

Stream shading and UVB exposure

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Abstract

Small streams may be the only surface water environment in which mitigation of ecosystem damage by increasing UVB radiation may be possible. Most of New Zealand's streams were originally heavily shaded under native forest, and plantings of trees in the riparian (bank-side) zone can restore the shade and, consequently, many of the important habitat attributes of pristine streams – including low solar UVB exposure. Riparian planting of streams is widely advocated in New Zealand to restore shade and thereby prevent damaging high water temperatures and the growth of algae and 'weed' aquatic plants to nuisance levels (Rutherford et al. 1999). Such management action may be expected to have the important additional benefit of reducing UVB exposure of stream organisms.

Methods have been developed for measuring visible light exposure of streams, and for predicting future light exposure as riparian vegetation changes (e.g. with growth of trees planted in riparian zones). Although light exposure of a site can be characterised by long-term light-logging, the best approaches use fish-eye optics to project the upper hemisphere as a circular image onto a horizontal surface (Davies-Colley & Payne 1998). Fish-eye images permit shading elements, including stream banks and hills as well as riparian vegetation, to be surveyed in relation to the sun path and the light scattered from the sky.

A very useful general index of (visible) light exposure is DIFN (DIFfuse Non-interceptance), defined as the light received at a (partially shaded) site as a proportion of that incident (i.e., received at an open site) (Davies-Colley & Payne 1998). This is very similar to the proportion of light received under an overcast sky – which closely approximates uniform lighting. Indeed, measurements of visible light under overcast conditions with cosine-corrected sensors may be used to estimate DIFN directly (Davies-Colley & Payne 2000). DIFN can be modelled for simplified shade geometry along streams, and a system of nomograms has been prepared from such modelling, giving DIFN as a function of the ratio of canopy height to stream channel width or to canopy gap in the forest (Davies-Colley & Rutherford 2001).

DIFN has been found to be a fairly good estimator of light exposure averaged over fairly long periods (e.g. a day or a year) or extensive space (e.g., a stream reach or a riparian forest stand) (Davies-Colley & Payne 1998, Davies-Colley & Quinn 1998). Obviously DIFN does not estimate light exposure of a point at any instant – at least not under clear sun conditions. Plant leaves are, of course designed to capture visible light, and they are also

rather efficiently absorbing of UVB, so the interceptance of a plant canopy is similar in the UVB and visible range. Because UVB is even more diffuse than visible light, DIFN is probably an even better general index of UVB exposure averaged over space than it is of visible light.

However, theoretical considerations and some experimental work (Flint & Caldwell 1998) suggest that DIFN may not be so good an index of time-averaged UVB exposure (e.g., of a point in a stream) as it is of spatially-averaged UVB exposure (e.g. of a stream reach). This is because UVB irradiance is strongly peaked around solar noon, which results in the UVB dose (as a proportion of that in the open) exceeding DIFN under clear conditions – owing to the higher canopy transmittances at high solar altitudes near solar noon. The bias is probably negligible in small streams, say < 5 m width, but may become more of an issue in larger streams (i.e. those with a canopy gap over the channel that admits direct sunlight at high solar altitudes, Davies-Colley & Quinn 1998).

A study of the UVB climate of streams is planned at NIWA-Hamilton, in tandem with studies on UV tolerance of keystone stream organisms.

References

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