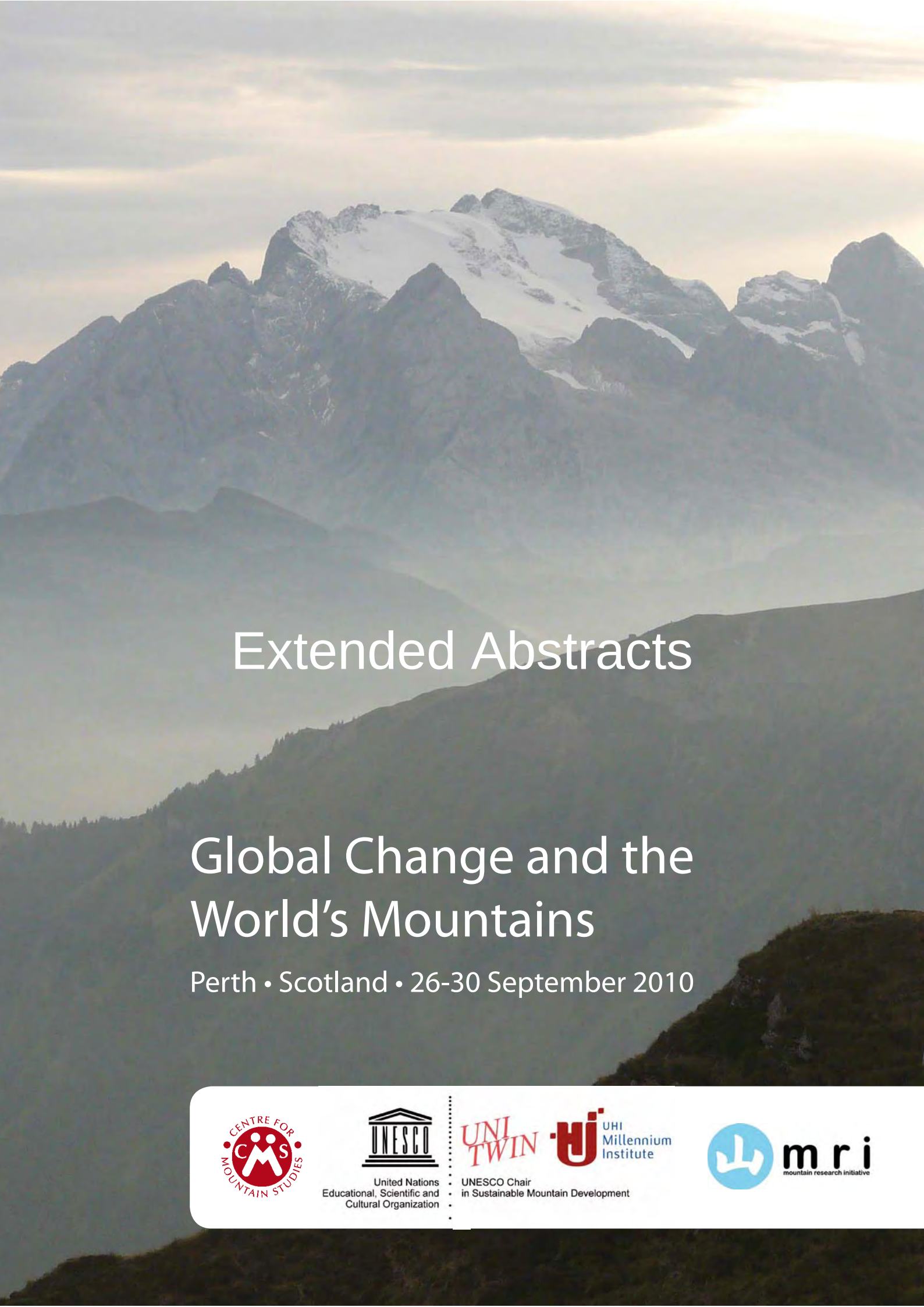

Extended Abstracts

Global Change and the World's Mountains

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Climate change and site-specific treeline ecotones dynamics on the Ural mountains

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Treeline is one of the climatic dependant boundaries, as is snowline, and the climate has been changing considerably since the 1830s in all parts of the Ural Mountains. Main alterations happened during cold season, when temperature gradually increased on 1.8-2.5°C and precipitation fluctuated with maximums in 1890-1920s and 1970-2000s. Summer temperature grew on 0.2-1°C, essentially due to changes in June which led to the prolongation of vegetative season by 3-7 days. Summer precipitation gradually raised 15-25%.

In this study, we have investigated how treeline ecotones in untouched areas of the Ural Mountains have changed during the last centuries by comparing 450 historic and contemporary photographs and by determining the tree age structure of 16 altitudinal gradients in the South, North, Sub-Polar and Polar Urals (the ages of more than 9000 trees were determined). In these four regions, the photographical analyses indicated that, in general, the boundaries of the open forest with sparse trees (cover>20%) and of the closed forest (cover >50%) have expanded by 20 to 80m in altitude and 200 to 600m in horizontal distance during the last century. Comparison of age structure on different sites has shown that beginning, course and intensity of changes depends considerably on average snowpack depth.

Thus, on wind-sheltered sites with thick snow cover, the active establishment of trees started simultaneously within all altitudes of modern treeline ecotone in the 1830s, reaching a maximum around the 1900s and stopping in the 1960s. However, on the sites of South and North Urals the dominant species was *Picea sibirica*, while on Sub-Polar and Polar, it was

Larix sibirica and *Betula pubescens* ssp *tortuosa*. On sites with medium snowpack, trees appeared in the middle of the XVIII century, but active regeneration started in the low part of the ecotone in 1880-1910, the middle part in the 1930s and the upper part in the 1970s. Larch dominates here on all regions except South Urals, where spruce prevails. On wind-swept sites with shallow snow-pack, trees appeared at the end of XIX century but intensive establishment began in the low part of the ecotone in the 1950s, in the middle part in the 1970s and has only just begun now in the upper part. Larch is also dominant here, but on the upper parts of the South Urals, birch prevails. During the 20th century, the dominant growth form of trees changed from multi-stem trees that had adapted to harsh winter conditions to single-stem trees, while 87, 31, and 93 % of the stems appearing before 1950 were from tree clusters with several stems in the South, North and Polar Urals respectively.
In a global meta-analysis, Harsch et al. (2009) found that treelines have advanced more strongly when they have experienced higher winter than summer warming, and explained this pattern by an amelioration of harsh winter conditions. Kullman & Öberg (2009) observed on Scandes that treelines reach higher altitudes in snow-rich regions and treeline changes during the last century have been strongest on wind-protected and concave slopes, suggesting that snow conditions are at least an important co-driver for the treeline advances. Supporting this idea are the increases in shrub abundance in Northern Alaska, mainly related to a positive feedback between increases in snow fall and plant growth: higher snow packs lead to higher soil temperatures, thereby increasing nutrient availability and plant growth which in turn promotes the accumulation of more snow. Climate reconstructions and instrumental records indicate that precipitation in the Northern Hemisphere has increased during the last millennia and within the last century (New et al., 2001), implying that forest-tundra ecotones have received more snow in the recent past. Obtained results point out the importance of cold season conditions for spatio-temporal dynamics of treeline ecotone and the necessity of a new approach formation for the investigation of these phenomena.

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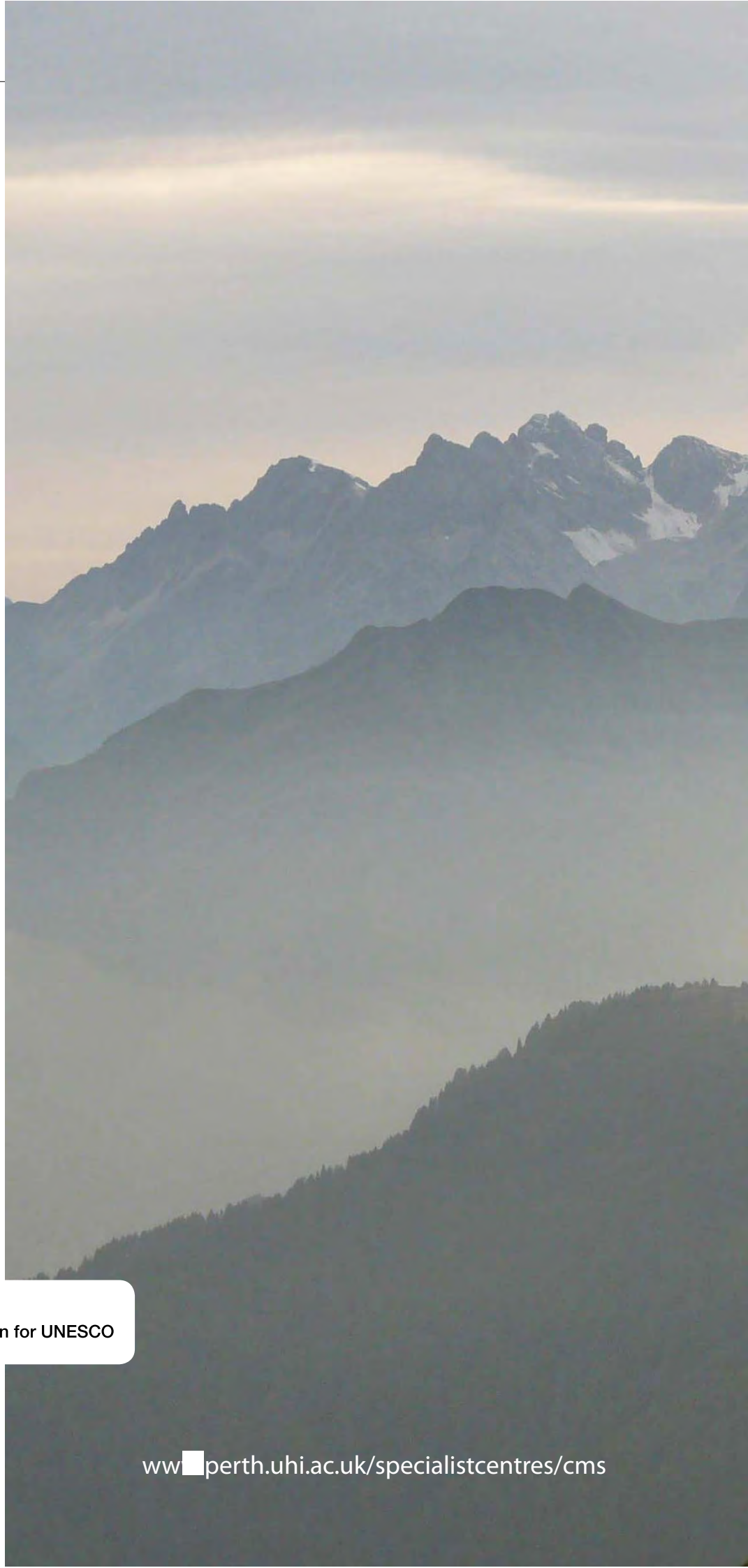

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