THE EFFECT OF SUMMER THUNDERSTORMS ON THE NEAR-GROUND TEMPERATURE REGIMEN WITHIN A SUBURBAN FOREST

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ABSTRACT

Recording three-point thermographs were used to gather time-series data on a 24-hour basis on the near-ground temperature regimen in a suburban deciduous forest and in a storm-created opening within the forest. Preliminary analysis of the data revealed a definite and well-defined near-ground temperature pattern occurring during intense summer thunderstorms. The preliminary analysis further suggested that differences in temperature between the daily maximum temperature and the post-storm re-stabilization temperature might be meaningful indicators of environmental differences between the two experimental areas and between the above-ground heights within each area. Detailed analysis of such difference values suggested considerable variation in individual storm influence on near-ground temperature patterns, and further suggested that we could differentiate on a thermal basis between the storm-created opening and the shaded areas, as well as between different near-ground heights (25 and 75 cm). Possible consequences of these differences for the extant biological community are discussed.

INTRODUCTION

In the course of evaluating time-series data on the micro climatic regime of a small (375 m²), naturally-created opening within a mature suburban deciduous forest, our attention became focused upon the magnitude and pattern of near-ground temperature variation during the course of summer thunderstorms. Our comprehensive review of the ecological, meteorological, and micrometeorological literature revealed a void of information on micrometeorological parameters during thunderstorm activity within the area of the Eastern Deciduous Forest of the United States. Since our data consisted of continuously recorded temperature variations at various levels (as well as ground-level solar radiation) under the canopy and within a clearing of a mature Piedmont forest, we decided to subject the temperature data to a detailed analysis for type and magnitude of changes which occur during summer thunderstorm activity.

The Atlanta, Georgia, metropolitan area—and the southeastern Piedmont in general—is an area in which the summer weather pattern is characterized by locally intense mid-afternoon thunderstorms of relatively short duration (generally < 1 hour). Our observations of the pattern of these storms revealed that they typically induce a variation in local air temperature similar to the pattern depicted in Fig. 1. In general, a gradual rise occurs in air temperature toward a daily maximum which is reached sometime after solar noon (stage 1, Fig. 1). Immediately prior to the onset of precipitation a slight but rapid increase occurs (seldom as much as 5°C) in air temperature (stage 2, Fig. 1)—a "prefrontal temperature peak." With the onset of precipitation and the consequent atmospheric cooling there is a rapid, oftentimes precipitous drop in ambient air temperature (stage 3, Fig. 1). As the storm passes, air temperature will reach a post-storm minimum (stage 4, Fig. 1) and will re-equilibrate to a relatively stable level slightly higher than the post-storm trough but several degrees cooler than the daily maximum prior to the thunderstorm's onset (stage 5, Fig. 1). Since each major summer thunderstorm followed this general pat-
tern with differences only in magnitude, the various stages or phases provide only a manageable example of data comparison
differentiation.

**METHODS**

**Study Area**

The study area, located in metropolitan Atlanta, Georgia, (33°44'N, 84°19'W), is a suburban Dekalb County woodland
area located in the Georgia Piedmont. The forest has been described
previously (Skaen, 1974) as a relatively mature hardwood
woodland dominated by Liriodendron tulipifera, white oak (Quercus alba), hickory (Carya spp.), American bass
(Fagus grandifolia), and red oak (Quercus rubra) species. There were
trees of various heights present in the forest, and the forest floor
was covered with a thick layer of leaf litter and other decaying
organic materials. The understory was composed of a variety of
herbaceous plants, including species such as ferns, mosses, and
mushrooms.

**Data Collection and Experimental Design**

Near-ground temperature data were continuously monitored and
recorded on a 24-hour basis by means of two three-point
thermocouples (Weathertronics, model 8005-32), one with sensors
located within the canopy and the other with sensors located at
a height of 1.5 m above the forest floor. The recording heads of
both instruments were housed in a single standard U.S. Weather
instrument type D-008 enclosure (Weathertronics MBD-10). All
sensors were calibrated at 0°C using an air calibrator. Open area
areas were shaded from direct solar radiation by weather vane
shaded shadecloth. In both open and closed areas, sensors were
mounted at three heights: (1) 25 cm above the forest floor, (2) 25 cm at
the forest floor, and (3) between 25 and 30 cm above the forest floor.

**Criteria Utilized in Selecting Thunderstorms for Evaluation**

To be considered for inclusion in the analysis, thunderstorms were
required to conform to several criteria: (1) They had to occur
long enough after solar noon that a daily maximum temperature
would have been established; (2) They had to occur sufficiently
before day's end and be of short duration that the reactivation/relaxation phenomenon would not be
masked by the normal atmospheric cooling of nighttime; and (3) They had to be observed
sufficiently to produce a statistically significant and clear
movement. Nine storms occurred between June 1 and August 28, 1974, which met these criteria. Consequently, data
for nine storms were included in the analysis.

**Effect of Summer Thunderstorms on Near-Ground Temperature Regimes**

**TABLE 1: Summary of preliminary analyses (paired t-tests) for three different classes of

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean</th>
<th>Standard Deviation</th>
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<tbody>
<tr>
<td>Canopy</td>
<td>1.84</td>
<td>3.04***</td>
</tr>
<tr>
<td>Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diff</td>
<td>Pre-storm peak temperature and post-storm peak temperature</td>
<td>2.56**</td>
</tr>
<tr>
<td></td>
<td>Daily maximum temperature and post-storm peak temperature</td>
<td>3.20**</td>
</tr>
<tr>
<td></td>
<td>Daily maximum temperature and post-storm re-stabilization temperature</td>
<td>10.02***</td>
</tr>
</tbody>
</table>

1. a) all analysis classes with 17 degrees of freedom
2. b) all analyses excepted to 17 degrees of freedom
3. c) statistically significant at P < 0.05 level
4. d) statistically significant at P < 0.01 level
5. e) statistically significant at P < 0.001 level

**FIG. 2: Mean differences between mean maximum and mean re-stabilization temperatures for both

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean</th>
<th>Standard Deviation</th>
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<tbody>
<tr>
<td>75 cm from soil surface</td>
<td>2.08</td>
<td>6.19, 1.44 ± 0.53</td>
</tr>
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temperature inversions. Soil temperature values were likewise used to determine weekly averages and differ-
ce between 2 cm (A) and 20 cm (Aa) horizons.

Getz (1961), also working in Michigan, obtained maxi-

mum and minimum temperatures on an alternate-day basis at 2 cm (A) and 20 cm (Aa) horizons.

Consequently the temperature regimen of ground-level residents, plant or animal, would be considerably medi-
ated by proximity to the soil system while the above-
ground environment is increasingly more variable, even at those near-ground levels, as the distance from the soil is increased. Whether these detectable differences in the near-ground physical environment are of suffi-
cient magnitude to measurably affect the extracted biological community remains to be demonstrated by a separate series of well-defined and closely controlled studies.

ACKNOWLEDGMENTS

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ERDA ANNOUNCES PROCEEDINGS OF 2ND THERMAL ECOLOGY SYMPOSIUM

The Energy Research and Development Administration in Oak Ridge has announced the release of Thermal Ecology II, which includes manuscripts and proceedings of the 2nd annual meeting which was sponsored by Savannah River Ecology Laboratory, University of Georgia and ERDA.

The book is available as CONF-750425 for $11.00 from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.