Geophysical Research Abstracts, Vol. 9, 06453, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-06453
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A comparison of forest and moorland stream microclimate, heat exchanges and thermal dynamics

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Several Scottish forestry and fisheries pressure-groups are promoting changes in riparian woodland management (particularly natural forest regeneration) to improve river thermal habitat for salmonids. However, the scientific basis for such management decisions is limited. To address this research gap, this paper provides a detailed comparison of stream microclimate, heat exchanges and thermal dynamics between a semi-natural forest and moorland (no riparian tree cover) reach of a Cairngorm stream, northeast Scotland. The study aims research are: (1) to characterise the nature and dynamics of stream microclimate, heat exchanges and thermal dynamics at the seasonal to inter-annual time-scale for both locations, for the 2003 and 2004 calendar years; (2) to compare results between a forested and moorland stream reaches; and (3) to explain temporal patterns and spatial differences with reference to meteorological and hydrological drivers. The two year data set affords a considerably longer-term perspective than previous river energy balance studies (normally confined to weeks); hence, the paper focuses upon seasonal to inter-annual time-scales rather than diurnal fluctuations.

Mean daily water column temperature was warmer for the moorland than forested reach, with daily minimum warmer (cooler) in spring and autumn-winter (summer). Maximum daily water column temperature is warmer for the moorland reach with greater differences in summer. In terms of riparian microclimate, mean daily air temperature is slightly cooler, relative humidity is lower and wind speed is increased for the moorland compared with the forested reach. Net radiation is greater for the moorland reach (except during winter) due to shading of solar radiation and emission of

longwave radiation by the forest. Sensible heat is lower (except during winter) and latent heat is almost invariably lower for the moorland than forested reach, both due to greater wind speeds. Total energy at the air-water interface is higher for the moorland than forested reach in summer but lower during winter. Streambed heat fluxes are smaller than those at the air-water interface, especially for the forested reach. Between-site differences in bed heat flux reflect contrasting groundwater-surface water interactions, which alter bed thermal gradients and so extent/ direction of heat transfer. Heat from fluid friction varies in direct response to river discharge, being greater for the downstream forested reach. Total energy available (all exchanges) was greater in summer for the moorland than forested reach and generally lower in the other seasons.

These findings yield new insights into the dynamic heat exchange processes that drive stream temperature under semi-natural forest and heather moorland. These results highlight the importance of considering hydrological fluxes (i.e. groundwater-surface water interactions) as well as atmospheric energy transfers when researching stream temperature controls. This work is novel as almost all existing forest stream energy balance studies have focused upon coniferous plantation rather than near-native, mixed woodland. This research provides a scientific basis to predict stream thermal impact given advocated changes to forest practice (above); and it has potential to inform decision making by land/ water managers.