ammonium sulphate [$(NH_4)_2SO_4$] may be used, the concentration of nitrogen is only 21% by weight. The amount to apply to achieve the target rate of application of 170 kg N/ha is:

$$\frac{170\text{ kg N/ha}}{0.21\text{ N}} = 810\text{ kg/ha}$$

A blend of forest grade urea plus forest grade ammonium sulphate results in a target application rate of approximately 520 kg/ha. The percentage of elemental concentration can be calculated from the chemical formula using the atomic weights for each individual element or more easily determined from conversion tables. An example of a table for nitrogen (N), phosphorus (P) and potassium (K) is provided below. There are two common ways for fertilizers to be named – the fertilizer material name or the grade. For example, urea is the material name for a nitrogen fertilizer with a grade of 46-0-0, that is to say 46% N, 0% P_2O_5 (phosphate) and 0% K_2O (potash).

All fertilizers can be referred to by either their material name or grade. Single nutrient fertilizers are called “materials” or “simple” fertilizers. Multinutrient fertilizers are called “mixed fertilizers.” Multinutrient fertilizers are given a numerical designation consisting of three numbers. This three-number designation is called a “grade.” The numbers are the content of nitrogen, phosphate and potash in terms of percent by weight. A zero designation in a grade indicates that that particular nutrient is not included in the fertilizer.

Conversion tables are available to calculate the actual amount of an element source provided in a simple or mixed fertilizer.

Conversion Table

Fertilizer material	Grade	Element source	To convert from (multiple by)	
(A)		(B)	A→B	B→A
urea $CO(NH_2)_2$	46-0-0	N	0.4665	2.1437
ammonium nitrate NH_4NO_3	35-0-0	N	0.3500	2.8557
ammonium sulphate $(NH_4)_2SO_4$	21-0-0	N	0.2120	4.7169
triple superphosphate $Ca(H_2PO_4)_2$	0-45-0	P	0.1962	5.0968
superphosphate	0-20-0	P	0.0873	11.454
potassium chloride (KCl)	0-0-63	K	0.5229	1.9124
ammonium sulphate $(NH_4)_2SO_4$	21-0-0-24S	S	0.2426	4.1220
granular borate	0-0-0-14B	B	0.1430	7
borax $Na_2B_4O_7$▲H_2O	0-0-0-11B	B	0.1134	8.8129

Note that both the P and K in the grade are not for percentage of these elements but for percentage by weight of phosphate (phosphorus pentoxide) and potash (potassium oxide), which are only in part composed of these elements.

Exercise to Determine Fertilizer Application Rates

Question #1

Show that it is more costly to apply ammonium nitrate fertilizer than it is to use urea. Assume that the growth response to a single application of 200 kg N/ha is the same for either form of N and that the cost per metric ton of material is $250/ha.

Answer:

Question #2

Show that the operational mix of 58% urea and 42% ammonium sulphate produces the blended fertilizer of 35-0-0-10S that is 35% N by weight. What is the application rate to achieve 175 kg N/ha + 50 kg S/ha?

Answer:

Question #3

For an operational trial, you have decided to use a blended fertilizer to correct the specific nutritional deficiencies discovered through screening trials. Your tree nutrition specialist recommends the application of 226 kg N/ha, 135 kg P/ha and 48 kg S/ha to address this forest nutrient problem.

What would be the combination of fertilizers to formulate such a blend, assuming it is best to use only urea (U), ammonium sulphate (AS) and triple superphosphate (TSP)? What would be the application rate of this mix?

Answer:

Checking Application Rate by Determining Swath Length and Drop Duration

Question #4

The coast version is in **bold** (interior version in parenthesis). The application of forest fertilizer by helicopter is frequently done using a Bell 205 equipped with a 1500 kg capacity spreader or hopper. The swath width has been determined at earlier calibration applications to be 60 m. If the target fertilizer material application rate with **urea** (urea + ammonium sulphate mix) is **450** kg/ha (510 kg/ha) and the swath overlap is for triple coverage, what is the estimated distance of each swath or run with the helicopter traveling at a ground speed of 90 km per hour? How long in minutes or seconds will it take to empty the spreader?

Answer: