# OPEN DISCUSSION

## CHAIRED BY ANDY POORE
## PANEL MEMBERS: PAUL BURGESS, MATHIAS DISNEY, RODNEY HELLIWELL AND MAURIZIO MENCUCCINI

***Andy Poore:*** I thought we might start by taking a subject which occurred to me during the presentations and which I found inspiring, and that is the idea of optimising light requirements. We are often interested in optimising the amount of light to enhance regeneration. We are also interested in optimising light to each element of the stand to maximise timber output, but the third element, and I have become more interested in this as I have tried to apply CCF to broadleaves over the last 10 or 15 years, is the question of optimising light with regard to tree form.

Lets look at oak and ash in the first instance. I have done a lot of planting of oak and ash in open fields, and I have increasing amounts of young oak elements in more open, developing irregular stands which have arisen by natural regeneration or by planting. I have looked at French practice in irregular forest and I have become more and more persuaded that actually we have a problem of too much light in conventional establishment practice. It seems that when we have species like oak and ash in completely open conditions, although there is clearly a genetic element in it, too much light produces poorer form. This is fairly radical because normally we are told we need lots and lots of trees because the straight oak is an oddity, but if you grow young oak trees in a more open forest structure with sufficient light reaching the lower levels (particularly if there are tall trees in that structure); they generally produce better form on average.

This was something that the French told me, and I thought "Well, possibly", but if you look round you see that there is something in it.

This morning we heard that a lot of species have developed with a certain level of light demand and I would like the reactions of the panel to this idea that there might be an optimum level for individual species, and there could be a problem with having too much.

***Mathias Disney:*** broadly, I would agree, I think there is some evidence that I know of (and that is not the genetic element of it). I am not an expert in this, but I see work that shows, not surprisingly, that evolution is essentially an incremental optimisation algorithm. It works with incremental improvements as a process towards finding a niche and being successful, so it makes sense that plant growth is heavily optimised to make use of not only the light available but also nutrients and water, which are the key three inputs which plant growth requires. In different environments the pressures are different, so whether you are light limited,

nutrient limited, water limited, none, or all three will determine the success or failure of a given species.

There is a lot of evidence to suggest that light function and nutrient use are optimised together, because the photosynthetic mechanism requires nitrogen in particular. Nitrogen and photosynthesis are very closely linked, so you are optimising not just to provide light but also to use nutrients in the most efficient way possible. So if optimisation was purely based on light, you might end up with a different form and function than if you were optimising for light and nitrogen.

***Andy:*** We are obviously talking about optimising specific characteristics that we want so it seems that the general amount of apical predominance and side branching on oak, for example, appears to be less in these not fully light environments. There is enough light but not too much. This is not scientific, it is purely observational.

***Mathias:*** Some of the results that I showed, and Maurizio showed, demonstrated that you can measure the photosynthetic rate, or growth rate if you like, of trees, and that light is not necessarily the limiting factor. The direct/diffuse ratio is arguably more important overall than the amount of light. That will clearly change with proximity and crown form so, for example, if you have trees far apart, widely spaced and open, you are going to increase the direct light and so change the direct/diffuse ratio. You are going to change the overall light levels a bit, but you are probably going to have more impact on the direct/diffuse ratio. If you scatter the amount of light before it arrives at the bottom of the canopy, and have it bouncing off things either side, you are going to get more diffuse light. It is coming from all directions which plants tend to find more effective. By definition diffuse illumination is coming from everywhere, whereas direct illumination is only coming from one direction. So if you can optimise to create diffuse radiation you are likely to collect a lot more of it, particularly in a climate like this where you get clouds. You are not concerned with the kind of light input you are going to get in a tropical or arid environment, where it is more about protecting the plant from damage or loss of water. So I would suggest that the canopy structure, including such matters as proximity and density, is going to have a major impact on how things grow.

***Maurizio:*** I would like to take up the issue of nutrients. It is difficult to separate light requirements from nutrient requirements, and I wonder whether, particularly when we are talking about coniferous plantations which have no component of broadleaves, we should in the long term be thinking about introducing a significant component of broadleaves because of the soil improvement properties which some of them have. We don't really know what happens in the long term to successive rotations and I don't know whether there are differences when you move from an even-aged to a more structured system.

***Andy:*** Talis Kalnars, who many of us knew, when you walked round a forest with him, he would say that tree formation of conifers was better in these completely irregular stands, he would also say it was better if you had birch elements with it. We all thought that was a bit far-fetched, because it was a long way from what we had been taught, but as you say, we are now beginning to think there is something in it.

***Maurizio:*** yes well, stem form, I think is complicated. The French certainly seem to have other components that are encouraged during the rotation cycle. I wonder whether the same principle applies anyway, if you have a number of minor species, even at lower densities, to encourage self-pruning.

The second point I want to make regarding nutrients is that we live in a changing world, with increased $CO_2$ concentrations, but plants don't just get free $CO_2$ from the air, they also need nutrients, so they need to scavenge the nutrients more, and I guess the pressure on nutrients will increase over time because we are seeing increased $CO_2$ in the atmosphere. I think the interaction between optimising the light environment and optimising nutrients is a crucial one.

***Paul:*** There is also the shelter effect. If you have got a tree growing in a more mature canopy, and it is not buffeted by the wind it will tend to grow taller and thinner and therefore more apically dominant. So sheltering would also contribute to better form.

***Rodney:*** I would echo the previous comment about evolution, because trees have not evolved to produce planking timbers. An oak tree might be quite happy growing with big branches, so I don't think we should be thinking about evolution too much, it is about what the situation is now.

***Andy:*** Can I open to the floor for either questions or comments.

***Alec Dauncey:*** Just trying to make sure I have understood some of that because one of the debates we have, which may be a bit idealistic, is whether there is a difference in productivity between continuous cover methods and even-aged methods. I explain that more light gets used in the deeper canopy, but usually I avoid these arguments because I don't think it matters that much. Is that the consensus of opinion?

***Andy:*** No, what I am saying is that when I started practising CCF in broadleaves the general feeling was that you were not going to have that many pole stage trees and you need thousands of oak trees to find one with good form. That was exactly what the state service originally said in France.

***Alec:*** Would more of the light turn into wood per hectare?

***Andy:*** That is a different question. I am beginning to think that trying to grow oak particularly (but also ash, and it may be the same for Douglas-fir as well although I don't know) in completely open conditions as we were under the plantation system is actually a problem; we are actually making it much more difficult for ourselves to generate a higher proportion of trees that have got better form,

***Rodney:*** it also goes into this business that a lot of people have been, or still are saying, that you can not manage oak under the continuous cover system. They see it as a pioneer species that needs so much light that you can't do it. I am of the opinion that that is wrong. I have seen oak in forests where it is maintaining itself with relatively little light in conditions where most British foresters would say oak wouldn't grow.

***Maurizio:*** I would not want to stick out my neck and say whether there was a difference in productivity between the two systems, but I would be prepared to say something about the overall carbon cycle of the forest, which is the trees plus the soil. I would probably argue that if you look at this, and incorporate disturbances that take place during harvesting of normal rotations in plantations, then as a generalisation you are looking at a much higher impact system with the plantation system than with CCF. The use of heavy machinery, tree removal, then the water table rises, new ditches have to be dug etc. mean there is quite a difference from the perspective of the carbon balance of the soil.

***Mathias:*** There are possibly also implications for water quality, which is a side issue but not insignificant. Carbon that runs out of the soil and into the water has implications if you are looking at management and DOC (dissolved organic carbon) in the catchment areas of water companies. The companies can spend a lot of money removing that carbon downstream to make it potable. That is a pure cost issue.

***Graham Taylor:*** On the other hand with CCF you are running machinery over the whole site every 5 - 10 years, whereas with clearfell you only do it once in every 15 years.

***Maurizio:*** I accept the argument. I don't think we have done the homework yet.

***Ted Wilson:*** I would like to go back to your comment about form and its relationship to productivity. In your example you had a tree which had better form but was growing in the shade, so would it take longer to reach a certain volume?

***Andy:*** In the stands I am thinking about the trees are not growing in shade because the overall growing stock is down to quite a low level. None of these trees are growing underneath anything else, they may be

next door to a taller tree, but not underneath. There is a threshold of light these species require, and you do need a much lower basal area for oak and ash than for Douglas-fir.

***David Pengelly:*** a classic example of oak growing in diffuse light and having very good form is the succession you get with oak and beech coming into a birch site, and we are in that situation with a fairly low density of oak and beech coming in and remaining quite healthy with quite good form, so they are probably using diffuse light at that point very successfully.

***Andy:*** Yes, or not having too much light because the birch is actually reducing the amount of light.

***John Ducker :*** During the presentations this morning there seemed to be the underlying presumption that the ground was always level, and of course it isn't. I mentioned this to Paul and he showed me a very interesting diagram which indicates that if you take measurements on a 30% slope facing the south you actually get a higher intensity than you would on level ground, and by contrast on a north facing slope you get a much lower intensity. That is common sense, but it is quite fundamental I would have thought to the discussion.

***Rodney:*** It will affect the direct sunshine, and that will particularly have an effect on the temperature so that the south facing slope tends to be warmer on a sunny day than the north facing slope. But in terms of the diffuse light that we have been concentrating on quite a bit today, the diffuse light on the north side will be the same as on the south side. So in terms of reliable light levels, the north side should not be that much different from the south side. But I am open to being contradicted.

***Mathias:*** There are graphs showing those sorts of light level differences, with 50% more total light if the slope is facing south.

***Rodney:*** But the difference is in the direct light.. It is not in the diffuse light, which will be the same. The diffuse light is all you have for more than 50% of the time in southern England and anything up to 75% of the time in the Highlands of Scotland. It is what the trees are geared up to using and can use most efficiently, as we have seen on some of the graphs this morning. If I were to go out on a site on an overcast day and I didn't know which was north, I don't think I could tell whether that site was on a north or south facing slope from the behaviour of the trees.

***Mathias:*** There is a fundamental difference because of the projection effect. If you face a basal area directly towards the sun and then turn it so that it is at an angle to the sun, you are spreading the amount of radiation that is arriving over a larger total area. So in terms of the total amount received you will reduce it by having a north facing as opposed to

a south facing slope. But you are right, the diffuse element will average out so if it is important how much diffuse light you are getting you are still going to get the same proportion of diffuse because it comes from everywhere, but the total amount of radiation will be reduced. For example if temperature is important, you will get a different temperature.

***Rodney:*** It seems to me that a south facing slope, on a thin soil particularly, will be more drought prone than a north facing slope because it gets the direct sun which will dry it out, and it may be that the trees will actually grow better on the north facing slope because they get enough diffuse light to grow and they are not under such moisture stress. But if you are somewhere where it is very cold then the south facing slope might be useful because it will increase the length of the growing season. So it is not a simple matter.

***Questioner***: If you have the same basal area on a north facing slope and on a south facing slope on the same soil type, you always get far more regeneration on the north slope. So there must be another element coming in which, as you say, is moisture.

***Andy:*** This is clearly demonstrated in the classic selection stands at Couvet in Switzerland. Series 1 is on the north facing slope, and Series 2 is south facing, and the north facing has higher productivity, less beech and more silver fir, and generally more production. It is moisture stress which is the limiting factor for the silver fir.

***Maurizio:*** That will come into effect further south where there is a larger proportion of direct light. What Rodney said is correct, but obviously in the UK there is a gradient due to how much cloud cover there is, and of course it is never cloudy 100% of the time. I wonder how important the fraction of cloudless skies is. Yes, trees are more efficient, they use diffuse light, and we have less direct radiation than we have diffuse light, but those fine days may turn out to be significant.

***Rodney:*** But on a sunny day there is more diffuse light as well. If you are on the north side of a hill and it is a sunny day, you might not get much direct sunshine, but you will be getting quite a lot of diffuse light because it is a bright day.

***Paul:*** It is not an either/or. Light doesn't suddenly become direct. Even if you look at diffuse light, it is still centred around the sun, there is a continuum.

***Questioner:*** I was going to ask about the impact of light on seeding. You mentioned three issues with light at the beginning of this session and I have been wondering whether there are things we could be doing to manipulate light levels for seeding in species. A classic is the shelter seeding felling they have been doing in France, but I don't know how

much that goes on in the UK and how much of it just happens by accident. Is there some contribution on the light issue that can inform us, and assist us with seeding, to say kick-start seeding and regeneration?

***Andy:*** I am dealing with fertile soils. On infertile soils it is a different case. If you over-open on fertile soils using the shelterwood approach you are in big trouble. It is also very difficult logistically to time good seed years with intervening across all the relevant areas.

Other factors are also involved; I have started for the first time to get extensive Norway spruce regeneration in 45 year old stands. It doesn't seem to be directly related to light because it also seems to be affected very much by the vegetation characteristics and it seems to me it is to do with heat as well. The two are linked to a certain extent, but it is quite noticeable with ash, for example, that so long as you have got reasonably open vegetation it is alright, but the spruce seems to be concentrated in the very bare areas. If there is grass around it (not dense mats but reasonably open) it doesn't seem to occur. So I think for certain species there are temperature thresholds as well as light thresholds, which are really linked, but what do other people think?

***Rodney:*** The tops of the trees have always got plenty of light so you can't give the ones that are going to be producing the seed more light than they have got already, but I would think vigorous large individuals would be more likely to seed than if they were overcrowded.

***Phil:*** Seed production is really a combination of circumstance, and depends on time of frosts, droughts and these sort of things. I think that, to a large extent, determines seed years, not the way you manipulate canopies.

***Paul:*** Although open grown parkland trees do have a habit of seeding more than forest trees.

***Phil:*** That is right, but they have a big crown and so have more disposable carbon and can put that towards seeds far earlier on than a tree which is struggling just to build itself because it is having to compete with other trees round about it. That would be the determining factor there.

***Mathias:*** Isn't that a function of the management as well?

***Phil:*** It is, yes,

***Maurizio:*** Changing the density of the stand might not necessarily change the total seed crop produced in a seed year. The individual tree would produce more, so there would be a compensation up to some point,

and then it would start to decline significantly if you have thinned the stems too much.

***Andy:*** Most of the permanently irregular stands that we are trying to develop end up with the mature trees being isolated in the top of the canopy, with the pole stage elements distributed throughout the stand. In that situation I would have thought those isolated mature trees are likely to be optimised in terms of seed production. Whether it is more total seed than if you have more trees in a less irregular stand, I don't know. It is all about thresholds, isn't it. It clearly works under the French shelterwood system. They are taking closed stands and then over a relatively short time they are heavily thinning them and that seems to work, so I am not sure we can say that irregular stands are likely to produce more seed than shelterwoods necessarily. But control of the ground vegetation in shelterwoods in the fertile south of this country is a big problem.

***Maurizio:*** Is there a feeling that seed production is potentially a limiting factor in continuous cover?

***Andy:*** I don't think so.

***Rodney:*** We don't want too many seeds.

***Andy:*** I am always talking about permanently irregular stands but we have to remember that shelterwood systems exist. In terms of shelterwood versus permanently irregular and seed production, I don't think you can say that the latter are better than well managed shelterwood.

***Rodney:*** The problem comes with something like Norway Spruce, when you are wanting to commence your transformation, but it hasn't reached the stage where it is producing any numbers of seed.

***Andy:*** With Norway spruce you have a short period because seeding is only really starting at 45 – 50, and unless you have been pretty assiduous in removing all the big trees from age 20 the problem of them reaching 60 – 70 cm diameter plus is going to hit you. So you are going to have to keep taking the big ones out early so that you maximise the period for transformation, so it is not impossible.

***Andy:*** Is there one more question?

***Esmond Harris:*** You had an interesting conversation with me about moving towards some sort of tables for continuous cover equivalent to yield tables for main forestry, could you expand on it briefly?

***Andy:*** Phil Morgan, David Pengelly, Huw Denman and I have become involved in a CCF research network which was originally based at ENGREF, the major forestry university in France. It was an initiative established by some private French forest managers. They have set up a network of research stands with a wide range of measurement on a five year cycle. We have extended it into the UK at Stourhead (Western) and into Ireland. The focus is on more advanced stages of irregular stand development. We have dendrological individual tree information based on samples, which was the type of thing I was talking about. These stands are at least half way towards fully irregular conditions, and we think that the management is on the right path in terms of overall amounts of growing stock; we are recruiting regeneration and beginning to get the pole stage in the middle structure. It struck me that we could encourage Mathias to actually use those data with a view to exploring the light characteristics of various structures. We could then apply sensitivity analysis to different species mixtures etc, vary basal area overall, vary the stem frequency size and see what effect that had on light levels. We are all operating on basal area as a crude target parameter, but these sort of approaches might allow us to relate basal area to something more fundamental. I think that probably somewhere in these fundamental light measurements there is a figure that we could relate to all these different basal areas, structures and site types.

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