Seasonal comparison of soil temperature and moisture in pits and mounds under vine maple gaps and conifer canopy in a coastal western hemlock forest

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Gap size determines whether a gap will have an environment much different from that of the closed canopy forest; small gaps in either tall or open canopies can have little effect (Pickett and White 1985). As opening size decreases, temperatures remain more constant (Geiger 1965).

Some canopy openings in coastal temperate forests contain the hardwood species vine maple (*Acer circinatum*), and some vine maple gaps show no evidence of having been formed by treefall (Spies et al. 1990; McGhee 1996). In some of these gaps, vine maple has been persistent since the time of stand establishment, resisting the regeneration of taller canopy dominants and subsequent canopy closure (McGhee 1996). These persistent openings in the forest canopy, which are not created by treefall, have been called priority gaps (McGhee 1996). It is thought that priority vine maple gaps originate when vine maple colonizes a site first, and establishes a dense mat of stems early in stand development that is large enough to prevent the subsequent regeneration of the sites by conifers and resists canopy closure

Table 2. Mean soil and air temperatures, throughfall rates, moisture contents and depths to the groundwater table in four seasons in vine maple gap and conifer canopy sites and in pit and mound microsites. Results (*P* values) of analysis of variance testing for effects of site type (vine maple gap or conifer canopy); microsite type (pit or mound) and site type × microsite type on climatic parameters in four seasons

	Mean values				*P* values		
	Gap pit	Gap mound	Canopy pit	Canopy mound	Site type	Microsite type	Site type × microsite type
Midday air temperature (ºC)							
Winter	5.03 (0.25)[z]	5.00 (0.22)	4.93 (0.23)	4.86 (0.20)	0.22	0.16	0.52
Spring	12.02 (0.69)	12.04 (0.61)	12.17 (0.60)	12.24 (0.49)	0.10	0.35	0.55
Summer	16.67 (0.55)	16.75 (0.61)	16.810	0.38 BT /F8 1 Tf(0.16)((0.20))-3721(0.5Tw (microsf5 Tw-7611(16.67n2*te)-6.7			
Gap	**GapWi9188 (0.25)Spring81TD 0 [(Gap)-7334(Gap)-46Tr5(**	**3T41T* 595f -7 0.8 448-7081cmTw8T* 597 0 (ga46 4503 644 Tm 3T41T* 595f -93a46 4**					

conifer sites as whole plots, and pit and mound microsites as sub-plots. We tested for the effects of site type, microsite type and the interaction of site type and microsite type using the following model:

$$Y_{ijkl} = u + B_i + S_j + M_k + SM_{jk} + e_{ijkl}$$

where Y is a measure for the lth experimental unit in the ith block, jth site type and kth microsite type; u is the mean; B is block (paired plots; i = 1, 2 ...6); S is site type (gap/canopy factor; vine maple gap or conifer canopy; j = 1, 2); M is microsite type (pit/mound factor; pit or mound; k = 1, 2) and e is random error within site type × microsite type combination. Unfortunately, the power of the statistical tests is likely to be relatively low due to small sample size, small effect size, and the high within-plot sample variability (Toft and Shea 1983). For each time period, Pearson correlations were used to investigate relationships between the environmental parameters and the expanded gap size for vine maple gaps, between the environmental parameters and site characteristics (slope, aspect, elevation) for all plots, and among the environmental parameters for all plots. Bonferroni adjusted probabilities were used to allow for multiple tests (Wilkinson 1996).

RESULTS

Midday Air and Soil Temperature

No significant differences were found in air or soil temperature between vine maple gap sites and conifer canopy site types in any season (Table 2, Fig. 1). There were lower air temperatures in the spring (P = 0.10) and summer (P = 0.11) and higher air temperatures in the autumn (P = 0.21) and winter (P = 0.22) in the vine maple gap plots as compared with the conifer canopy plots (Table 2).

Air temperature was significantly lower in the pit microsite as compared with the mound microsite in the summer and it was higher in the pit microsite in the winter (*P*

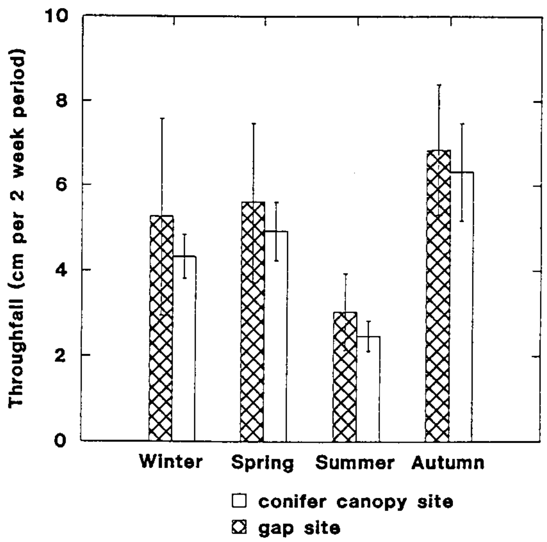

Fig. 2. Seasonal mean throughfall values in vine maple gap and conifer canopy sites. Data are pooled for pit and mound microsites to compare gap and canopy sites and for gap and canopy sites to compare pit and mound microsites. Error bars represent one standard deviation from the mean. *, ** Significantly different value for a property between site types, or between microsite types at $P < 0.05$ and $P < 0.01$.

Throughfall and Soil Moisture Content

There were no significant differences in throughfall amounts between vine maple gap and conifer canopy plots in any season. However, throughfall amounts were higher in vine maple gap plots as compared with conifer canopy plots in all four seasons (Table 2, Fig. 2.).

There were no significant differences in soil moisture content at any of the three depths measured (30, 50 and 80 cm) between vine maple gap and closed canopy plots (Table 2, Fig. 3). The moisture content at 30 cm depth was higher in the pit microsites as compared with the mound microsites in the autumn (P = 0.16) and winter (P = 0.12) (Table 2). Soil moisture content was significantly higher in the pit microsite as compared with the mound microsite at both the 50 and 80 cm depths in all four seasons (Table 2, Fig. 2).

The larger the expanded gap the greater the amount of moisture received as throughfall in the spring (r = 0.75, P = 0.04) and summer(r = 0.70, P = 0.08)). Soil moisture values were not significantly related to expanded gap size in any of the time periods. Southeasterly facing sites had higher soil moisture values at the 30 cm depth than northeasterly facing sites in the summer. The moisture contents at the 50 and 80 cm depths were negatively correlated with the depth to groundwater table in the winter, spring and autumn (r values range from –0.63 to –0.77, P values range from <0.001 to 0.02).

Depth to Groundwater Table

The groundwater table was significantly shallower in the summer and was shallower in the spring (P = 0.17) and autumn (P = 0.27) in vine maple gaps as compared with the conifer canopy plots (Table 2, Fig. 4). The groundwater table was significantly shallower in the pit microsites as compared with the mound microsites in all four seasons (Table 2, Fig. 4). Sites with steeper slopes had deeper depths to the groundwater table in the winter (r = 0.57, P = 0.08), spring (r = 0.61, P = 0.03) and autumn (r = 0.61, P = 0.03).

DISCUSSION

Influence of Vine Maple Gaps on Soil Temperature and Moisture Status

MIDDAY AIR AND SOIL TEMPERATURE. Since the vine maple gaps which we studied have a lesser amount of biomass per unit area than the surrounding closed canopy forest, we expected light intensity to be higher and consequently midday air and soil temperatures to be higher in the vine maple gaps than in the closed canopy forest. No significant differences in midday air or soil temperature between vine maple gaps and the closed canopy forest were found.

In treefall gaps in tropical forests (Denslow 1987) and temperate forests (McGee 1976; Ash and Barkham 1976; Pontailler 1979), canopy openings were found to have higher light intensities, and higher air and soil temperatures than the surrounding closed forest. It would appear that the vine maple gaps behave differently than treefall gaps with regards to air and soil temperature regimes.

A number of factors may help to explain the lack of significant differences in air and soil temperatures between vine maple gap and closed canopy forest. Counter to what one might expect, light intensity may not be greater near the ground surface in vine maple canopy gaps than in the conifer canopy forest (McGhee 1996). Using hemispherical photographs taken at 1.3 m above the ground in midsummer, McGhee (1996) found no significant differences in total incoming solar radiation in vine maple gaps as compared with conifer canopy plots. This result suggests that vine maple foliage may create essentially the same light environment that a closed canopy of conifers creates. The lack of differences in the amount of solar energy reaching the forest floor in vine maple gaps and the conifer canopy forest may partially account for the lack of differences in soil and air temperature between these site types.

The relatively small size of the vine maple gaps may also partially account for the lack of significant differences in midday soil and air temperature. The D/H ratios (gap diameter to height of the surrounding canopy) for five of the vine maple gaps were quite low (0.10–0.23) while one of the gaps had a relatively high ratio of 0.35. Canham et al. (1990) found that, because of low D/H ratio (approximately 0.15), single-tree gaps in old-growth Douglas-fir/western hemlock forest in Oregon had little effect on understory light regimes. They found that in four other forest types (northern hardwoods, spruce-fir, southern hardwoods and tropical rain forest) the D/H ratios of single-tree gaps were higher (approximately 0.30 to 0.39) and resulted in significant overall increases in understory light levels. In very small gaps, the development of extremes in surface temperatures is hindered by shade from surrounding trees (Smith 1986).

Evapotranspirational cooling may partially explain the finding of a non-significant trend towards slightly lower air

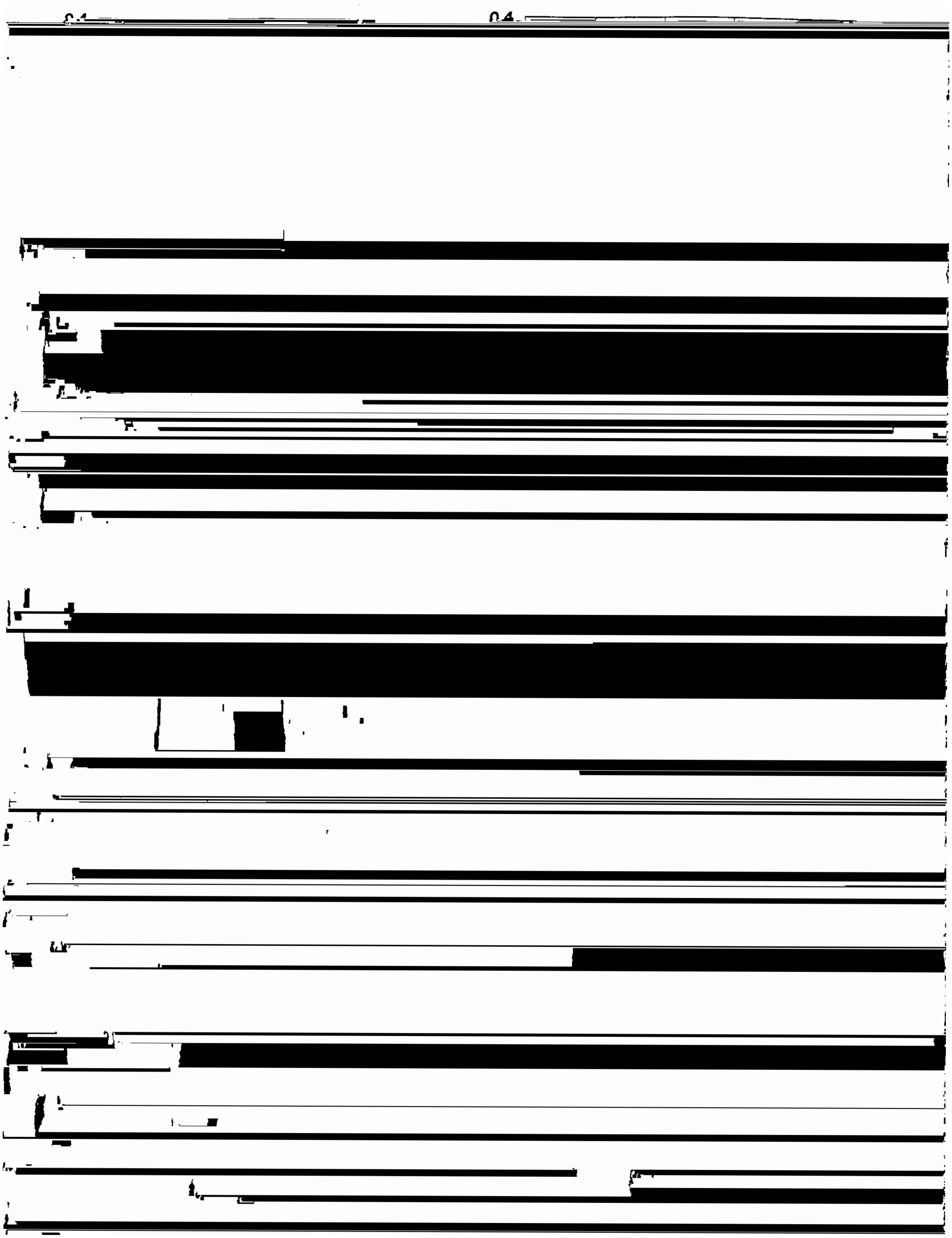

Fig. 3. Seasonal mean soil moisture contents at 30, 50 and 80 cm soil depths in vine maple gap and conifer canopy sites, and in pit and mound microsites. Data are pooled for pit and mound microsites to compare gap and canopy sites and for gap and canopy sites to compare pit and mound microsites. Error bars represent one standard deviation from the mean. *, ** Significantly different value for a property between site types, or between microsite types at $P < 0.05$ and $P < 0.01$.

temperatures in vine maple gaps compared with the conifer canopy forest in the summer. The lower mean seasonal midday air temperatures in gaps in the summer may be due to high transpirational demands of vine maple at this time of year, as observed by Drew (1968), leading to cooler air temperatures.

Midday air and soil temperatures in vine maple gaps were related to expanded gap size: mean seasonal air temperatures were significantly higher in larger gaps than smaller gaps in the summer; and mean seasonal surface soil temperatures were significantly higher in larger gaps than smaller gaps in the spring and summer. The effect of expanded gap size on air and soil temperatures was consistent with the observation of Smith (1986) who notes that the development of extremes in surface temperatures in and around gaps is hindered by side shade; whereas, in larger gaps environmental conditions are similar to conditions in larger cleared areas. The results are also consistent with those of Denslow (1987), who found that in a tropical forest differences between gap and understory light levels were lower in small gaps than in large gaps, and of Canham et al. (1990), who found that in an old-growth forest in Oregon as gap size increased, the mean and range of light levels within gaps also increased.

Mid-day soil temperature was positively correlated with moisture content at 50 and 80 cm in the winter and at 30 and 50 cm in the autumn. The high specific heat of water accounts for its moderating influence on soil temperature in

trees (Canham et al. 1990). Vine maple foliage may have a significant moderating effect on soil temperature and moisture status. It is possible that there were significant differences between vine maple gaps and the surrounding conifer forest that were not detected due to low power of the statistical tests associated with small sample size (Toft and Shea 1983). Further research, therefore, with a larger sample size may be warranted.

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