Lammas Shoots in Nurseries and Plantations

by Thomas D. Landis

Lammas shoots are shoots that resume growth, or "flush", after budset in some woody temperate zone plants during the late summer. The name refers to Lammas day (August 1), which is the Celtic harvest festival (Wikipedia 2012a). This type of shoot growth is also known as second flushing (Kohnmann and Johnsen 1997), or summer shoots (Rikala 1992). Lammas growth was first documented by Theophrastus, a Greek contemporary of Artistotle who is considered to be the father of botany (Roth and Newton 1996).

Lammas growth is particularly relevent in nurseries and reforestation because it is most commonly observed on young plants under managed conditions, such as nurseries, plantations, provenance trials, and Christmas tree farms. In fact, one of the most extensive surveys on lammas growth was conducted because of the high incidence of these shoots in Douglas-fir (*Pseudotsuga menziesii*) plantations on the University of British Columbia (UBC) research forest (Walters and Soos 1961). They noted that seedlings of the same genetic source had a higher percentage of lammas shoots in the UBC forest nursery than in outplantings and, in these plantations, the occurrence of lammas shoots increased with site index. Curiously, seedlings with lammas shoots were not found in natural forest stands.

Concern about adverse effects of lammas growth in commercial forest plantations and genetic trials was considerable in the 1930s to 1970s. For example, a Journal of Forestry article (Carvell 1956) stated:

"Unless branches and double tops originating from lammas growth are removed, repeated formation of summer shoots . . . could eventually deform a sufficient number of stems to eliminate all possibility of future saw timber production from these plantations".

This concern seems to have tempered somewhat since then. After their survey of lammas growth in Douglas-fir plantations, Walters and Soos (1961) concluded that although common, lammas shoots usually only have a temporary influence on tree form. Likewise, an analysis of stem deformation in Scots pine (*Pinus sylvestris*) plantations found that trees with lammas shoots seemed to outgrow the apparent distortions and terminal forking (West and Rogers 1965). Other published

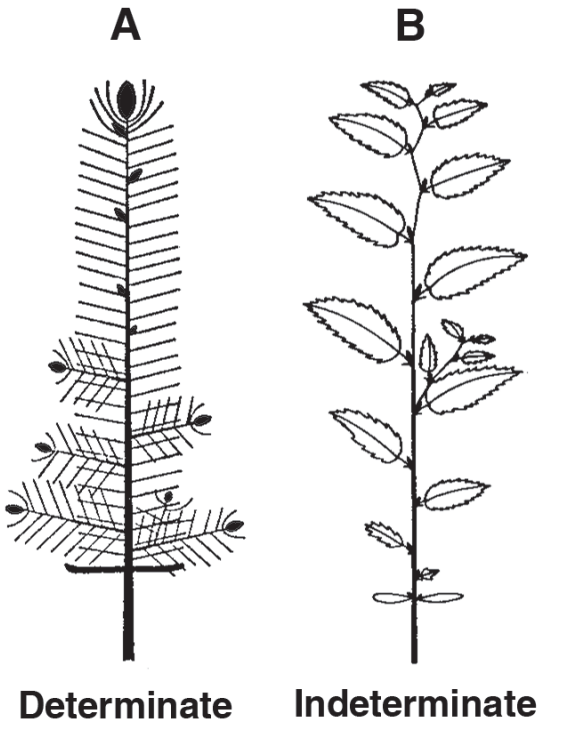


Figure 1 - Woody plants with determinate growth form firm buds (A), whereas those with indeterminate growth do not (B). Firm buds (C) have traditionally been a visible indication of dormancy, and therefore seedling quality.

reports conclude that lammas growth in plantations may actually be an asset. For example, lammas growth has been considered desirable when selecting for fast growth in tree improvement plantations. Lammas growth in genetically improved Sitka spruce (*Picea sitchensis*) plantations accounted for an average of 22% more height growth (Mboyi and Lee 1999). Lammas growth was also deemed beneficial in Douglas-fir plantations along the Pacific coast where deer browse is a problem (Roth and Newton 1996).

So, lets take a good luck at the phenomenon of lammas shoots and how they might affect nursery management and seedling quality. Before we can proceed however, we need to review some basic botany about how the shoots of woody plants grow. Two general types of shoot growth are recognized (Kozlowksi 1971; Wikipedia 2012b).

1. Determinate - Woody plants with a determinate growth habit exhibit a single growth flush in the spring from the elongation of pre-formed stem units in a dormant bud (Figure 1A&C). Species with determinate stem growth include many commercial conifers including pines and spruces, but also some hardwood species.

2. Indeterminate - With the indeterminate growth habit, the shoots of woody plants expand at regular intervals during the growing season and may or may not originate from a dormant bud. The shoots of some species, such as juniper (*Juniperus* spp.) or western redcedar (*Thuja plicata*), never form a dormant bud at the end of the growing season when shoot growth stops due to cold weather and short photoperiod (Figure 1B). In other species, the shoot beyond the last lateral bud dies back due to frost, and then that lateral bud acts as a terminal bud for the following season's growth.

Many scientists define lammas growth as only occurring from the terminal bud (Figure 2A). Other related terms include syllepsis, which has been defined as the flushing of lateral buds in the terminal cluster (Figure 2B), and prolepsis, the flushing of new buds from the lateral meristem after terminal budset. In one study, 73% of the second flushing came from lateral buds, 22% from terminal and lateral buds, and only 5% strictly from terminal buds (Rudolph 1964). I haven't taken any actual measurements but I have observed that container plants grown closely together in blocks tend to flush primarily from terminal buds; conversely, I have seen more flushing of lateral buds in more widely-spaced bareroot stock, especially in pines. For this discussion, however, we will define lammas as as any foliar growth that occurs after initial budset.

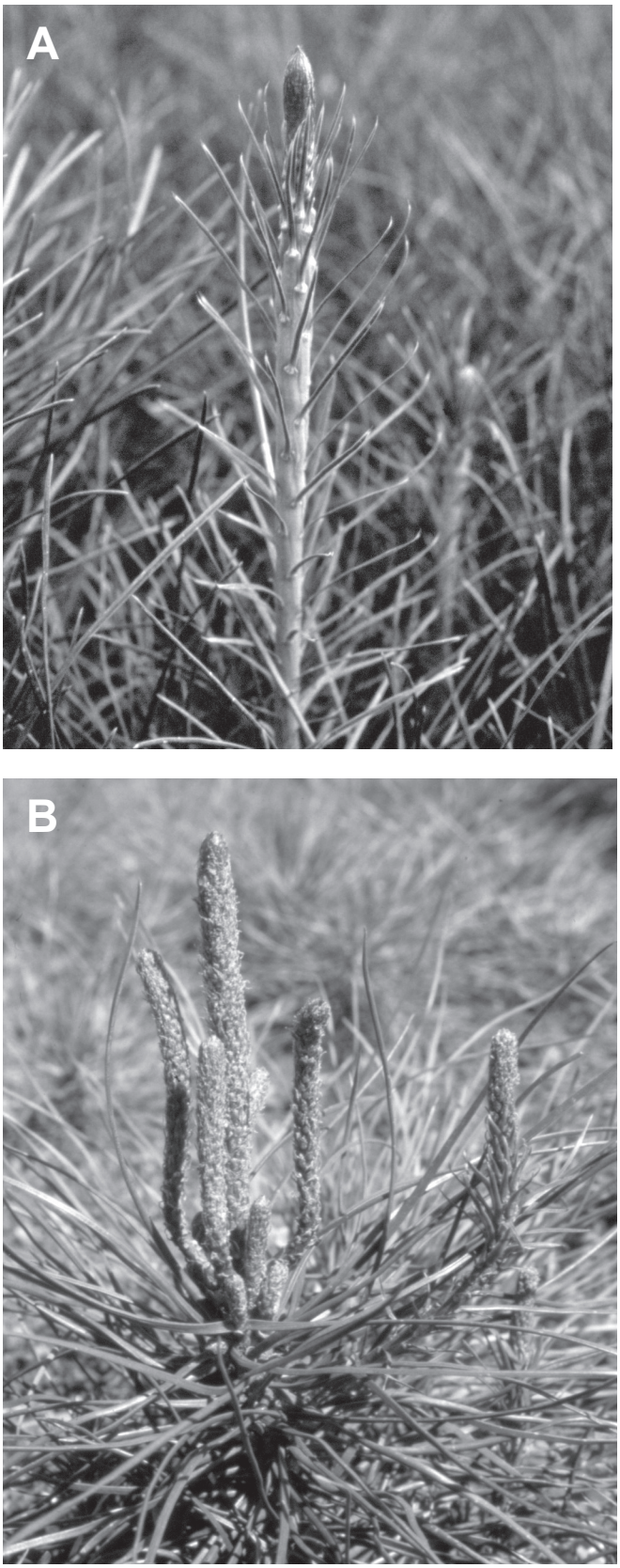


Figure 2 - Although some distinguish between growth flushes of the terminal (A) and lateral buds (B), we will consider any secondary flushing as lammas growth.

Another important distinction is that lammas growth is a juvenile trait because it rarely occurs in plants more than 10 to 15 years old (Adams and Bastien 1994).

Genetic and Environmental Factors Affecting Lammas Growth

Not all woody plants with the determinate growth habit exhibit lammas growth, although it has been documented in many conifers of commercial importance including true firs (*Abies* spp.), spruces (*Picea* spp.), pines (*Pinus* spp.), Douglas-fir and hemlocks (*Tsuga* spp.). Lammas growth also occurs in some broadleaved genera including oaks (*Quercus* spp.), beech (*Fagus* spp.) and maple (*Acer* spp.). Other genetic links have also been noted. Numerous studies (for example, Rudolph 1964) have shown that lammas shoots are much more common with certain seed sources. In a growth trial with Douglas-fir, seedlings from an interior seed source had significantly more lammas growth than those from a coastal source (Kaya and others 1994).

Nurseries and especially greenhouses optimize many environmental factors that can stimulate production of lammas shoots. Scots pine seedlings grown in a greenhouse produced more lammas growth than those grown outside. Of the cultural factors modified by the greenhouse environment, irrigation, fertilization, and carbon dioxide enhancement stimulated lammas growth (Alden 1971). Not surprisingly, the same 4 environmental factors that are used in nurseries to induce budset have been shown to stimulate the formation of lammas shoots (Figure 3A).

Warm Temperature - When dormant container seedlings of Japanese red pine (*Pinus densiflora)* were moved from outdoors into a heated greenhouse in mid to late winter, they developed lammas shoots. The earlier the seedlings were exposed to the warmer temperatures, the higher the percentage of plants with lammas growth and the earlier this second flush started (Kushida and others 1999).

Irrigation - The cultural practice of reducing irrigation to cause a moderate moisture stress has been used to induce budset in bareroot and container nursery stock. However, several nurseries have noticed that lammas shoots develop when normal irrigation is resumed. In a study with container Scots pine (Alden 1971), a strong relationship was shown between percentage of seedlings with lammas shoots and the moisture content of the growing medium (Figure 3B).

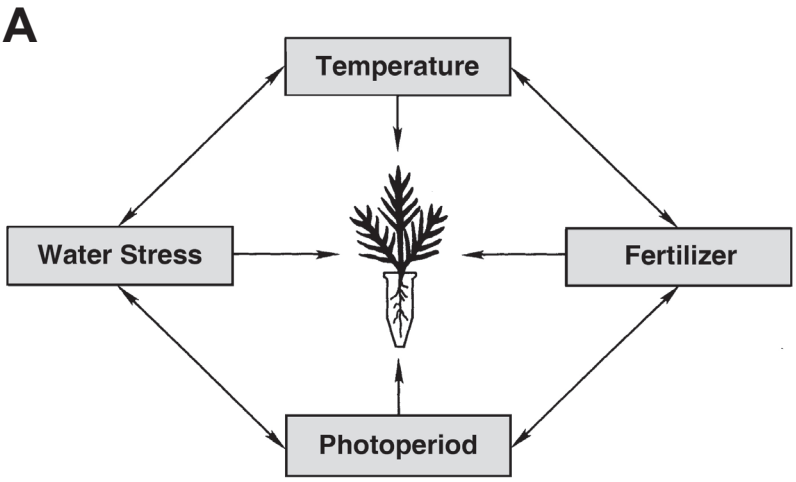
Fertilization - Fertilizer applications, especially nitrogen, are one of the most effective ways to stimulate additional shoot growth in bareroot and container nurseries (Landis and van Steenis 2003). Many growers are concerned that excessive fertilization, or fertilizer that is applied in late summer, may cause bud break and the development of lammas shoots. In one study, bareroot Scots pine received 3 top dressing applications of fertilizer containing nitrogen, phosphorus, and potassium and were then monitored for the development of lammas growth. Although lammas shoots were more prevalent in seedlings with higher foliar nitrogen concentration (Figure 3C), this study concluded that merely decreasing fertilizer concentration would not eliminate the occurrence of lammas shoots (Rikala 1992). Another study with Douglas-fir found that fertilization significantly increased the production of lammas shoots and that nitrogen was the nutrient responsible. Ammonium nitrate fertilizer had the greatest stimulating effect of all the fertilizers tested, whereas those containing only phosphorus or potassium had no effect on lammas shoot formation (Walters and Kozak 1967).

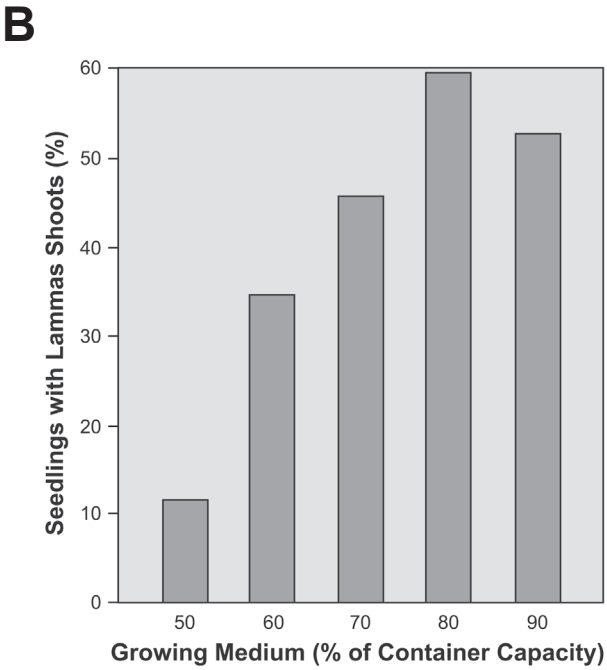
Many nursery managers are reluctant to fertilize later in the growing season because of concerns about stimulating lammas shoots. However, a review of late season nitrogen fertilization ("nutrient loading") of conifer seedlings in both bareroot and container nurseries concluded that such fertilization was beneficial as long as foliar nitrogen was kept in the ideal range of 1.5% to 2.5% with a moderate moisture stress to limit budbreak (Dumroese 2003).

Photoperiod - Manipulation of photoperiod, especially the timing and duration of blackout treatments, has also been shown to promote lammas growth. For example, when short blackout treatments was applied to Norway spruce (*Picea abies*) early in the summer, the plants were prone to break bud and develop lammas shoots (Kohmann and Johnsen 2007). In subsequent experiments with the same species, this stimulation of lammas growth was reduced by extending the blackout treatment for longer than 2 weeks (Luoranen and others 2009).

Lammas Shoots and Seedling Quality

Because of the large number of commercial conifers grown in nurseries, the occurrence of lammas growth is a source of serious concern by some managers and





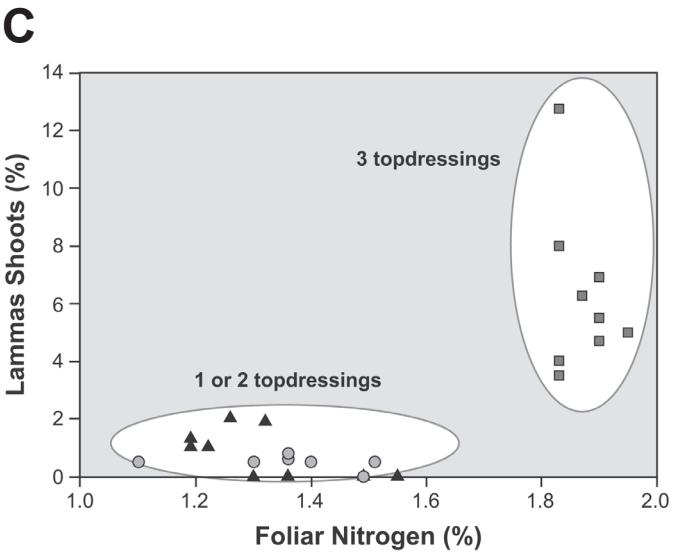


Figure 3 - The same 4 environmental factors used to induce bud dormancy in nurseries have been related to lammas growth (A). Applying irrigation after a period of drought stress stimulates lammas growth (B), as does nitrogen fertilization, especially later in the growing season (C). (A, from Landis and others 1999; B, modified from Alden 1971; C, modified from Rikala 1992).

particularly by nursery customers. Many foresters believe that a firm terminal bud is an indication of seedling quality, and lammas growth is considered undesirable. As we have just discussed, many woody plants with determinate growth habit will develop lammas shoots under a favorable nursery environment. These shoots may or may not develop a bud by the end of the growing season and the concern is that these plants are not dormant. Because the new growth occurs late in the growing season, seedlings with lammas growth are slower to develop cold hardiness and may be more susceptible to early fall frosts. I'm not aware of any published research that actually tested the dormancy or cold hardiness of plants with lammas growth, but these tests wouldn't be difficult and would provide some needed information. In outplanting trials with Sitka spruce, no evidence was found to suggest that lammas growth suffered increased frost damage (Mboyi and Lee 1999). A detailed study of the causes and effects of lammas growth on Scots pine in Finland determined that seedlings with lammas growth should not be culled (Rikala 1992), and I tend to agree with this conclusion.

Undoubtedly, foresters and other customers will occasionally express concern about nursery stock with lammas shoots, but most studies have found that forking and other growth deformations are temporary and seedlings will outgrow them. When you think of it, the very occurrence of lammas shoots shows that seedlings are well established and capable of rapid growth — a major expression of seedling quality.

Because lammas growth is strongly controlled by environment, nursery managers can at least partially control the development of lammas shoots by careful regulation of irrigation and fertilization, especially late in the growth season. Still, lammas shoots may develop

as a result of late summer rains or after irrigation of transplanted plug+one stock so nurseries should inform and educate their customers about the causes and probable outcome of lammas growth.

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