

## **Summing up: review of need for further studies, publications or training**

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I was surprised when Rodney asked me to do the summing up for the day, because as manager of Kielder Forest I look after currently the largest clear-fell and replant forest in England, and I think I am also responsible for the largest FSC certified felling coupe in the world! But we have been looking at continuous cover and as part of that I have learned something about the importance of light.

Even in the more sheltered parts of Kielder we are dealing with peaty gley soils and are looking at higher wind hazard. Our most sheltered areas are about wind hazard class 4 and the text books say "don't even try continuous cover" here. But we have done a bit, particularly where the management objectives are for recreation and landscape so that we want to keep the canopy cover.

We started looking at this some years ago. It is really Sitka spruce stands of 50 to 60 years old that have had at best a little thinning but not very much, so they are heavily stocked stands. We jumped in and cut holes in the stands and expected them to regenerate, but the holes filled up with grass and nothing germinated at all. We then planted trees into these holes and the deer came and ate them, so we fenced around the regeneration holes and that was expensive, and a tree on the edge would blow over and let the deer in and the plants got eaten again.

So we have changed systems now. Understanding a bit more about the importance of light, we are keen to develop what the Commission would call a complex structure rather than a simple 2-storey structure, and have applied a variable-density thinning to these stands, thinning some bits of the stand very heavily and other bits quite lightly, removing something like 30% or so of the basal area (the relatively unthinned stands are standing at 70 – 80 m<sup>2</sup> to the hectare). Having removed the 30% we find we do get a carpet of germinants. We have not left enough light for the grass to come in so we get seedlings germinating, but there is still not enough light for them to grow.

Now, 5 years on, we have gone back to some of these stands and thinned only the bits that we thinned heavily the first time, and taken a further 30 % of the basal area out, which has allowed the seedlings to develop. We are still at about 35m<sup>2</sup> to the hectare so we shall need to do some more removals before we actually get these trees to continue growing, but we

are getting regeneration starting to appear. We have had one or two places where wind has come in and blown the trees down and my foreman tells me it is terrible forestry and really untidy and he is quite horrified by these fallen trees, but it is exactly what I was after. The wind-blow has allowed more light into these heavily thinned bits and because the seedlings were already there they are now getting away ahead of the grass, so that bit does seem to be working.

I was really interested by the light meter measurements this afternoon. I couldn't believe that when we were standing in a brightly lit part - with canopy round about - it was only 10% of the light in the open area.

From this morning's talks it is pretty clear that now, or quite soon, we are going to be able to model the light environment, and quantify it in quite considerable detail. We have seen hugely detailed models with modelling of individual leaves and needles. I think the models will allow us to make changes to the forest structure and see what effect that has on the light environment, helping us to answer Maurizio's question, "Do we know what the light environment is?" If knowing about the light environment is going to be useful information, then we also need to know how the plant will respond to different light environments. As we have seen, plants, and especially the shade tolerant ones, are remarkably versatile in adapting their structure and physiology to take maximum advantage of whatever light environment is prevailing. We have seen the value of diffuse light and how plants will adapt their structure to make maximum interception of the diffuse light. Also, it is not just how the plants themselves change. The light regime also affects other factors such as insect prevalence or the moisture regime. So we not only need to know the influence of the light regime, we also need to know the physiology and structure of the plants and how they will adapt to it.

Guidance that would answer how we should go about assessing light levels in the different parts of the forest, and how that relates to the requirements of seedlings, both to germinate and for their continued growth, would be very useful.

There is a whole range of techniques for measuring light levels. We have seen light meters and hemispherical photographs, but there are also concepts like stand density index (although I was struggling with the mathematics of that!) and basal area. How do these relate? Even the simpler ones, by looking at the regeneration and looking at leader length compared with laterals, are useful. I don't think there is guidance on how foresters should go about assessing light levels in a practical way and, although there is some information around about how much light is needed for germination, and how much is needed for continuing growth, I haven't seen it collected into a coherent set of guidance. So that is one area where I think more guidance would be useful. [Useful guidance is contained within Forestry Commission Information Note 63 "Managing

Light to Enable Natural Regeneration in British Conifer Forests" by Sophie Hale, December 2004]

In terms of research needs, I was also thinking about the wood quality aspect, and its relationship with how much regeneration is enough. For even-aged stands we know quite a lot about the relationship between plant density and wood quality; – or I should say in Sitka spruce we know quite a lot about that relationship, maybe not so much in other species! For the simple structure of continuous cover and shelter woods that information may well be relevant, but when you get on to the more irregular structures and the permanently irregular structures it is not just the competition with neighbours, it is also what is happening in the upper canopy to each side, and what is the impact of light on tree form. I think that does need more research, leading to more guidance.

The next area was growth and yield models and the mystical J-shaped curve. I think there is quite a lot in what we have been learning about light which could inform us about what the shape of that curve should be. When you ask people who have been practicing with these J-shaped curves for a long time it is really hard to pin down where it came from. It ends up just being years and years of experience, I think, but there must be some association with light and the shape of that curve and I am not sure that we have looked into that at all.

*Questioner:* What curve is that?

The J-shaped curve is the stem-size distribution curve. Within irregular forest structures there is a classical shape to this curve that foresters keep trying to move the growing stock closer to.

*Audience:* Some foresters!

I think another bit that never seems to be discussed much is where the curve lies in relation to the axes. Is it further in or further out. I guess that is really to do with the basal area on the site, so it is not just the shape of the curve, it is also how far in or out it is from the axes, and I think what we are discovering about light and its importance has a bearing on that.

The last thing I was going to mention was regarding total yield. Alec was discussing whether there is more yield, more efficiency converting light into timber in continuous cover or in even aged forest and, like Alec, I thought it was so close that it is not all that important, but I think it is becoming more important as there is more interest in carbon and carbon storage.

Carbon storage is not just about timber yields, it is also about how much light is getting converted into storable carbon, not just in terms of total

quantity of timber, but also in terms of saw-log and small round-wood proportions because it is these product out-turns and the length of storage which is important. – Is it put into a great hall or is it going into fuel wood? The amount of carbon that is stored over the life of a piece of timber varies hugely between the two, so product out-turn and saw log proportion are really important factors in the carbon balance. So I have become rather more interested in total yield and product assortment because of the carbon issue as opposed to just commercial wood production, *per se*.

I have certainly found it an interesting day and learnt a lot more about light – and micromoles!

**Graham Gill** gained a degree in Ecological Science from Edinburgh University in 1975 and joined the Forestry Commission in the same year. He has managed forests around Inverness, worked as a conifer tree breeder, and headed up the Commission's Environment Branch at a time when the environmental guidelines were being introduced. He is a founder member of the Continuous Cover Forestry Group and a Fellow of the Institute of Chartered Foresters. For the past 15 years, he has been Forest Manager of the FC forests in north east England, including Kielder Forest. He has a keen interest in developing techniques for introducing continuous cover silviculture on the margins of upland spruce forests.