KAMLOOPS, B.C.
March 27th, 1985
File: 162-0-5

WORKING PLAN FOR DIRECT SEEDING UNDER VARIOUS TYPES OF
SHELTER CONES AND FUNNELS

PURPOSE:
This trial 5X85-112K is a continuation of 5X84-302K which was carried out in
the Kamloops Region during 1984. It is to test the use of direct seeding
using Fincone, Connel funnels and Carfon cones as an effective method of
reforestation. These trials should determine the most effective operational
methods. The installations will be on dry and moist sites, various number
of seed per cone, and at times more than one species on the same site. This
trial should give participating field personnel - hands on - experience, on a
tool that might have some future in our reforestation program.

DISTRIBUTION:

Silviculture Branch Library, Victoria,
Silviculture, Kamloops
Salmon Arm, Lillooet Forest districts

PROGRESS:
All trials will be established in April and May depending on rate of snow
melt. The spot selection will follow the same specifics as with planting, 2.6
to 2.8 m triangular spacing.

SITE DESCRIPTION:
Various sites have been selected by licensees, and Ministry staff for this
seeding project. All sites have to be mechanically site prepared, but are
located at various exposures and elevations.

On all sites selected for this trial, cattle control must be enforced. Last
years trial showed low germination where cattle trampling occurred, and made
this information useless.

RESPONSIBILITY:
Supervision will be the responsibility of the local R.O. Silviculture, or the
licensees representative in charge of the project.

Individual reports are expected from all participants by September 15th, 1985
on first years germination.

Survival checks should be reported in the fall 1986, 1988 and 1990 for final
survival and height measurements. For the collection of data, permanent plots
shall be established. All trials should be entered on history records.
OBJECTIVES

The original objectives of this trial were to assess the effects of aspect, site preparation and solar exposure on the germination and survival of lodgepole pine seeded under Cerkon shelter cone types in an operational-sized plantation of about 9,500 seeding spots. These objectives were somewhat compromised when, at the last minute, only some 280 Cerkon cones were available, with the balance offered being Hakmat cones and Cerbel funnels. It was decided to incorporate a comparison between the performance of the various shelter cone types into the trial, although the proportion of Cerbel funnels planted in the one-day project was constrained by having only 4 of the specialized seeding tools needed, and one of those broke early in the day.

SEEDING

The seeding site had been selected for its shallow, rocky soil, an area difficult to plant by conventional means, and for the variety of aspects, slopes and site preparation it presented.

The study area was first broken into 3 units of comparable ground (Units H, N and P), each having exposed (south and west), shady (north and east) and flat aspects on comparable ground for shelter cone type comparisons. The remaining units (A and Q) were filled with Hakmat cones and Cerbel funnels, respectively.

The 2 types of cones were implanted using mattocks to create a level clearing to mineral soil, on which was placed a cone secured by 1 to 3 cm of soil pressed around the lip. Seeding was done using a hand-held, squeeze-action, reciprocating "seeding gun" initially calibrated to dispense 3 seeds per squeeze, with planters instructed to squeeze once per cone. However, the guns often seemed to jam in a mode where no seed would fall into the reciprocating chamber for up to 10 squeezes in a row, probably due to the elongated shape of the seeds. Checking out suspicions of non-dispersion of seed was time consuming, and of questionable accuracy in any case, trying to see dark seed on dark soil in the cones; the planters were told to assume the guns were always putting out the calibrated number of seeds per squeeze since this was to be an operational trial. It was felt that recalibrating the guns to dispense 1 seed per squeeze would reduce both the statistical variation in the number of seeds per cone and the number of cones without any seed at all, and this change was made early in the day.
There was some debate as to the amount of soil needed to anchor the cones in place and prevent toppling, but even the minimum 1 cm seemed sufficient on this site, judging by later observations. Almost all the toppling observed was caused by people who walked through the area at the time of seeding; kicking over unnoticed cones, and the deepest-buried cones were at greatest risk of going unseen by walkers.

Planters definitely preferred the Cerbal cones to the Hakmat model for their sturdiness. The latter were prone to being collapsed inwards by the downward pressure applied to hold the cone in place while backfilling. The detrimental effects of seeding under cracked or caved-in cones can only be speculated upon, but casual observations made during data collection indicated that pinched Hakmat cones broke down more readily and exhibited poorer survival than their intact comrades.

The Cerbal funnels were poorly suited to this site as any attempts to force the special seeding tool into rocky or compacted soil led to the hinged funnels breaking open, defeating their purpose. Many of those actually implanted were left sitting far higher out of the ground than they should ideally have been because the planters were instructed to avoid breaking them apart.

The seeding tools for the Cerbal funnels were calibrated to dispense 5 seeds per funnel (although, again, the numbers actually dispensed varied widely) and were prone to jamming like the hand-held guns. However, the Cerbal tool did have one advantage over the seeding guns in this regard because seeds could generally be heard bouncing down the metal tube after they were discharged from the reciprocating chamber.

None of the planting crew had previous shelter cone experience and their production was not what would be expected of a full-scale operation. Planting costs on the FS 753 of $4.27/seeded spot, exclusive of the cost of the cones or seed, were inflated by the ratio of supervisors to planters and by the concentration of fixed costs of the project on a small number of spots. It was felt by planters and supervisors alike that an experienced shelter cone planter could seed as many spots in a day as an experienced tree planter could plant plugs on similar ground.

The seedbed was moist at the time of seeding and there were a few showers interspersed among mostly warm, dry days in the ensuing two weeks. Many of the cones exhibited condensation on their inner surfaces in the early morning one month after seeding. However, the summer weather became hot and dry for an extended period, and favourable germinating conditions became poor survival weather. A survival survey of the adjacent F bareroot and PI plug seedlings planted a week or two after the shelter cones indicated 30% survival after one year, an abnormally low figure.
OBSERVATIONS

Forty-four 0.05 ha permanent sample plots with numbered 1" x 2" plot-center stakes were established and observations made on the site on August 3 and 4, 1985. Plot locations were selected to provide a range of shelter cone types, aspects, slopes and site preparation types within the seeded area. The location of each cone and natural tree within each plot was recorded on a FS 707 card, and the number of germinants at each cone was recorded, as well as whether they were alive or dead, inside or outside their cone. Other data recorded on a plot by plot basis included shelter cone type, aspect, sideslope, slope position, site preparation method and degree of shading on the plot, along with general comments about plot conditions and guesses at factors influencing germination and survival. Sideslope and slope position were estimated by considering the terrain 15 m uphill and 15 m downhill of the plot center. Shading was generally provided by deciduous material (fireweed and sprouting brush and trees) although there was a little year-round shade due to adjacent standing timber, stumps, slash, etc.

CALCULATIONS

The raw data collected has been classified by plot characteristics in an attempt to reach conclusions about the factors most heavily influencing germination and survival of the seeded trees. Slopes were broken into 4 categories (flat, 0-14%, 15-30%, and 31%) because that division gave a relatively close balance between the number of plots in each category, and, for the same reason, aspects were broken into 3 groups (west to south-southeast, southeast to north and flat) to represent sunnier, shadier and neutral aspects, respectively. The simplest example of plot grouping, totalling and averaging by a given characteristic (in this case, by planting unit) is included in this report. Many other calculations were done but have not been detailed in their labour-intensive entirety; only their bottom lines, displayed in graphic form for ease of recognition, are included here. Nor has every possible combination of factors been explored for this report; only sufficient calculations to indicate the influence of the specific germination and survival factors under consideration have been performed.

It is important to note that with the categorization and subdivision of this data into small groups, and with the variance between plots, the calculated values have very little statistical validity, with standard deviations characteristically in the range from 50-100% of a given mean value. However, the graphs do indicate trends which will allow significant factors to be identified, if not accurately quantified. On the other hand, it should be recognized that both the relative and absolute values of any given factor are going to vary with site specific edaphic, climatic and biotic factors.
One non-graphical calculation with respect to germination was made as follows:

<table>
<thead>
<tr>
<th>Seeding Unit</th>
<th># Plots</th>
<th>Germinants in Plots</th>
<th>Plot Multiplier</th>
<th>Area (ha)</th>
<th>Germinants on Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>9</td>
<td>153</td>
<td>200</td>
<td>0.59</td>
<td>2,006</td>
</tr>
<tr>
<td>N</td>
<td>9</td>
<td>351</td>
<td>200</td>
<td>0.21</td>
<td>1,638</td>
</tr>
<tr>
<td>P</td>
<td>9</td>
<td>415</td>
<td>200</td>
<td>0.79</td>
<td>7,286</td>
</tr>
<tr>
<td>Q</td>
<td>6</td>
<td>97</td>
<td>200</td>
<td>0.92</td>
<td>2,975</td>
</tr>
<tr>
<td>A</td>
<td>11</td>
<td>285</td>
<td>200</td>
<td>1.14</td>
<td>5,907</td>
</tr>
<tr>
<td>TOTAL</td>
<td>44</td>
<td></td>
<td></td>
<td>3.65</td>
<td>19,812</td>
</tr>
</tbody>
</table>

Actual germination may be calculated as follows:

Overall Percent Germination \( g = \frac{G \times N}{S} \times 100 \)

where \( G \) is the total number of germinants on all units, \( N \) is the nursery germination test factor, and \( S \) is the number of seeds put on the site.

\[
g = 19,812 \times \frac{.95}{(9,500 \text{ spots} \times 5 \text{ seeds/spot})} \times 100 = 43.9\%
\]

This figure seems suspiciously low, considering that ungerminated seed was very rarely observed in cones whose seedbed could be seen and there was no sign of animals eating seed. Certainly there were a proportion of seeds which fell on an inhospitable seedbed, or missed going into the shelter cones as they were planted (especially the Corbel funnels) or were lost in handling. However, it seems unlikely that less than two-thirds of the seeds would have germinated, and more probable that the amount of seeds provided was far less than the 9,500 spots x 5 seeds/spot expected.

Several further numbers were calculated for interpretation with respect to survival, as follows:

- percent of cones with no germinants at all \( (A) = 17\% \)
- percent of cones with no germinants surviving \( (B) = 42\% \)
- percent of cones with some germinants surviving \( (C) = 17\% \)
- percent of cones with all germinants surviving \( (D) = 41\% \)

From this information, initial stocking \( s \) of the trial site at the time of the germination survey can be calculated by:

\[
s = \frac{(C+D) - (100\%-A) \times T \div P \times M}{s = \frac{(17\%+41\%) - (100\%-17\%) \times 298 \div 44 \times 200}{652/ha}
\]
The calculated percentages with respect to the completeness of survival show that 83% of all cones with germinants exhibited either full survival or zero survival, and 17% showed no germination at all (of which a sizeable fraction is attributable to mechanical problems with the seed dispensers). While biological factors associated with the seeds can significantly affect germination, the preceding data suggests that environmental factors are far more significant in initial survival. Furthermore, by noting on the PS 707 plot cards that survival commonly varies from 0% to 100% between cones within a plot, it is also clear that those environmental factors which can vary significantly within the space of 2 meters must be examined to understand the reasons for the survival pattern seen in this trial.

INTERPRETATIONS

The accompanying graphs indicate that (other than seed dispensation problems) the factors which affect the number of cones without germinants most significantly are shelter cone type and slope position, brought together in Graph 1. The curve of "blank" cones by all cone types is very closely correlated to the relative abundance or scarcity of soil moisture, as implied by slope position. In addition, the curve for funnels shows a much higher rate of failure to produce any germinants at a seeded spot than do the curves for either type of cone. This discrepancy could be attributed to a general failure to get the funnels deep enough into the ground to reach an adequately moist soil layer to initiate germination, or to a failure of the seeding tool to deliver seed to the funnel once it was implanted in the ground. The similar nature of the germination curves for cones versus funnels in Graph 5 and the strong bow in the curve for funnels in Graph 1 indicates that soil moisture rather than planting tool malfunction is at the root of the problem.

Graph 2 hints at a tie between gentleness of slope and completeness of germination but yields no firm relationship, and conflicts somewhat with Graph 3. The latter indicates more thorough germination on the warmer aspects, as might be expected, but consistently points to slopes of intermediate steepness as having worse germination than greater or lesser slopes. The explanation for this appears to be that most slopes in the 15% to 30% range occurred in plots which had slope positions b, c and d, the locations with the greatest number of "blanks" in Graph 1.

Graphs 4 and 8 indicate little connection between germination and either site preparation type or shading. Deciduous shading was probably not leached out to any limiting degree at the time that air and soil temperatures achieved the necessary levels to promote germination. However, germination on skid trails and landings seems to be superior to that on other sites in both Graphs 4 and 8, and Graph 12 indicates that these sites have the best survival as well, although the seedlings tend to be chlorotic. The likeliest explanation
for this observation may be that the compaction of soil in these areas has reduced the ability of water to percolate down and out of the soil, so, once again, soil moisture is implicated as the critical factor.

Graph 6 shows no relationship between slope and germination which is not overridden by other factors, as in Graph 2.

Graph 7 is modestly complementary to the finding in Graph 3 that warmer aspects produce better germination.

Soil moisture, as represented by slope position, is clearly demonstrated to be tied into initial survival of the germinants in Graphs 9 and 10, although survival is independent of shelter cone type or slope.

Graphs 11 and 12 show the interdependence of aspect and broadcast burn intensity, which can be confirmed in the individual plot data. More heavily burned areas tended to be on the shadier aspects due to the relative density of the understory there and the contribution of the understory component to the fuel loading prior to burning. All other things being equal, better survival would be expected on north aspects after one season due to less danger of critical surface temperature regimes, but the adverse effects of aspect-correlated burn intensity skew the results in the opposite direction. This data seems to relate the effects of site preparation type on survival primarily to high surface temperatures rather than to critical soil moisture levels. The possibility that there may be an element of hydrophobicity in the soil due to the intensity of the broadcast burn on the northerly aspects seems unlikely, as it ought to be reflected in equally poor germination results by site preparation type in Graphs 4 and 8. If the observed poorer survival on shadier aspects is, in fact, soil moisture related, it seems probable that the soil moisture must in turn be influenced by soil surface temperatures. Certainly surface temperatures are implicated in mortality by several instances in which germinants within shelter cones were dead but those outside were living, and also by the overall survival rates of 32% inside cones versus 73% outside cones. It might also be possible to interpret the trend to better survival in deeper shade to the effects of lethal surface temperatures; however, it is more probable that brush biomass reflects soil moisture levels, already clearly linked to survival. Supporting the latter theory is the observation that the best height, needle length and colour of the germinants seemed to occur in the deepest shade, as well as in the most deeply implanted cones.

Two further casual observations made during the data collection are worth mentioning here. Survival of germinants seemed to be proportional to the depth the shelter cone was implanted in the soil. This may be attributable to either the distancing of the germinants from lethal surface temperatures or to an effect whereby deepening the seeded level with respect to the soil surface could be likened to artificially shifting the slope position of that microsite towards the
receiving positions since it would afford the germinants a greater measure of protection against drought.

The other note was that shelter cones in which species of vegetation other than the seeded lodgepole pine had germinated seemed to exhibit particularly good seedling condition. This probably reflects relatively high soil moisture levels and implies, as does Graph 12 showing better survival with increasing vegetation biomass, that moisture stress due to vegetative competition is not a critical factor on this site or present vegetation densities. On the other hand, it may be possible that, where soil moisture is not limiting, additional vegetation within a shelter cone increases the relative humidity inside the cone through evapo-transpiration and shading, and thus provides a lower temperature and higher moisture regime for the seedlings. Another possibility is that cones filled with more biomass may have reduced air circulation within the cone and decreased rates at which moisture is drawn through the opening at the top of the cone.

CONCLUSIONS

The generally red colour of dead germinants and the heights being comparable to those of living germinants imply that the bulk of the mortality seen in this survey took place within the previous month, an exceptionally hot, dry July. Whether the results of this shelter cone trial can be held up as representative is questionable; an assessment of this sort should be put into context by a comparison between the survival in this trial and overall survival of 1985 planting stock in the area, with an allowance made for the site of the shelter cone trial being harsher than virtually any other planted. It must be remembered that any quantification of results arising out of this sort of trial is valid only for a similar meteorological and edaphic set of circumstances.

It would appear that only two environmental factors, soil moisture and air temperature, were critical in affecting germination and initial survival in this trial, although these factors present themselves in several recognizable forms: air temperature is related to site preparation type, aspect and shading, and soil moisture is related to those same site characteristics and, above all, to slope position. Of these two, soil moisture has the greatest importance as it can drop to critical levels beginning soon after snowmelt, as evidenced by germination and survival curves by slope position. Air temperature probably reaches critical levels on this site only in mid-summer.

Besides environmental factors, germination was affected by two technical factors: shelter cone type and seed dispensation equipment. Under the conditions present on the trial site, cones were much easier to properly implant than funnels and resulted in vastly superior germination. However, there was no indication in variation in performance between Haskett cones and Gerken cones. Inconsistent seed
Dispensation equipment presented a significant stumbling block to successful stocking of the trial site.

RECOMMENDATIONS

The initial results of this trial, although necessarily tempered by recognition of the severity of both the site and the summer weather, indicate that further small operational trials would be prudent before embarking on a major project.

Sites chosen for further studies should, perhaps, be typical planting areas so that results can be more readily compared to standard planting techniques. Future trials should stress choosing seeding spots which are moisture-receiving microsites. Furthermore, cone bases should be implanted 2 cm (or preferably 3 cm) below the normal soil surface level to minimize moisture stress on the germinants. Candidate sites for shelter cone seeding might best be left for one or two years following site preparation to allow for the regrowth of vegetation which could contribute towards the moderation of extreme surface temperatures, should this problem be anticipated.

Shelter cones should be concentrated upon in future trials rather than funnels, although another cone-versus-funnel comparison on a substrate favouring funnel implantation (soft, well-drained and relatively rock-free soil) would be of interest. Two seeds per cone would seem plenty to achieve a high percentage of seeded spots with germinants, assuming an 80%+ nursery germination factor. However, the modification of a reciprocating seeding gun to include a transparent holding chamber which would allow visual confirmation of seed dispensation would go a long way towards ensuring the efficiency of operational seeding projects in the future.
Survival of seedlings germinated in this shelter cone planting trial were determined by sampling 44 permanent staked plots of 50 square meters in August of 1985 after one growing season, and again in June of 1986 after a full year. The results are set out in the tables below.

### After one growing season:

<table>
<thead>
<tr>
<th>UNIT</th>
<th>PLOTS</th>
<th>TOTAL # OF CONES</th>
<th>TOTAL # OF GERMINANTS</th>
<th>TOTAL # SURVIVING</th>
<th>% SURVIVORS</th>
<th>% CONES WITH SURVIVORS</th>
<th>% CONES WITH SURVIVORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
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<td>57</td>
<td>193</td>
<td>118</td>
<td>77.1</td>
<td>32</td>
<td>58.1</td>
</tr>
<tr>
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<td>9</td>
<td>60</td>
<td>251</td>
<td>192</td>
<td>54.7</td>
<td>33</td>
<td>55.0</td>
</tr>
<tr>
<td>P</td>
<td>9</td>
<td>63</td>
<td>415</td>
<td>253</td>
<td>61.0</td>
<td>38</td>
<td>60.3</td>
</tr>
<tr>
<td>Q</td>
<td>6</td>
<td>33</td>
<td>97</td>
<td>34</td>
<td>35.1</td>
<td>8</td>
<td>24.2</td>
</tr>
<tr>
<td>A</td>
<td>11</td>
<td>76</td>
<td>285</td>
<td>98</td>
<td>34.4</td>
<td>28</td>
<td>36.8</td>
</tr>
<tr>
<td>ALL</td>
<td>44</td>
<td>269</td>
<td>1301</td>
<td>605</td>
<td>53.6</td>
<td>139</td>
<td>48.1</td>
</tr>
</tbody>
</table>

### After one full year:

<table>
<thead>
<tr>
<th>UNIT</th>
<th>PLOTS</th>
<th>TOTAL # OF CONES</th>
<th>TOTAL # OF GERMINANTS</th>
<th>TOTAL # SURVIVING</th>
<th>% SURVIVORS</th>
<th>% CONES WITH SURVIVORS</th>
<th>% CONES WITH SURVIVORS</th>
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<tbody>
<tr>
<td>H</td>
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<td>57</td>
<td>162</td>
<td>97</td>
<td>59.9</td>
<td>27</td>
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<tr>
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<td>9</td>
<td>60</td>
<td>359</td>
<td>169</td>
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</tr>
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<td>P</td>
<td>9</td>
<td>63</td>
<td>423</td>
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<tr>
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<td>33</td>
<td>99</td>
<td>32</td>
<td>32.3</td>
<td>8</td>
<td>24.2</td>
</tr>
<tr>
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<td>11</td>
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<td>292</td>
<td>74</td>
<td>25.3</td>
<td>25</td>
<td>32.9</td>
</tr>
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<td>ALL</td>
<td>44</td>
<td>289</td>
<td>1335</td>
<td>568</td>
<td>42.5</td>
<td>129</td>
<td>44.6</td>
</tr>
</tbody>
</table>

Stocking can be estimated by multiplying the % of cones with survivors by the number of cones per plot and dividing by the number of hectares per plot. The results are a stocking of 632/ha after one growing season and 586/ha after one year, quite closely comparable, as a percentage of planted spots, to the first year survival figure for the adjacent P var. septiflorus and P1 plug stock planted immediately after this trial was established. Note that these stocking figures assume all cones are well-spaced and ignore the few naturals found in the plots.

Clearly 80% of the germinants that died did so over the summer of 1985, largely due to the drought stress during that unusually hot, dry period. The remainder of the mortality taking place in the first year can be partially ascribed to residual effects of the drought, but the data suggests that much of those losses were within overstocked cones since the percentage of cones with survivors did not drop nearly so much as the percentage survival of germinants within this period. New germination in cones previously not stocked accounts for only a little of this percentage difference. It seems probable that competition between germinants is responsible for this situation where some germinants live and some die within the space of 5 cm.
In some cases the germinants are tangled and coiled up within their cones unsuccessfully trying to push a leader out the top of the cone (in this regard the Corbi cones seem to be problem-free). The Bismarck cones are breaking down more quickly than the Corkon model, but the former tend to split from the top into petal-like shards which then curl into the "greenhouse", flattening the germinants or restricting their growing space. Cones located on soil trails seem more likely to be shattered or toppled, possibly due to deer traffic although there was no sign of active browsing noted on this site. Some mortality must be attributed to adverse effects of the shelter cone environment because there are several cases in which germinants that have established outside the cones have survived while those 5 cm away inside the cone have died en masse, presumably of overheating.

The heights of the germinants range from 1 to 20 cm after one year, with an average of about 7 cm. Needle length and color were related to height, with small chlorotic plants on compacted ground and good growth and color on the sites with the best availability of soil moisture. In general, the survivors are in fair condition.

The trail soil visited July 3, 1976 by
John West and Dave Westergard. At that
time, shrubs were very difficult to find
and only one survivor was observed during
a good walk-thru.

[Signature]
89.03.30