Outreach
Warnell School of Forestry & Natural Resources
UNIVERSITY OF GEORGIA

Life-Stage Nitrogen Prescriptions For Trees

by Dr. Kim D. Coder, Professor of Tree Biology & Health Care
Warnell School of Forestry & Natural Resources, University of Georgia

Supplemental nitrogen enrichment should be treated as a fined-tuned, carefully considered, constantly modified, whole tree prescription process. The whole tree wins or loses with changing reactions of one major organ or resource. Nitrogen prescription involves prudent and reasonable treatments carried out in a timely manner without site and tree damage.

The nitrogen dose provided by supplemental additions, and its timing, are part of a comprehensive management prescription which should vary primarily by ecological season of the year, a tree's ability to successfully and effectively utilize nitrogen additions, and by the life-stage a tree. These considerations deal with successful capture and use of nitrogen by a tree as it grows, and with minimizing environmental impacts to untargeted systems (i.e. nitrogen to weeds, streams, and soils).

No Dumping

Dosing trees correctly with supplemental nitrogen involves discarding dumping concepts. Trees try and maintain a steady-state, internal nutritional balance governed by nitrogen demand and carbon availability. Under this internal system, one large application of nitrogen dumped on a tree makes little biological sense. Ecologically and chemically, the chances are greater for more of any massive dose to go to nontarget species or processes, such as weeds, pests, erosion, and denitrification. The total nitrogen provided at one time is not as critical as the nitrogen recycling rate through the tree / site system.

A monetary analogy would be a steady, controlled cash flow (of nitrogen) rather than a one-time, disruptive lottery jackpot. For example, animals are not given a once-a-season (or once every two or three seasons) feeding. Under these conditions, food can not be effectively used, and may be wasted or used by other organisms. Trees should not have a valuable resource dumped onto a site when and where a tree can not effectively use it, nor control its distribution.

Ecological Investment

The further away from ecological equilibrium a site is kept, the more management and resource investments must be supplied. Over time it is easy to forget how a tree / soil system is propped-up by resources from outside a site. Large doses of resources supplied over a number of years can generate both a chronic ecological addiction to added resources, and a human perception of resources needed far removed from actual natural site processes.

When management and resource inputs are removed or drastically changed by new owners, different objectives, or climbing expenses, a tree / site can undergo a number of highly variable / chaotic changes in falling back into equilibrium with the environment. Tree health may be sacrificed in this process. In addition, perceived values of nitrogen enrichment in large doses can decline over time as a site uses and discards more nitrogen (i.e. "big dump" syndrome.)

Dosing Schedules

Throughout a growing season, a tree's nitrogen requirements and its ability to effectively utilize nitrogen, declines until the first sign of senescence presents in Fall (first visible leaf color changes with leaves still green!) or 80% of the growing season has past. At the first sign of senescence, nitrogen additions should be cut back to dormant season maintenance levels.

Even though many supplemental nitrogen enrichments are listed on a per year basis, applications for the greatest benefit to cost ratio for a tree occur during the growing season. The growing season for nitrogen enrichment is counted from just after full leaf expansion until the first sign of senescence (or 80% of growing season is past). Figure 1. Maintenance levels of supplemental nitrogen vary by geographic location and activity of roots, but should be minimized to prevent use of food reserves, to reduce run-off, and to prevent soil systems from destroying usable nitrogen availability (conversion of dollars into nitrogen gas!)

Mature Dose

In a mature tree there are nitrogen needs, but at reduced levels from earlier life stages. Figure 2. Growth rate is less, compartmentalization more complex, and many site resources are already under control in a mature tree. The model of nitrogen dosing for a mature tree presents opportunities for low maintenance applications during the dormant season with a jump to full loading just after full leaf expansion. This is the point when a tree is at its full productive potential and carbon supplies are rebounding after spring start-up.

The Young

Young trees, once completely established (after at least one full growing season in diffuse-porous trees and two full growing seasons in gymnosperms and ring-porous trees), can move into a rapid growth stage of life. Figure 3. Timing targets for growing season nitrogen additions are the same as for mature trees. After full leaf expansion, a young tree will be able to handle nitrogen additions effectively and these additions can be maintained through the growing season. At first sign of senescence, nitrogen additions should be dropped to dormant season levels.

Establishment

Another life stage of a tree requiring careful consideration when adding nitrogen is during establishment. Figure 4. It is critical newly planted trees be allowed to sense and respond to site resource levels, and to internal resource changes, before superimposing a carbon- and energy-expensive treatment like supplemental nitrogen enrichment. Low rates of nitrogen addition should be used which hover near dormant season maintenance levels. Just after full leaf expansion, a slightly increased rate of nitrogen enrichment can be used which gently fades into dormant season levels as Fall approaches.

Life Stages

When prescribing nitrogen enrichment using tree life stages, remember total nitrogen amounts can be added in one dose or many progressively smaller doses. Dosing throughout the year in small additions, rather than in one "dump" is an appropriate ecological response. Nitrogen additions at low

levels will pass through a tree / soil ecological system with some losses occurring. Healthy soils and trees will keep nitrogen recycling.

Setting dormant season maintenance levels of nitrogen are dependent upon soil temperature, soil moisture levels, and root activity, but should be defined at an absolute minimum, if used at all. The dormant season (or more precisely, the portion of the year after leaf senescence begins until full leaf expansion is completed) is a time when nitrogen losses can be great.

Hitting Targets

It is difficult to determine if an application is reaching the targeted tree system. Dormant season applications without an active target organism to use any nitrogen provides many opportunities for erosional, denitrification, and off-site losses. General poor timing and dosing assure tree growth disruption, nitrogen waste, or both.

Life-stage planning and a periodic sun-leaf tissue analysis program using fully expanded leaves are needed for assurance of effectiveness and need for supplemental resource additions. Soil testing for nitrogen is fraught with problems and, away from toxicity and extreme deficiency, may have little meaning. Soil testing is critical for other essential elements, soil physical and chemical attributes, and soil organic matter determinations.

How Much

For agronomic crops where a grain product is being removed each year, 5.7 pounds of nitrogen per $1000ft^2$ is considered a high enrichment rate and 2.3 pounds of nitrogen per $1000ft^2$ is considered a moderate enrichment rate. These levels of nitrogen enrichment do not make sense in shade and street tree culture.

Figure 5 provides a rough estimate of supplemental nitrogen amounts which could be provided to trees at different life-stages and at different targeted leaf nitrogen percentages. The amount shown should be applied evenly over tree rooting areas on open soil surfaces where water flow and gas exchange to roots are not inhibited.

Soil limitations, rooting area / volume limits, and element holding capacity of soil are limitations to full applications. Smaller amounts of nitrogen in multiple applications may be an alternative. These calculated enrichment amounts include several assumptions provided by research, including 60% of tree nitrogen (on average) is internally recycled each year, while only about 50% of the nitrogen applied to healthy soils may be eventually present in the target tree. Both of these conflicting / opposite results are usually treated as off-setting sums and not included in calculations.

Dosing Examples

Several figures provide examples of using a prescribed dose for mature trees. Note each enrichment graph corresponds to a mature tree's nitrogen utilization curve. Also note how the amount of nitrogen per application changes. Figure 6 shows a nitrogen enrichment of 1.5 pounds per 1000 square feet of open soil surface area all in one application just after full leaf expansion.

Figure 7 shows the same amount of nitrogen enrichment applied in three applications during the growing season. Figure 8 shows the same amount of nitrogen enrichment as before, but divided into five applications during the growing season.

Figure 9 shows a early Spring application of a slow to very slow-release nitrogen enrichment product designed to deliver a continuous supply of nitrogen over a growing season. Here the area under the curve (shaded in the figure) is equal to 1.5 pounds nitrogen per 1000 square feet.

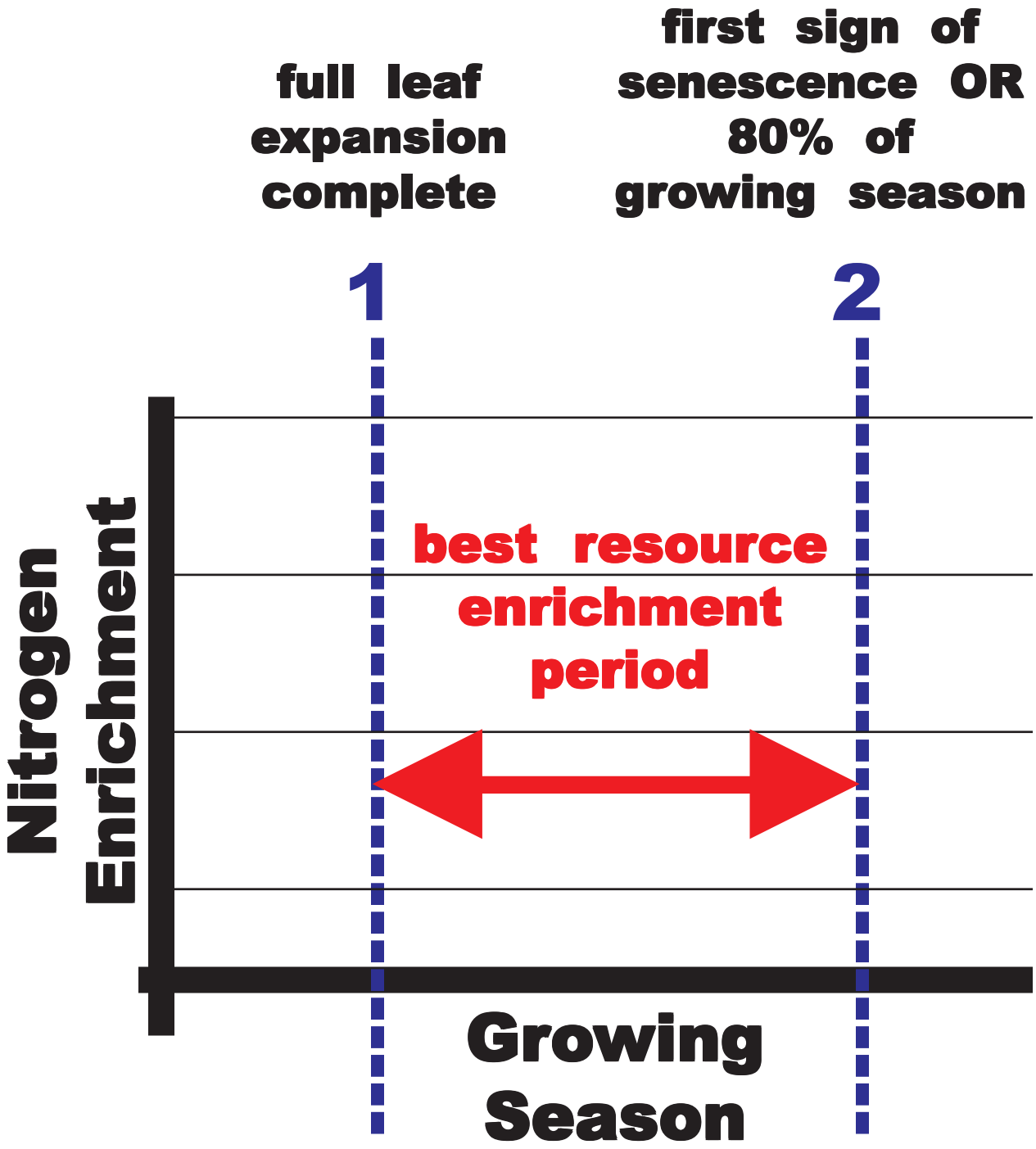

Figure 1: Initiation and suspension targets for nitrogen enrichment in trees for the most effective and efficient element uptake and utilization.

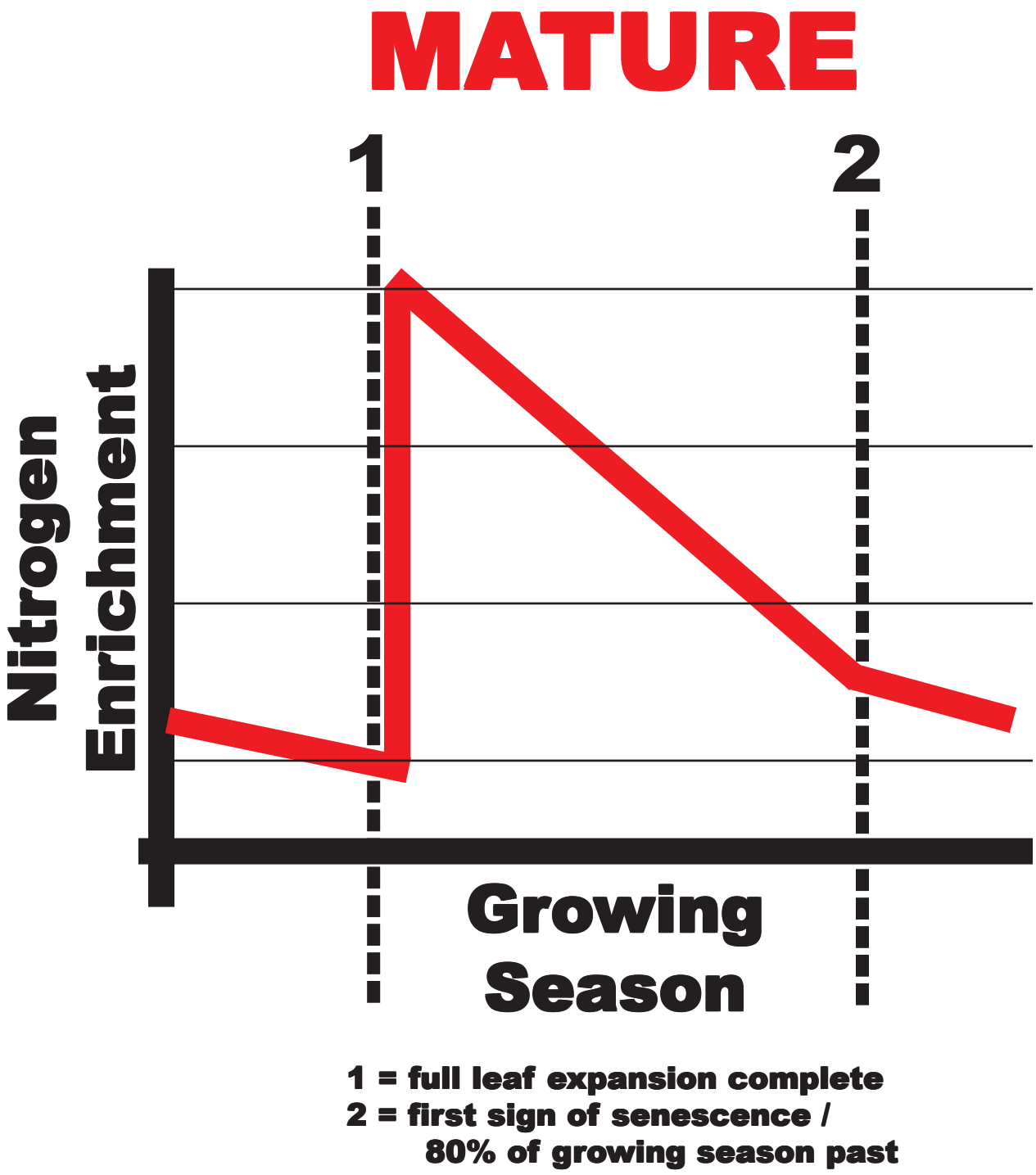

Figure 2: Most effective and efficient period for nitrogen enrichment in mature trees.

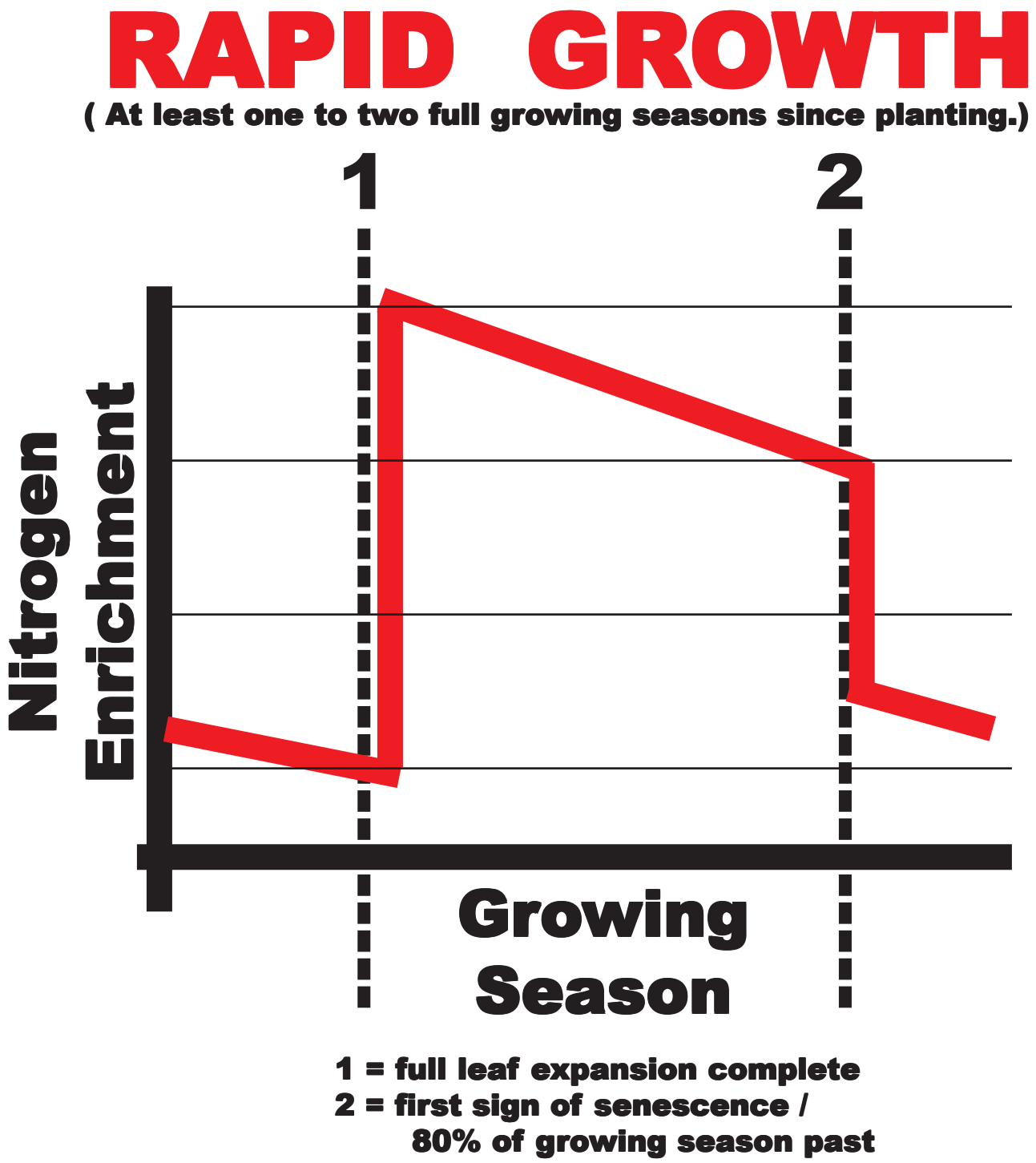

Figure 3: Most effective and efficient period for nitrogen enrichment in trees out of their establishment phase and into their rapid growth phase.

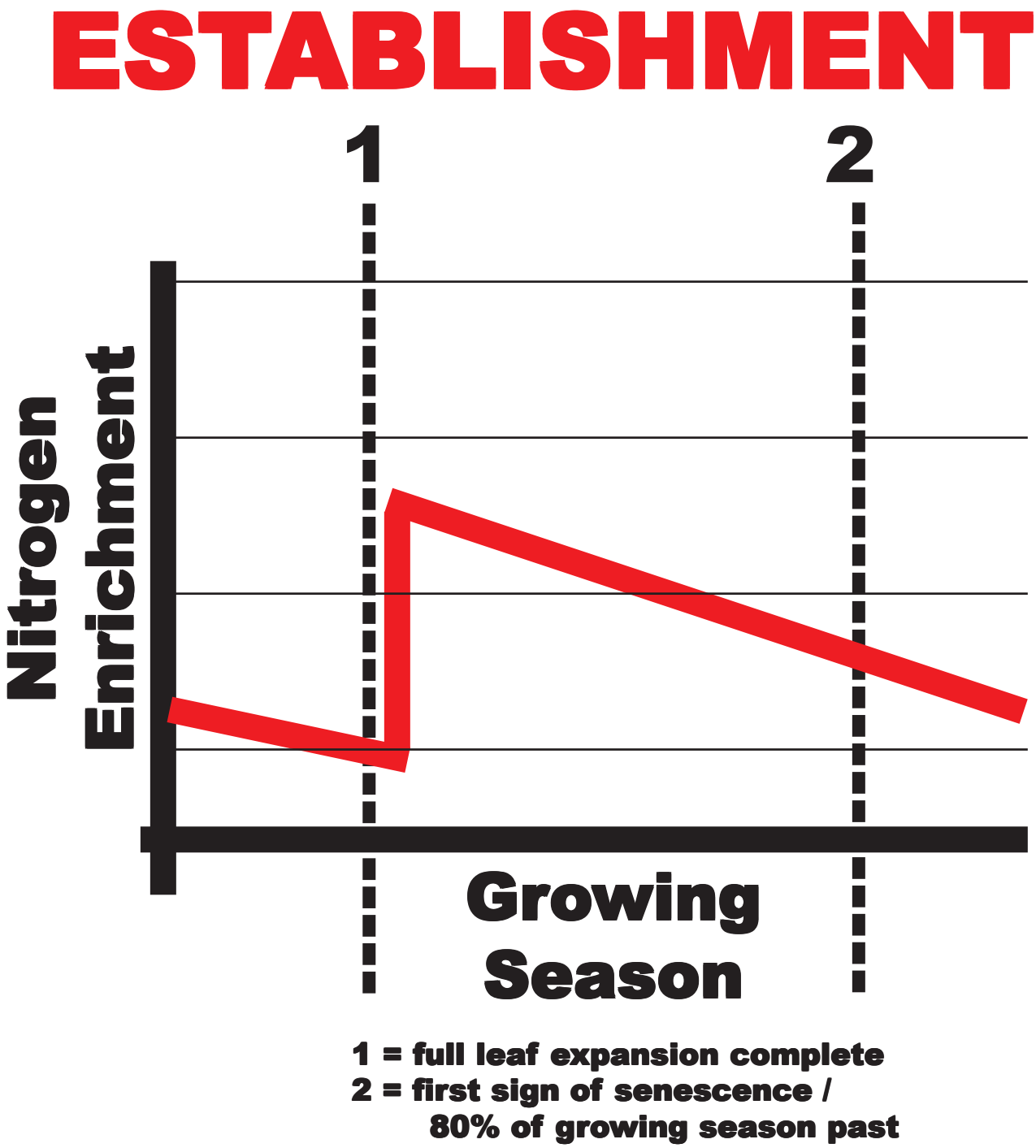

Figure 4: Most effective and efficient period for nitrogen enrichment in trees during their establishment phase.

% nitrogen in tissues	Skin / Core Life Phase Multipliers in Trees (already multiplied into values)			
	(establishment)	1.0X (rapid growth)	0.83X (transition)	0.66X (mature)
	pounds N per 1000ft^2 defined area	pounds N per 1000ft^2 defined area	pounds N per 1000ft^2 defined area	pounds N per1000ft^2 defined area
0.5 %N	0.2	0.4	0.3	0.25
1.0 %N	0.3	0.8	0.7	0.5
1.25 %N	0.4	1.0	0.85	0.65
1.5 %N	0.5	1.2	1.0	0.8
1.75 %N	0.55	1.4	1.2	0.9
2.0 %N	0.65	1.6	1.3	1.0
2.25 %N	0.7	1.8	1.5	1.2
2.5 %N	0.8	2.0	1.7	1.3
3.0 %N	1.0	2.4	2.0	1.6
3.5 %N	1.1	2.8	2.3	1.9
4.0 %N	1.3	3.2	2.7	2.1

Figure 5: Nitrogen enrichment amounts for trees based upon life-stage or phase. Maximum total pounds available nitrogen enriched annually per 1000 square feet of open soil surface. Values based upon tissue nitrogen content percentages (dry weight) and total living mass of tree throughout its four life phases.

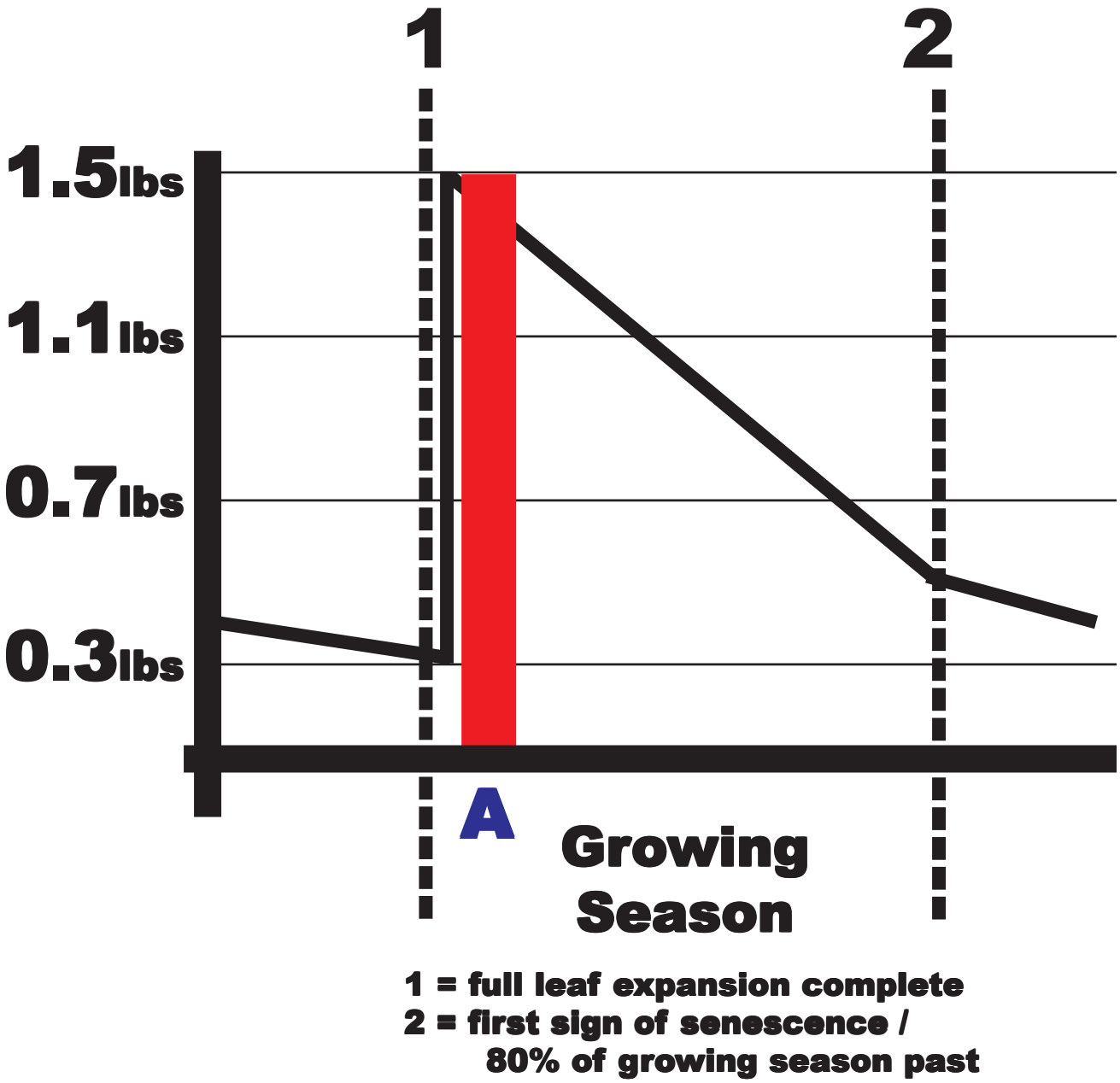

Figure 6: Example mature phase tree nitrogen enrichment with 1.5 lbs. N per 1000ft^2 per year prescribed in one application (A).

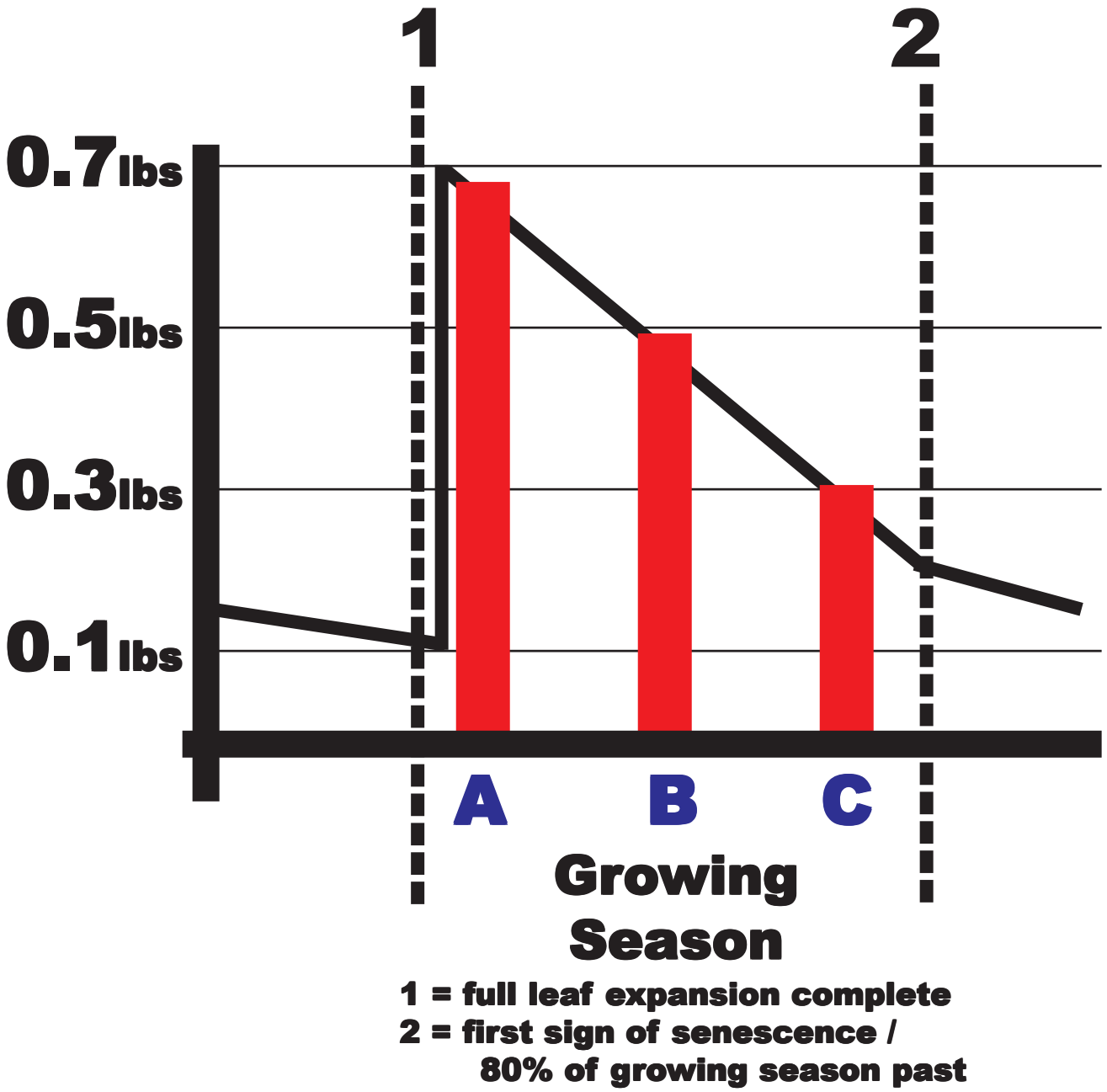

Figure 7: Example mature phase tree nitrogen enrichment with 1.5 lbs. N per 1000ft^2 per year prescribed in three applications (A + B + C).

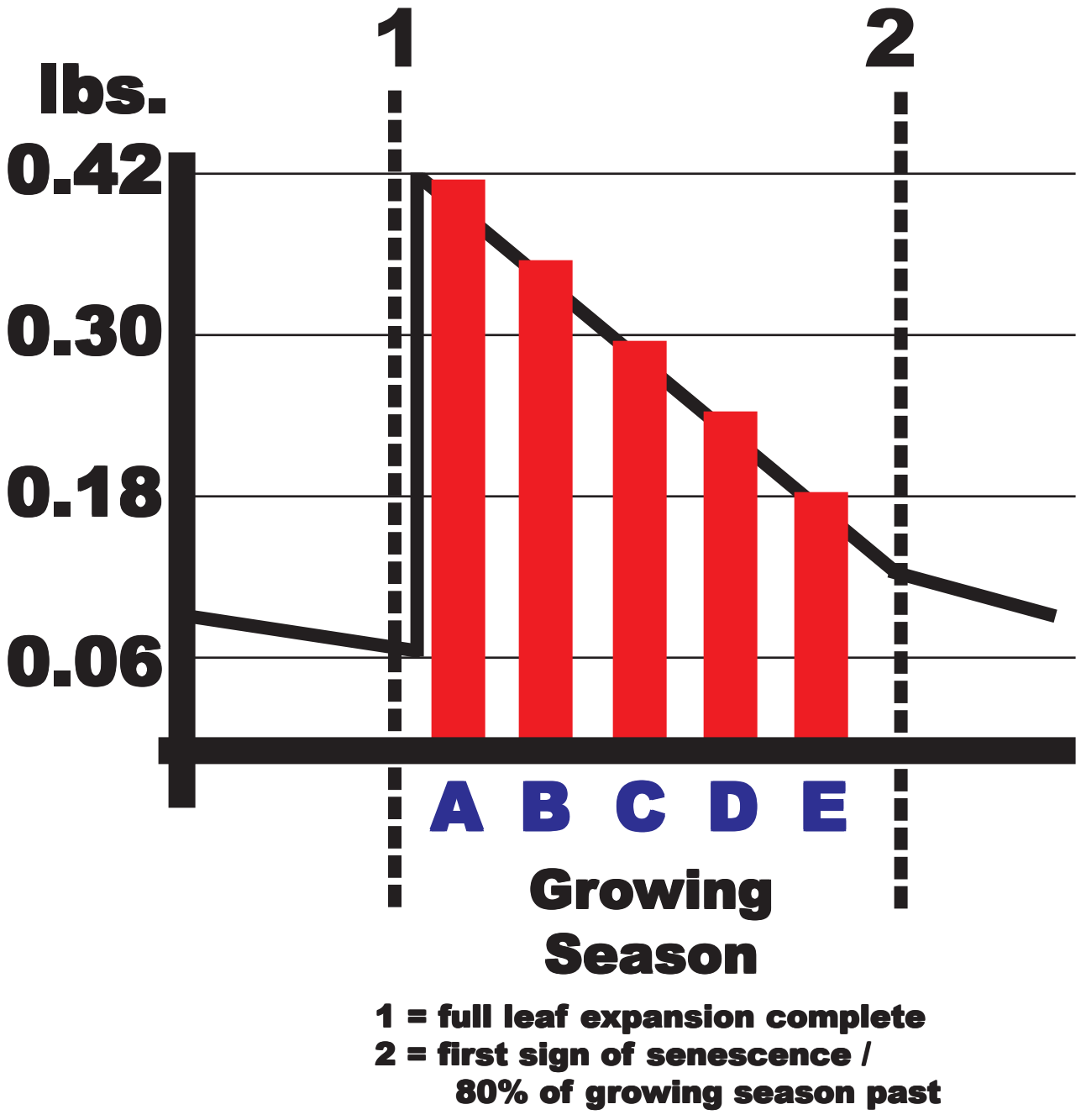

Figure 8: Example mature phase tree nitrogen enrichment with 1.5 lbs. N per 1000ft^2 per year prescribed in five applications (A + B + C + D + E).

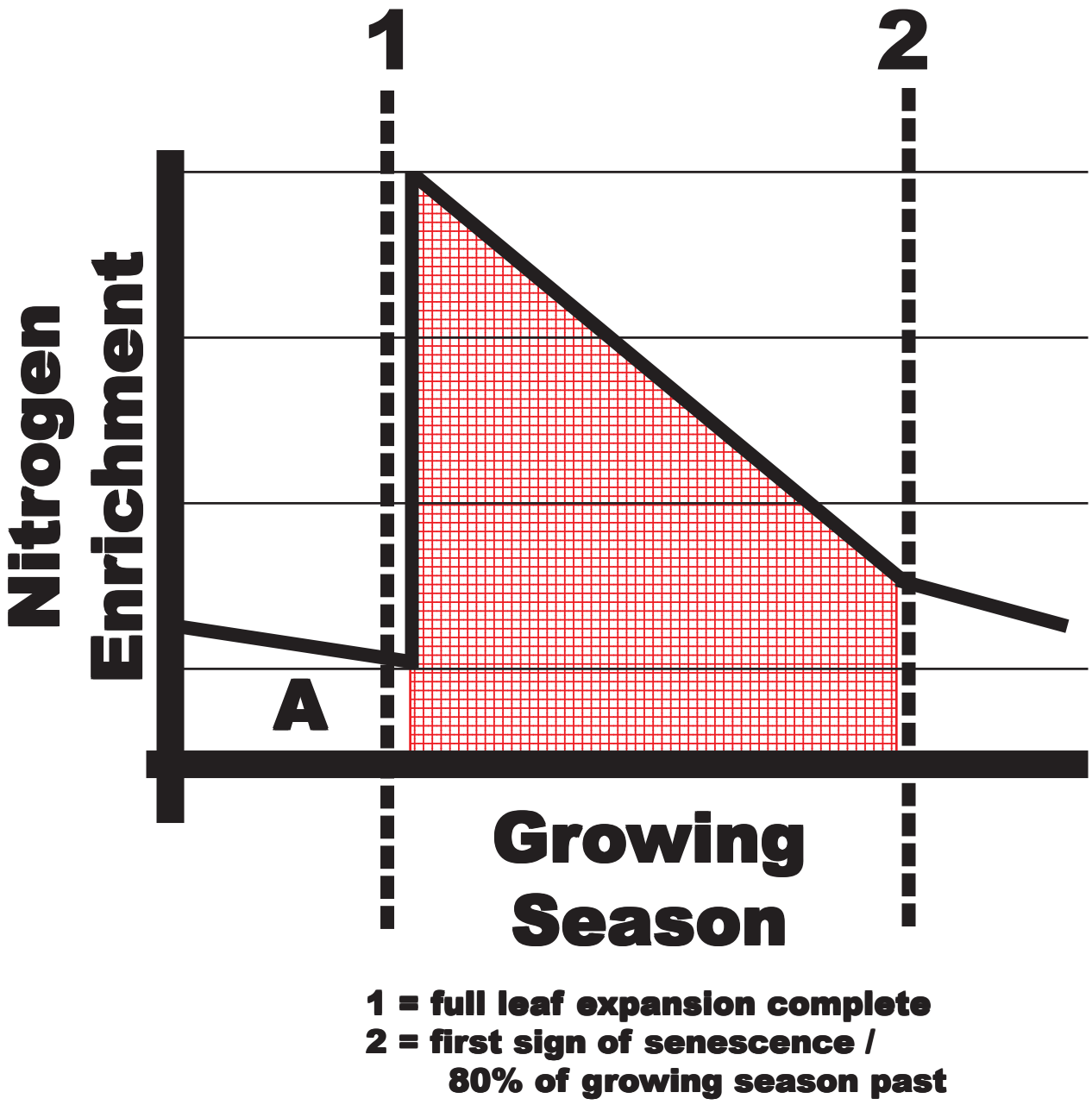

Figure 9: Example mature phase tree nitrogen enrichment with 1.5 lbs. N per 1000ft^2 per year prescribed for a single slow release / very slow release application (A). The shaded area beneath the mature tree curve represents the total prescribed dose for the season.

Outreach

Warnell School of Forestry & Natural Resources

UNIVERSITY OF GEORGIA

Citation:

Coder, Kim D. 2017. Life-Stage Nitrogen Prescriptions For Trees. Warnell School of Forestry & Natural Resources, University of Georgia, Outreach Publication WSFNR-17-45. Pp.13.

Publication WSFNR-17-45 **November 2017**