Investigation of Forest Canopy Temperatures Recorded by the Thermal Infrared Multispectral Scanner at H.J. Andrews Experimental Forest

Steven A. Sader

NASA - Earth Resources Laboratory
National Space Technology Laboratories

Thermal Infrared Multispectral Scanner (TIMS) data were collected over the H.J. Andrews Experimental Forest in Western Oregon on July 29, 1983 at approximately 1:30 p.m., Pacific Standard time. Canopy temperatures recorded by TIMS were nearly equal to maximum daily air temperature recorded at eight reference stations. The objective of the investigation was to relate changes in canopy temperature to green leaf biomass levels in reforested clearcuts and old-growth forest. A digital data base was generated in order to isolate that portion of the thermal emission that could be attributed to surface properties (i.e., sun angle effects) other than the vegetation biomass component.

An analysis of variance were performed on the 10 meter data using a randomized complete block design. The null hypothesis was tested: no temperature differences occur between age classes, aspects, or slope gradients. Age classes were used as blocks and the F test revealed that age class and aspect were highly significant but slope and aspect-slope interaction was nonsignificant. Response curves of aspect plotted by slope class for each age class indicated that age class 1 (0-12 years) and age class 2 (13-25 years) were contributing most of the variability in ERT related to terrain positions. The terrain had little effect on ERT for age class 3 (25-33 years) and age class 4 (old growth). The effect of aspect within age class 1 and 2 were tested using single degrees of freedom for each aspect sum of squares. In age class 1, the north aspect had significantly different mean ERT (@ .01 level) from the east,

south, and west aspects. The south aspect in age class 2 was highly significant and north, east and west aspects were nonsignificant.

ERT differences corresponding to aspect and slope variation in age class 1 and 2 may be attributable to the amount of green leaf area and canopy closure present in the sensor field of view. Differential heating and cooling related to sun angle had a greater influence on ERT recorded by TIMS when forest canopies were not completely closed. As the forest matures and the canopy closure and green leaf area approaches maximum, the influence of surface emittance below the canopy contributes less to the total return. This may explain why aspect and slope variation appeared to have little effect on ERT in the older age classes. Near maximum canopy leaf area at H.J. Andrews may occur at around 25 to 30 years on sites replanted to Douglas-Fir.

The TIMS appears to be capable of detecting subtle differences in ERT as related to canopy closure and green leaf biomass, however calibration techniques are needed to correct for emissivity and atmospheric effects. Calibration techniques are the subject of other investigations at the Earth Resources Laboratory in Mississippi. The capability to record surface temperature remotely may become a valuable research tool for forest climatology and hydrology studies where estimates of evapotranspiration rates, plant-water stress and nighttime energy budgets are difficult to measure accurately for large land areas.