Lesson 2 Introduction to Forest Fertilization

45 minutes

Objectives

- Understand "Why fertilize?"
- Review the principles of forest nutrition and forest fertilization
- Introduce the main biological factors associated with a positive growth response to fertilization
- Demonstrate examples of stand responses to fertilization for the British Columbia coast and interior
- Review the legislative requirements regarding fertilization

Equipment Needs

- Overhead projector
- Lesson 2 transparencies
- Flip chart, wide-tip felt pens and masking tape

Method

Lecturette and class discussion with overheads

Instructions

The key points for the lesson are:

- Nutrition is only one of many factors controlling site productivity
- Fertilizer cannot replace the soil, where the complex processes of cycling nutrients in the ecosystem occur, following site degradation
- The potential to eliminate non-nutritional limiting factors may provide opportunities for fertilization treatments
- The combination of two plant physiological factors – increased foliar efficiency and foliar biomass – produces increased stem growth following fertilization
- Two Forest Practices Code regulations (Operational Planning Regulation and Silviculture Practices Regulation) provide the framework for fertilization planning and operations

Group Exercise

"Why Fertilize?"

Break up the participants into groups of two, and ask them to think of reasons to fertilize stands. Give them five minutes for this task then reconvene as a single group and list the reasons on the flip chart. Encourage group discussion and try to get each participant to provide input. Participants may have some reasons *not* to fertilize which should not be discouraged by the facilitator but listed separately on a separate flip chart page.

Post the flip chart pages on a wall where they are in good view for participants through the remainder of the workshop.

Points for Facilitator

"Why Fertilize?"

- Increase tree growth
- Increase vigour of forage species
- Reduce green-up time
- Increase conifer height growth on sites with high brush competition (e.g., salal) – may reduce risk of brushing treatment later to reach free growing stage
- Mitigate projected timber supply shortfalls
- Reduce rotation to achieve the planned stand diameter and volume
- Increase piece size and merchantable volume if rotation not reduced
- Optimize benefit of density control from juvenile spacing
- Optimize benefit from pruning treatment to produce clear wood

Growth Response to Fertilization

N → **N**

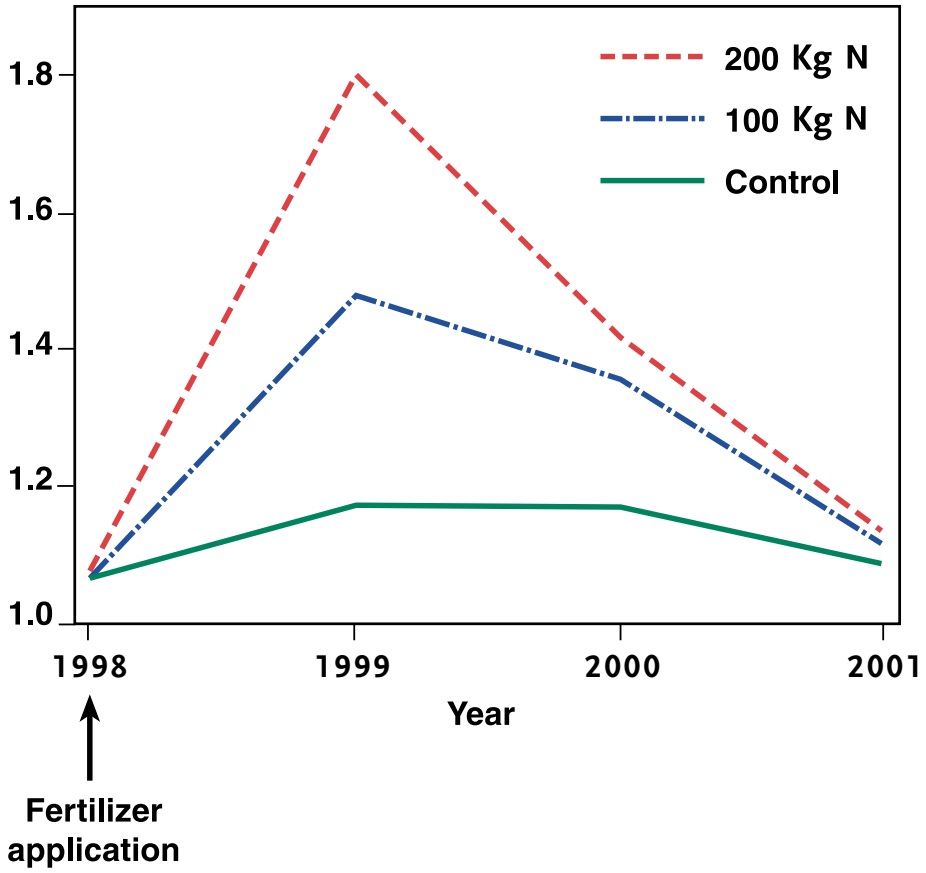
Mineralized 2–3%

Overhead: Growth Response to Fertilization

Key Points

- Fertilization adds only a small relative component of nutrients to the site and cannot significantly compensate for degraded soil
- Response depends on amount of added fertilizer taken up and stored in tree tissues and on tree species
- Mineralization is the process by which organic nitrogen is converted to ammonium nitrate, which the tree can use through root uptake. The opposite of mineralization is immobilization, in which NH_4^+ becomes organic and unavailable for uptake.
- Mineralization rate is usually only 2–3% annually of the site's total N pool
- N has to be inorganic for uptake

Foliar Nitrogen

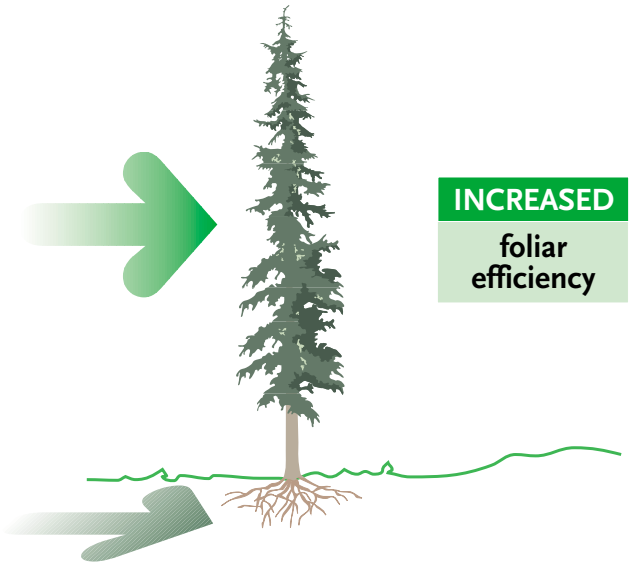


Overhead: Foliar Nitrogen

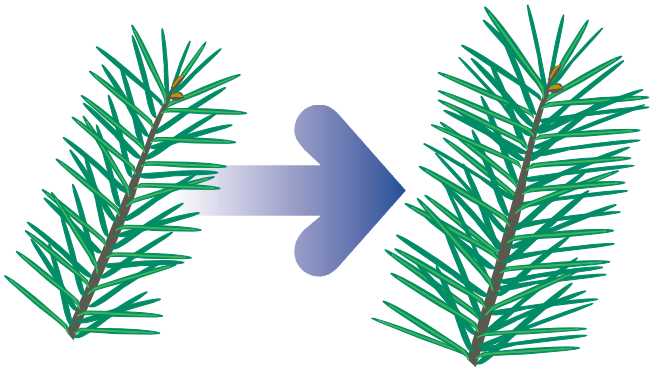
Key Points

- Differences in foliar nitrogen for different application rates
- Sharp drop off in foliar nitrogen the first year after fertilization, especially for the operationally used application rate of 200 kg N (i.e., short duration of response)

Response to Fertilization



INCREASED
foliar efficiency



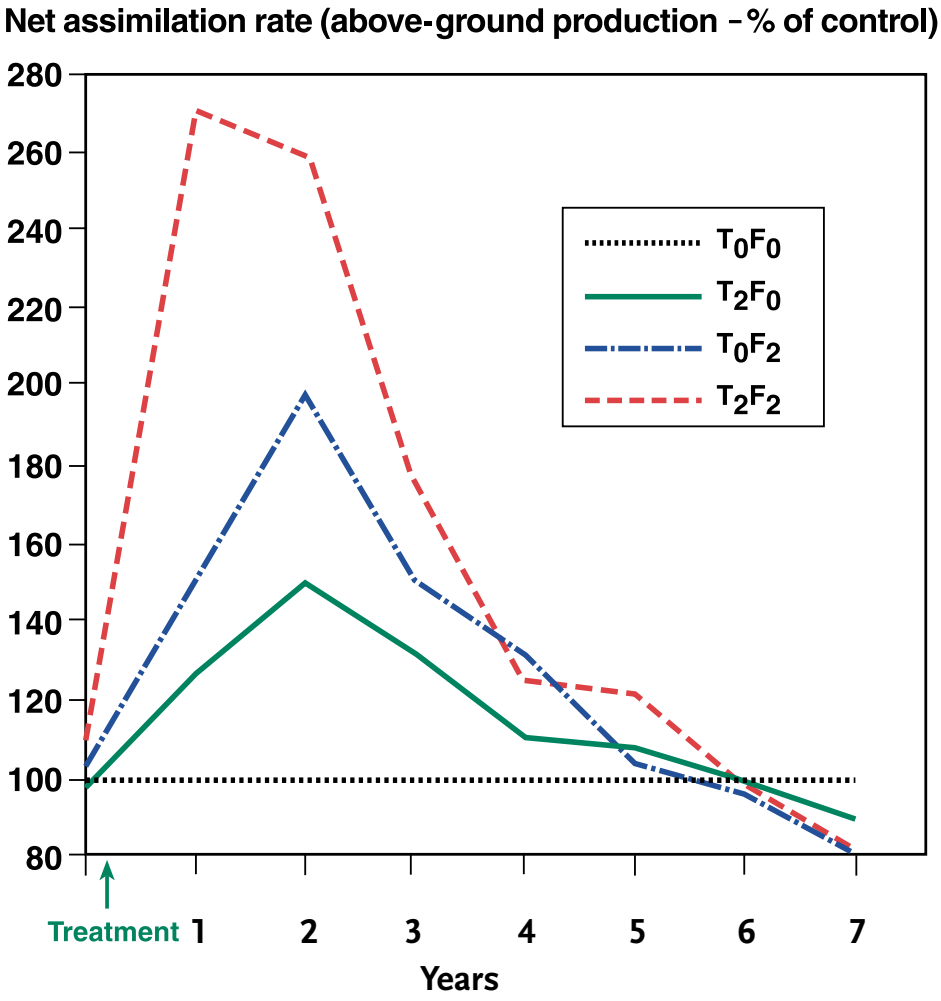
INCREASED
foliar biomass

Overhead: Response to Fertilization

Key Points

- There are two factors following fertilization that increase tree (stem diameter) growth:
  - The tree's photosynthetic rate is improved, which allows the tree to reallocate biomass from fine root growth to stem wood growth
  - Fertilization also increases the number and weight of needles and their lifespan on the tree, which increases the tree's photosynthetic surface area and thus the "factory" for wood production

Net Assimilation Rates



Net assimilation rates by years based on total above-ground dry matter production.

* Rates with thinning and fertilizer treatments are expressed as % of rate for control.

Overhead: Net Assimilation Rates

Key Points

- Difference in treatments – point out on overhead graph and explain the treatment types (combinations of thinning and fertilization: 0 = no treatment, 2 = highest level of treatment)
- Ask the participants if they can explain the differences
- Note that all treatments drop below the control seven years after treatment – ***why?*** This is because these are **net** assimilation rates. The gross fertilization rates for the fertilized stands are still probably higher than the control but the fertilized stands' older needles are more for respiration now which increases the relative demand on the site. This higher demand is due to the increased foliage from the fertilization treatment. The lower net assimilation rate compared to the control is more common on drier sites that are moisture deficient, not nutrient deficient.

Foliar Biomass Increases

Foliar biomass increases five years post-treatment (adapted from Brix, 1981)

	Treatments			
	Control	Thinned	Fertilized	Thinned and Fertilized
Total # of needles	21 000	30 600	60 100	68 300
# of shoots	269	326	572	750
Needles/shoot	78	94	105	91
Ave. shoot length (cm)	4.58	4.81	5.76	5.12
Needle density (#/cm)	16.3	18.8	17.1	16.7
Total needle weight (g)	82.8	132.0	247.3	305.0
1000 needle weight (g)	3.95	4.31	4.11	4.47

Overhead: Foliar Biomass Increases

Group Exercise

Display Overhead 2–5 on overhead projector (also available in participant's workbook) and ask the participants to look for trends in the data based on the treatment(s) and the change in foliar biomass five years after treatment. Give them 3–5 minutes to think about this and jot down their observations in their workbook.

Key Points

- Data are for Douglas-fir from Shawnigan Lake research trial on Vancouver Island
- Ask the participants what they notice from these data. Why would these results be happening, based on the treatments and the associated stand responses?
- Thinning increases most variables over the control (untreated) by up to 50%
- Fertilization increases the results further, and thinning and fertilization produce an even further increase
- Are there any anomalies in the data? ***Any possible explanations?***

Explanation of Trends

The total number of needles and number of shoots increased from thinning, then almost doubled further after fertilization. The third treatment regime, thinning and fertilization combined, created a further increase in these measurements. This resulted from the ability of the crowns to expand after thinning using the nutrient boost from fertilization. Each tree became a better "factory" for growing wood through improved photosynthetic capacity. This is one of the key responses from fertilization and it demonstrates the critical need for ample space for crown expansion to realize the potential fertilization effect.

The number of needles per shoot, average shoot length and needle density decrease from fertilized or fertilized only to thinned and fertilized. This is due to the results of the above measurements. With crown expansion from the increased number of shoots and needles, the tree has become more efficient, especially from the combined thinning and fertilization treatments. The total needle weight and 1000 needle weight show that the thinned and fertilized trees have heavier needles. The middle three measurements must be regarded in the context of changes to the tree from the two silviculture treatments.

When a tree has been growing in a suppressed or intermediate canopy position, it adapts to the low light levels by growing shade needles. Shade needles minimize respiration and are able to maximize photosynthesis in low light but at low photosynthetic levels. When a stand is suddenly opened up through thinning, the trees (or overtopped part of each tree's canopy) have to adapt to the increased light by converting to sun needles, which are more efficient at photosynthesis. This process can take a year or two. Fertilization soon after thinning will help the tree undergo this adaptation but can overload the tree with heavier foliage, as shown in the measurements in the above table. If the tree has a high height/diameter ratio, the tree may be unable to withstand heavy snow or strong wind. These factors should be considered at the stand management prescription stage when thinning and fertilization are considered for a stand.

Operational Planning Regulation

Part 6 – Stand Management Prescriptions

Treatments and objectives for treatments

49. (1) For the purposes of section 24(2.1) of the Act, the treatments may be one or more of the following:

- **(c)** fertilization

Content of stand management prescriptions

50. (3) A stand management prescription must, for each standards unit, specify all of the following:

- **(j)** if the proposed treatment is fertilization,
- **(i)** the type of fertilizer,
- **(ii)** the rate of application,
- **(iii)** the method of application,
- **(iv)** the season the proposed treatment is to be carried out, and
- **(v)** if in a community watershed, the known water quality objectives.

Overhead: Operational Planning Regulation

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Silviculture Practices Regulation

Division 3 – Stand Management

Use of fertilizers

21. (1) A person who carries out a silviculture treatment and uses fertilizer must store, handle and apply the fertilizer in a manner that protects forest resources.

(2) A person who carries out a silviculture treatment and who applies fertilizer other than on spot areas in a community watershed must not

(a) apply fertilizer

(i) closer than 100 m upslope of a water intake, or

(ii) within 10 m of a perennial stream that is observable from the air, at the height the fertilizer will be applied, unless otherwise authorized by both the district manager and the Minister of Health, and

(b) cause

(i) nitrate nitrogen levels in a stream to exceed 10 ppm measured immediately below the area where the fertilizer is applied,

(ii) chlorophyll levels to exceed

(a) 2 micrograms/litre in a lake, or

(b) 5 milligrams/square metre in a stream, or

(iii) water quality to fall below any known water quality object

Overhead: Silviculture Practices Regulation

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