Developing Container Conifer Seedling Specifications... A Balanced Approach?

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Abstract—Seedling morphological specifications give "seedling growing contracts" something legal and binding that can be upheld in a court of law, and help guide the grower in producing stock of reasonable uniformity and quality to ensure a desirable level of plantation survival and establishment. However, seedling specifications should also insure that seedling customers obtain the maximum return from seed supplied, and encourage or allow the seedling growing industry to operate at the highest possible efficiency.

In British Columbia, seedling specifications are set by stock type (species/growing cycle/container type combination), based on what is perceived to be producible by growers at the time, and necessary for proper plantation establishment. In the past, biological and statistical principles were often not considered or adhered to when setting new standards and/or amending old ones. A typical scenario was to generate a caliper distribution for a new stock type, set minimum caliper at a 30% throw away rate, and target caliper slightly in excess of average. The assumptions being that lower caliper classes are genetically inferior, growers need something to strive for and... "bigger is better".

This presentation is not about seedling physiological quality, but about carbon fixation, as it relates to plants and photosynthesis. Using operational examples, it will attempt to challenge some existing assumptions and present a new way of relating stem caliper specifications to available nursery growing space per seedling.

INTRODUCTION

Carbon fixation, or biomass production, per unit of growing area, is limited. Growers get paid to fix carbon in a specific way by a specific time. One approach is to imagine the forest seedling crop as a miniature forest, governed by similar principles.

A number of inputs drive the biological systems we refer to as forests or forest seedling crops. Basically, these are light, CO_2, water, mineral nutrients, temperature, and time. However, the ultimate driving or controlling factor, the one which in practical terms limits the ability to utilize all others, is light. Assuming all other inputs are not limiting, as we attempt to do in our container growing systems, a seedlings' biochemistry will produce dry matter (fix carbon) at a maximum rate determined by the available light level (quantity and quality) to all photosynthesizing parts. The total accumulation per stem will be a function of the amount of growing (or light capturing) area it is allowed

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to exploit or occupy with its own photosynthetic machinery. **Dry matter production is thus limited, rate by available light level and total (per stem) by available growing area (assuming time is constant).**

In a mature forest, "productivity" is measured in various ways, one being "stem basal area production" per unit of growing area over time. For a given biological system (set of inputs), productivity is constant per unit of available growing area, hence the productivity per individual tree is a function of its *share* of the available growing area (assume canopy closure). **The more stems/unit of growing area the lower the stem basal area production/stem!**

The same principle can be applied to seedling crops. Inputs are limited hence dry matter production is limited. The number of seedlings grown in a set area determines how much dry matter can be produced per seedling. The more seedlings are crammed into a set growing area the smaller (skinnier) they will be.

Stem caliper (diameter) production does not relate linearly to stem basal area production or its determining factor, available growing area/stem. E.g. doubling available growing area might lead one to believe you can double stem caliper demand. **Wrong!** Doubling stem caliper quadruples stem basal area, requiring a quadrupling of growing area to produce it.

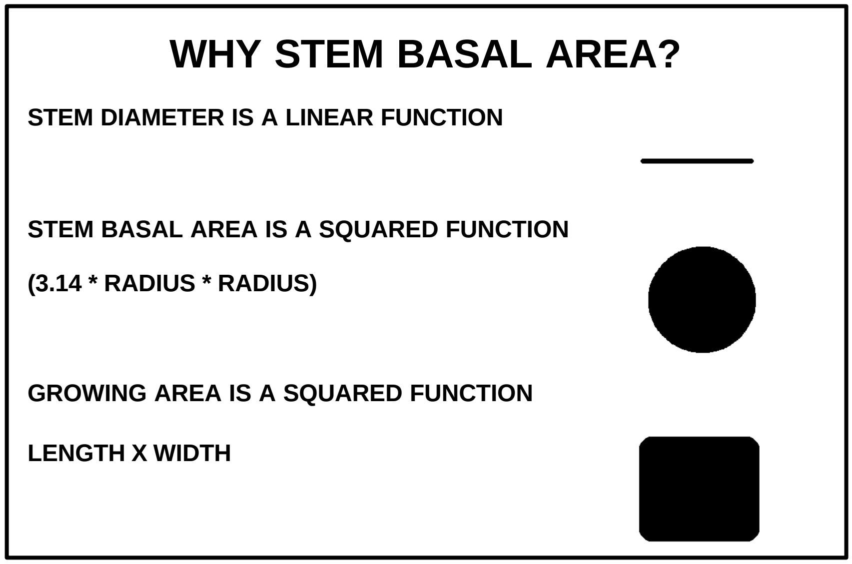

Figure 1

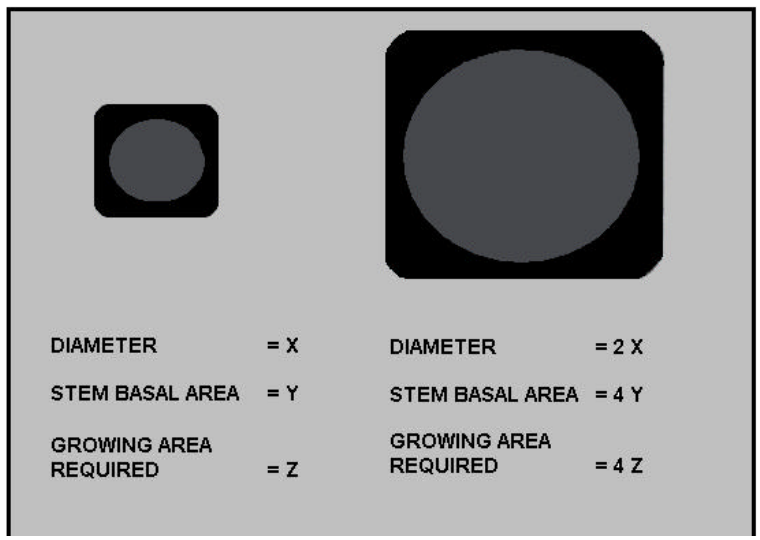

Figure 2

DISCUSSION

Consider a dozen species, up to 3 growing cycles and 20 different container choices, each combination requiring a separate standard, and the system becomes fairly unwieldy.

Most importantly, field morphological requirements and specific container requirements need to be separated. The choice of specifications for field requirements is basically unlimited, however, what is biologically achievable in a set container type, given the available resources at the nursery, ***is*** limited. For instance, field requirements in terms of seedling morphology and/or physiology can be produced in a variety of containers. e.g. If a 3.0 mm caliper is the minimum requirement for a snow press area then the container it is grown in is irrelevant. As long as root integrity exists for the particular application, the 3.0 mm seedling will be as suited for the purpose, regardless of the chosen container. “Creaming” a seedling crop for the larger caliper types only results in the acquisition of rootbound plants at an inflated price. If minimum caliper requirements for field purposes consistently cut too far into a certain seedling crop type then a lower density container (more growing space/seedling) should be utilized (assuming other inputs are not limiting).

Noting the variability in the embling sample (one clone, every plant genetically identical), there is obviously more to variability than genetics! Seed orchard seed crops also show variability distributions similar to “wild” crops. Concern has been expressed regarding crops grown from genetically improved seed... “why are cull rates just as high as in crops grown from wild seed?”. There are two possible answers. One, genetically improved seed is not, or two, culling criteria have little or nothing to do with genetics. I would opt for the latter. Growers have enough to strive for without going outside what is biologically achievable.

COMPARISON OF CALIPER DISTRIBUTION FOR 211 AND 313 1+0 LODGEPOLE PINE

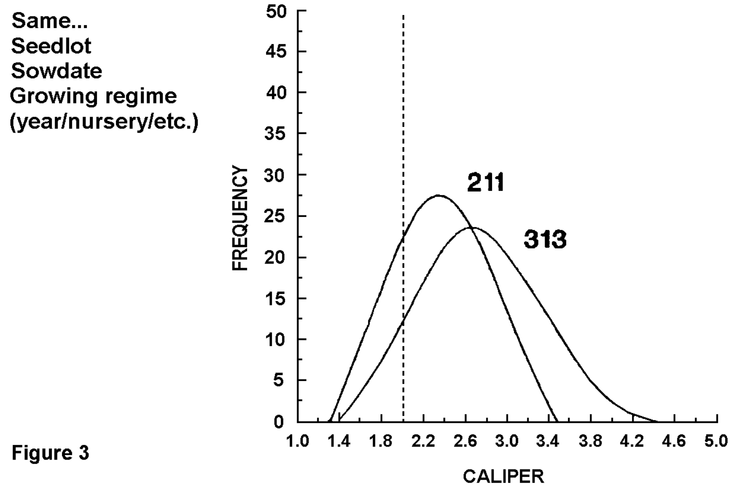

Figure 3

With respect to “bigger is better” we know that within any population there is a degree of variation in size, and the relative growth rate (amount of production per unit of production, e.g. cm^3/cm^3/year for stem volume) of small and large seedlings is basically the same. Larger specimens do not necessarily grow faster but by having a head start may be better able to maintain an advantage. Sort of like interest in the bank or

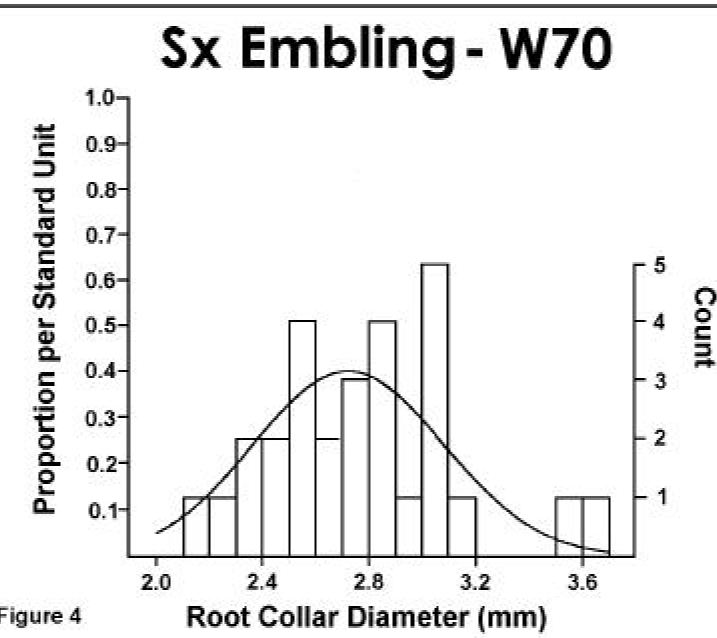

Figure 4

making snowballs. Selecting *populations* of larger seedlings overall may be the way to apply this principle rather than creaming larger seedlings out of each existing population.

A seedling crop produces a range of stem caliper, due to variability in germination characteristics and growing environment. Variability due to genetics is negligible, hence culling out smaller seedlings on the assumption that they are genetically inferior is *not* sound practice. So what are we throwing away? Culls created by density dependent competition effects?

Note that there is variability, and the whole population shifts with available growing area/ seedling. Also imagine a 3mm diam. min. caliper imposed on these crops and the subsequent cull rates. Would the 412 population contain a higher proportion of genetically inferior seedlings?

Table 1. **MINIMUM STEM BASAL AREA REQUIREMENTS FOR 1+0 CONTAINER WHITE SPRUCE. B.C. 1994. (mm 2)**

Block Type	# Cavities Per Block	MSBA Requirement Per Block
211A	240	912
313A	198	895
313B	160	723
410	112 (shallow)	550
415B	112 (deep)	690
412A	77 (shallow)	544
415D	77 (deep)	619
615A	45	565

By converting minimum stem caliper specs to Minimum Stem Basal Area specs and multiplying by the number of cavities in a block we can generate a current MSBA/Block demand. (block types listed are all the same size).

From the above table one can see that biological demand is not equal across the variety of container types utilized for this species/crop cycle combination. This would not be obvious from looking at stem caliper standards. Can anyone guess which container types might have the highest cull rates? Correct, the 211A and 313A, which are dubbed “poor” containers. The new 410 block is currently looked upon as a “successful” container. Could the “status” of the container have anything to do with the standard imposed on

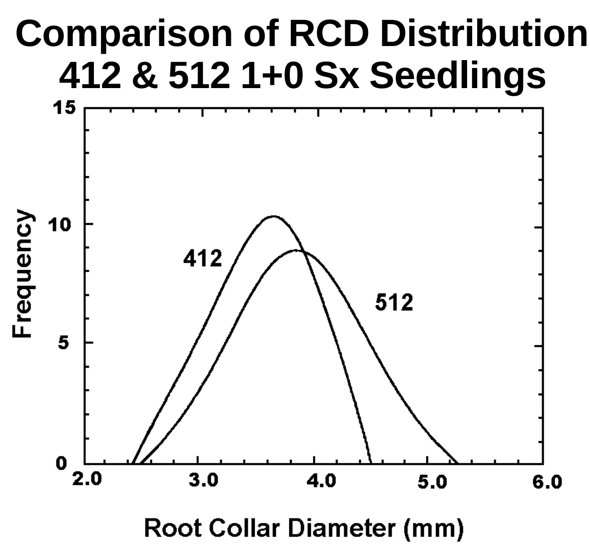

Figure 5 __*** 29% more growing area per seedling in 512__

it? 410 crops during good years can sometimes be packaged without grading!

Note the shift due to the difference in available growing area per seedling. Curve is similar to caliper distribution but has a wider range due to being a squared function.

Note the similarity, theoretically there should be no shift ie. 512 has a lower production per unit of growing area (9%). This lower production in the 512 is likely due to the fact that it takes longer for the seedlings to completely occupy their available growing space. Perhaps 9% of crop cycle time?

Note that production per stem increases **(see Table 2)** with increasing growing area per stem while production per block or unit growing area, remains fairly constant for a given set of inputs (Nursery G vs V). Also as growing density increases growing time until canopy closure is reduced perhaps accounting for the reduction in the difference in production per unit growing area (9% to 6%).

Pl 211 vs 313A/B mixed:

This is the same crop used to construct figure 1. Note the relationship holds up better at these high densities **(see Table 3**). The time frame from sowing until canopy closure is relatively short compared to total crop cycle growing time.

COULD WE ALIGN EXISTING, OR GENERATE NEW SPECS?

We know from experience what can be produced in existing crops. Using SBA production per unit of growing area one can extrapolate to new container types (plant densities) to determine what is achievable (other inputs being constant). This could be done with existing specifications to make them fair (relatively speaking) across the variety of container types currently used.

To determine what is achievable with a new stocktype in a new facility (different input levels) one needs to grow some operational crops. From these,

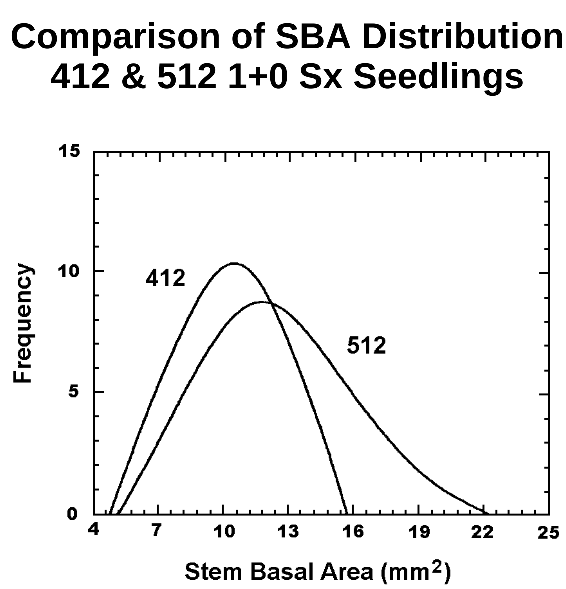

Figure 6. 412 vs 512 SBA (per stem) Distributions

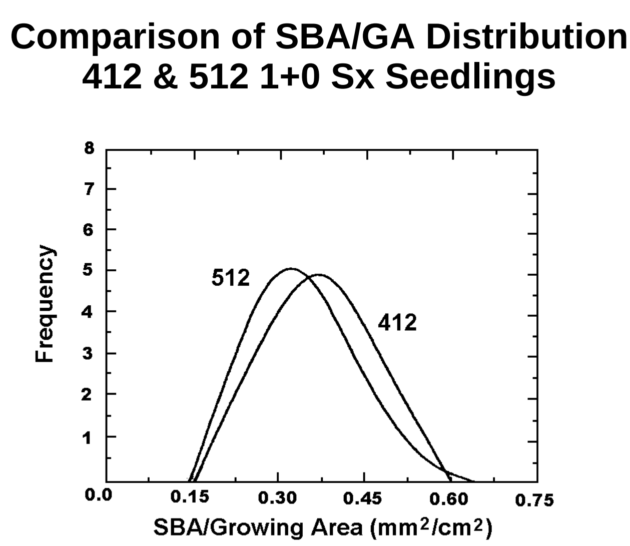

Figure 7. 412 vs 512 SBA/GA Distributions

Table 2. White Spruce 1+0 Average Stem Basal Area Production

Block	# Cavities Per Square Meter	Available Growing Area/tree (sq cm)	Per Tree (sq mm)	Per Blk (sq mm)	Per Unit of Growing Area (sq mm/sq cm)
412G	366	27.32	10.13	780	0.37
Difference...		(29%)	(18.6%)	(9%)	(9%)
512G	280	35.26	12.01	721	0.34
410V	527	18.98	12.72	1424	0.67
Difference...		(43%)	(35%)	(6%)	(6%)
412V	366	27.32	17.21	1325	0.63

Table 3. Lodgepole pine 1+0 Average Stem Basal Area Production

Block	# Cavities per square meter	Available Growing Area/tree (sq cm)	Per Tree (sq mm)	Per Blk (sq mm)	Per Unit of Growing Area (sq mm/sq cm)
211	1130	8.85	4.34	1042	0.49
Difference...		(34%)	(37%)	(2%)	(2%)
313A/B Equal mix	936 & 764	11.89 (ave)	5.94	1063	0.50

frequency distributions and SBA production capabilities can be determined on average (long term, if possible). Minimum standards can then be generated to reflect biological capability and desired capture limit of variability.

Ideally, seedling customers should take out to the plantation all the biomass produced at the nursery (since they are paying for it all). The key is to select a container/specification combination which will allow all the dry matter produced to be concentrated in the "spec" seedlings, ie. including the dry matter previously contained in "culls". This "optimum" specification for a container type might allow utilization of 95% of a crop. A crop producible under normal (long term average) conditions.

GRADING!?

As an industry, we are spending hundreds of thousands of dollars per year grading seedlings. To reduce this cost we are currently also investing large sums to develop grading equipment. However, if we succeed in reducing the cost of grading through equipment development there are still the approximately 50+ million seedlings per year in British Columbia being discarded as “culls”. This is an immense waste of seed, seedlings, and growing space possibly making us one of the most inefficient greenhouse growing industries on the globe!

So let's turn the whole concept around. Perhaps, by starting with the final desired product (minimum stem caliper and an acceptable % cull factor) and designing the growing system to produce it, we could instead ..... *eliminate* grading, and all the costs and headaches associated with it!? **Would it not be nice to just package everything?**

DOLLARS RECOVERED PER UNIT OF GROWING AREA

Costs in a greenhouse operation are calculated on a per unit area basis, ie. facility depreciation, heat, lighting, soil mix, etc. In order for the operation to remain viable, there needs to be a certain amount of monetary input. The break even point for nurseries will differ depending on local situations (weather, labour) but the principle remains. Each square meter under cultivation needs to make a certain return to stay in business. Hence if stiff specifications (or poor growing techniques) lower the number of saleable units per square meter, the price per unit has to be higher. Competition will take care of the poor growers but specifications will reduce efficiency of even the best. **Basically, the seedling customer is paying for the whole seedling crop, culls included, and chooses (through specifications) which portion to take.**

SUMMARY

1. Attainment of specifications is largely a function of density dependent competition effects.

2. Growing (light capturing) area available per seedling is the main limiting factor in higher density container culture growing regimes.

3. Stem caliper production does not relate linearly to stem basal area production or its determining factor, available growing area/stem.

4. Knowing the biological capability of a system allows realistic determinations of specifications (caliper).

5. Knowing the customer specifications demand (caliper) allows development of growing systems with plant densities that will allow them to be achieved.

6. Grading out lower caliper classes (creaming for higher caliper classes) within a seedling crop is an expensive make-work project.

REFERENCES

Annevelink, E. 1990. Operational Planning in Horticulture: Optimal Space Allocation in Pot-Plant Nurseries Using Heuristic Techniques. J. Agricultural Engineering Res.(1992)51, 167-177.

Boyer, James N.; South, David B. 1986. The Influence of Seedbed Density on Loblolly and Slash Pine Seedling Grade Distributions. Auburn University Southern Nursery Cooperative, Auburn University, AL 36849-4201. November 1986, Number 29.

Decoteau, Dennis R.; Hatt Graham, Heather A. 1994. Plant spatial Arrangement Affects Growth, Yield, and Pod Distribution of Cayenne Peppers. HortScience 29(3):149-151.

Gray, David.; Benjamin, Laurence. 1991. Reducing the Grade-Out Pile. Grower, July 11, 1991.

Hulten, Hakan. 1989. Current Levels of Planting Stock Uniformity and Grading — A Scandinavian View. Forestry Supplement, Vol. 62, 1989.

Kahn, Brian A. 1990. Reduced Plant Populations Save Seed Costs Without Reducing Yield Or Quality of 'Alltop' Turnip Greens. Hort Science 25(2): 179-180

Knowe, Steven A.; Foster, Sam G.; Rousseau, Randall J.; Nance, Warren L.; 1994. Eastern Cottonwood Clonal Mixing Study: predicted diameter distributions. Can. J. For. Res. Vol. 24:405-414.

Simpson, David G. 1991. Growing Density and Container Volume Affect Nursery and Field Growth of Interior Spruce Seedlings. Northern Journal of Applied Forestry, Vol. 8, No. 4, 160-165.

South, D.B.; Mitchell, R.J.; Zutter, B.R.; Balneaves, John M.; Barber, Brad L.; Nelson, Derek G.; Zwolinksi, Janusz B. 1993. Integration of Nursery Practices and Vegetation Management: Economic and Biological Potential for Improving Regeneration. Can. J. For. Res. Vol. 23 2083 – 2092

Sutherland, D.C.; Day, R.J. 1988. Container Volume Affects Survival and Growth of White Spruce, Black Spruce, and Jack Pine Seed-Lings: a Literature Review. Northern Journal of Applied Forestry 5(3):185-189

Sutton, B.C.S.; Grossnickle, S.C.; Roberts, D.R.; Russell, J.H.; Kiss, G.K. 1993. Somatic Embryogenesis and Tree Improvement in Interior Spruce. J. Forestry 91(10):34-38

Rikola, Risto. 1989. Planting Performance of Size graded Scots Pine Seedlings. Forestry Supplement, Vol. 62, 1989.