I. Prescribed Burn Activity at Fort Benning

The last two prescribed burns of FY03 were conducted this month with 549 acres, see Table 1, amounting to a total of 28,816 acres, which is about 31% of the total managed land on the installation.

### Table 1: Prescribed burns conducted in Training Areas (TA), with location (distance and direction) relative to Oxbow Meadows Environmental Learning Center (OLC), for May 2003.

<table>
<thead>
<tr>
<th>Date</th>
<th>TA</th>
<th>Burned acres</th>
<th>distance km</th>
<th>dir from OLC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/13/03</td>
<td>A-7-A</td>
<td>298</td>
<td>8.5</td>
<td>111 ESE</td>
<td>31</td>
</tr>
<tr>
<td>5/28/03</td>
<td>W-2-A</td>
<td>251</td>
<td>8.5</td>
<td>201 SSW</td>
<td>31</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>2549</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Summary of average meteorological and air pollutant quantities for the individual burn days, separated for the morning pre-burn conditions, the afternoon flaming stage (yellow), the evening smoldering stage (orange), and the nocturnal post-burn (purple) and potential plume impact stages (grey).

<table>
<thead>
<tr>
<th>Burn Day</th>
<th>Start Info</th>
<th>Stop Info</th>
<th>T</th>
<th>RH</th>
<th>WS</th>
<th>WD</th>
<th>PM2.5</th>
<th>CO</th>
<th>NOx</th>
<th>NO</th>
<th>O3</th>
<th>CO/NOx</th>
<th>NO/NOx</th>
<th>CO/NOx slope</th>
<th>NO/NOx slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/12/03</td>
<td>6:00 12:00</td>
<td>6:00 12:00</td>
<td>19</td>
<td>77</td>
<td>1.5</td>
<td>2.2</td>
<td>319</td>
<td>8.9</td>
<td>8.9</td>
<td>9.6</td>
<td>0.9</td>
<td>249</td>
<td>4.6</td>
<td>0.9</td>
<td>27</td>
</tr>
<tr>
<td>5/13</td>
<td>0:00 6:00</td>
<td>6:00 12:00</td>
<td>20</td>
<td>72</td>
<td>1.5</td>
<td>2.2</td>
<td>319</td>
<td>8.9</td>
<td>8.9</td>
<td>9.6</td>
<td>0.9</td>
<td>249</td>
<td>4.6</td>
<td>0.9</td>
<td>27</td>
</tr>
<tr>
<td>5/14</td>
<td>0:00 6:00</td>
<td>6:00 12:00</td>
<td>20</td>
<td>72</td>
<td>1.5</td>
<td>2.2</td>
<td>319</td>
<td>8.9</td>
<td>8.9</td>
<td>9.6</td>
<td>0.9</td>
<td>249</td>
<td>4.6</td>
<td>0.9</td>
<td>27</td>
</tr>
</tbody>
</table>

6 June 2003

Study of Air Quality Impacts Resulting from Prescribed Burning (PB) on Military Facilities
Project #: 3506B24
School of Earth and Atmospheric Sciences, Georgia Tech
Sampling and Evaluation Period
May 1 to 31, 2003
Deliverable #: 10

1. Achievements for this period
Table 2 also lists the day before and after each burn for comparison; note, that 5/23 was a Tuesday, and 5/28 a Wednesday, so none of the listed days represents a weekend day. The highest NO/NOy fractions coincide with the lowest CO/NOy ratios during the 0600 to 1200 morning periods. For these periods the NO is most significantly correlated with NOy at a fraction between 30 and 53 %, indicating relatively fresh emissions. The CO/NOy ratios for these periods are not clearly indicating the sole influence from traffic sources, as this ratio varies between 12.9 and 21.6 for the highly correlated cases. The fact that the 0600-1200 periods cover the tail end of the rush hour peaks may also contribute to the larger ratios, as certain NOy species may be removed from the atmospheric boundary layer [esp. via surface deposition] more rapidly than CO. Typical CO:NOx emission ratios for mobile sources are 8 to 9. All data for periods with easterly component winds are tabulated in bold, and all of these periods were associated with CO/NOy ratios larger than what is typical for mobile emissions, possibly indicating a mixed influence from both mobile and biomass burning sources, also reflected by the mostly poor correlations. The top pollution levels occurred during the first half of the day, indicated in bold or red, under either calm conditions or predominantly easterly flow.

II. Overview and Regional Comparison of Measured Pollutant Quantities
This month was characterized by a record rain fall across the State. Only the last week of May saw drier conditions, with PM$_{2.5}$ averages and O$_3$ maxima rising region-wide, as seen at all sites in Figure 1. The fine PM mass concentration appears again regionally distributed and homogenic as previously observed. Since precipitation is the most effective removal mechanism for atmospheric PM, the first three weeks showed regionally low [PM$_{2.5}$]. Significant increases occurred region-wide under increasingly clear skies and stagnant conditions on the 23$^{rd}$ and 24$^{th}$, here indicated by the increasing differences in daily minima and maxima ambient temperatures and relative humidities, combined with regionally low wind speeds.

The wind rose plots shown in Figure 2 compare average wind conditions and fine PM mass concentrations at Columbus with the greater region, i.e. Griffin, Macon, and Augusta. Topographic features that are specific for each site become apparent; e.g. the preferred wind directions at Augusta are from the W, NNE, and S, while Columbus–OLC receives most winds from SSW, SE and NW, the latter two represent the greater orientation of the Chattahoochee river basin. The Griffin site experiences the strongest winds with a general westerly component, while at OLC the strongest winds blow from NW. The Macon SBP site indicates no preferred wind direction and wind speed. Since the wind measurements are made between 7.5 m (at Augusta, Macon and Columbus sites) and 11.5 m above ground (Griffin site), the above features are indicative of topographic differences in the immediate surroundings of each individual site. Also, the 4 m difference in sensor height may be the reason for the systematically greater wind speeds observed at Griffin.

Despite the large differences in near surface air mass transport as indicated in the above wind rose plots, the PM$_{2.5}$ rose looks relatively uniform. All sites seem to be subject to higher average fine mass loadings from westerly directions, which is a distinct difference to last month, where highest average PM loadings were associated with more southerly directions. Columbus–OLC in particular does not show any wind directions with PM$_{2.5}$ concentrations that are distinctly higher than all other sites, which was the
case in April, when significantly larger amounts of biomass was burned (9145 acres compared to 549 acres in May). The information of the more regional distribution of fine mass is of significant importance for the interpretation of the data collected locally at OLC, as discussed in the following.

III. Observations at OLC

Figures 3 and 4 correlate individual species concentrations with each other and with time and boundary layer air mass flow.

![Figure 3: Scatter diagram for 30 min averaged [CO] and [NOy] at OLC during May 2003. The top graph is color-coded for wind direction, and size-coded according to the NO/NOy ratio (top right). The bottom graph is color-coded for time of day according to the legend (bottom right).](image)

As observed previously, the largest primary pollution levels (CO and NOy) are associated with northerly and south-easterly flows, and are highest during the calm early morning hours, i.e. most likely associated with rush hour traffic. In contrast to previous observations, however, the largest fine PM mass concentrations in May are associated with westerly and south-westerly flows, and follow a more regional pattern [see above], which corresponds to the relatively small amount of biomass burned on the nearby installation. The following evaluates the last 8 days of May, when the regional build-up in [PM$_{2.5}$] and ozone took place, in more detail.
Figure 4: Wind frequency distribution in % occurrence, wind speed rose in m/s and NO/NOy fraction in % (right), and main pollutant concentration rose for entire month of May (left). Note that wind speed and NO averages are multiplied by 2 and 5, respectively, for graphing purposes, i.e. for NW winds e.g. the average speed is ~2.5 m/s, and maximum NO average is ~1.5 ppbv; inversely, CO averages to ~250 ppbv for SE winds.
Figure 5: PCM flows, meteorological and air pollutants (30 min) data collected continuously at OLC during the last eight days of May; prescribed burning of 251 acres was conducted on the 28th, 8 km to the SSW, depicted by the yellow vertical bars. The largest increase in [PM$_{2.5}$] occurred on the 24th coinciding with the highest [CO]. This was the Saturday of the Memorial Day weekend, and the maximum CO occurred under mostly calm conditions between 0700 and 0900 LT, correlating with NOy at an $r^2$ of 0.91 and slope of 29, while NO/NOy was 0.60 at $r^2 = 0.87$, clearly indicative of fresh emissions but at much higher CO/NOy ratio of what is typical for mobile sources! Burnings on private lands might have contributed to this observation. The possibility of an increased number of OLC visitors arriving by diesel buses is being investigated as an additional possibility.

IV. PM$_{2.5}$ mass and composition overview

![PM$_{2.5}$ mass and composition overview diagram]


![PM$_{2.5}$ Mass Fraction diagram]
Figure 6: Preliminary data from the Particle Composition Monitor (PCM) averaged for the various sampling periods. Mass balance concentrations (top) and relative mass fractions (bottom) follow the same color-coding for individual species. TEOM Mass are the fine PM mass concentrations from the semi-continuous measurements of the Tapered Element Oscillating Microbalance averaged over the corresponding PCM intervals. OOE are other organic elements that are presented as 40% of organic carbon (OC) in the top panel, and calculated from the mass balance in the bottom panel. The fraction unidentified mass (Un-ID, top) is the difference between the gravimetric filter mass and all identified species. The values in the bottom panel represent the ratios of organic mass to organic carbon (OM/OC) needed for mass closure.

The PM$_{2.5}$ mass concentrations determined gravimetrically from PCM filter samples agree well with the averaged semi-continuous TEOM values. With increasing time and acres burned, the fine mass concentration increases and with it the organics fraction. Also, the OM/OC ratio increases as the burns are conducted in the warmer season, possibly indicating the increased abundance of more oxygenated particulate organics and more rapid formation of secondary organic aerosol (SOA).

Preliminary POC data are available from high-volume samples taken during the February 2-6 period, which were analyzed using gas chromatography with mass spectrometry (GC/MS). These data are compared with the PCM results as well as the continuous meteorological and trace gas data in Figures 7 and 8 below. Note, that all 937 acres were burned on February 5\textsuperscript{th} on three TAs between 27 and 29 km E of OLC. The Hi-Vol and PCM samples were taken at the Oxbow Learning Center (OLC) as indicated in Fig. 7 top panel. The 24 h background sample, split into two 12-h Hi-Vol samples, was taken on Sunday, 02/02/03 and five 5-h burn event samples were taken beginning at noon on Wednesday, Feb 05. The prescribed burns were started shortly before noon that day. The synoptic weather condition during this period was characterized by a low pressure system associated with an area of low clouds moving northeast out of AL into and through central GA with winds increasing from Feb 3\textsuperscript{rd} to 4\textsuperscript{th}. The dynamic front produced showers and elevated thunder storms that moved rapidly through northern GA. In the wake of this front, colder air moved into the region from the north, causing below normal temperatures across the State, as freezing temperatures were reached at OLC early morning of the 5\textsuperscript{th}. VOC samples were successfully taken at OLC and Fort Gordon, where a prescribed burn was conducted under SSE flow. The analyses of those samples is pending.

The largest NO/NOy fractions occurred during calm mornings, when the lower atmosphere was poorly mixed and the site was potentially influenced by emissions from very local sources. These air masses did not always carry the signature of vehicular emissions only, with CO/NOy ratios ranging from 2.4 to 12.9. None of the ratios detected during and after the prescribed burn on 2/5 lie outside this range, therefore leading to assume that the site was not directly impacted by PB emissions. Although, the CO/NOy ratios > 9 were associated with easterly and southerly component flow and seemed independent of daytime (see report No. 7 for more details).
Figure 7: PCM flows, meteorological (1 min) and air pollutants (30 min) data collected continuously at OLC during the prescribed burning of 937 acres on Fort Benning’s TAs K-14 and K-20 on 2/5/03.

The PCM data from Fig. 8 indicate a significantly higher PM$_{2.5}$ mass loading of organic compounds after the active (flaming) burn period, beginning with the “smoldering” phase at 1700, while the sulfate mass fraction is clearly decreasing. Among the light organics, acetate seems to be particularly increased during the burn period, as is elemental carbon, both indicators for biomass burning. The biomass burning markers levoglucosan and resin acids are the main contributors to the identified organic mass in the post-burn samples, indicating an important influence of the prescribed burning to the overall fine PM loading. Although the primary indicators (CO, NOy, PM$_{2.5}$) did not suggest a direct impact of the prescribed burning plume, a significant contribution to the fine PM mass was detected in the highly dilute indirect and probably more regional impact.
Figure 8: PCM (top) and HVS (center and bottom) sample results from the February 5th burn event. The numbers in the top panel again represent the OM/OC ratio from the mass closure approach. The larger organic fractions in the post-burn samples after 1700 correlate with the larger concentrations of biomass burning markers, in particular levoglucosan and resin acids.

2. Outlook and work planned for next period

The most interesting VOC whole air canister samples to be analyzed were identified, and the GC/FID, /ECD, and /MS analyses of those are pending. A presentation of the latest results will be given at the DOD/EPA/State P2 Partnership Conference at Atlanta, on June 24-26. We will continue to merge and evaluate the measurement and laboratory analyses results that we obtained so far, and continue to generate new results from the latest sample collections. All meteorological, gas- and particle-phase measurement results will be merged with the specific burn events and fuel conditions, and evaluated in an integrated fashion. The first VOC results with quantitated volatile organic species are expected to become available for integration.