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Tampa Bay Area Photochemical Oxidant Study

Final Appendix C

Determination of Emission Rates Of Hydrocarbons From Indigenous Species Of Vegetation In The Tampa/St. Petersburg Florida Area.

FINAL REPORT

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Washington State University
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Title: Determination of Emission Rates of Hydrocarbons from Indigenous Species of Vegetation in the Tampa/St. Petersburg, Florida Area

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ABSTRACT

This report describes the methodology used to develop a natural hydrocarbon emission inventory for a 60 x 81 km region which includes the Tampa and St. Peterburg Florida. As part of the study a field program was conducted in which over 600 emission rate samples were collected and analyzed. The hydrocarbon emissions were quantified chromatographically in terms of Total Nonmethane Hydrocarbons, Paraffins, Olefins, Aromatics, Methane, and for each major hydrocarbon peak. The report also includes a detailed study of the distribution and quantitation of the vegetation in the area. Hourly emission factors were determined for each hydrocarbon component and species. These emission factors have been coded onto a computer tape for each of the 2,160 1.5 x 1.5 km grids in the study area.

The inventory calculates that natural emissions during the summer months approximate 160 metric tons/day. This is equal to an average emission flux of approximately 1350 $\mu g/m^2$ hr during the daytime (30°C) and 700 $\mu g/m^2$ hr during the nighttime (25°C). Isoprene is the single largest nonmethane emission component, and is approximately 18% of the daily TNMHC emission. The next largest emission component is α-Pinene (10% of daily TNMHC emission). Methane emissions were calculated to be $\sim$33% of the TNMHC plus methane total. The emissions are distributed fairly uniformly throughout the study area with respect to time and space; however, "evergreen forests" which occupy approximately 10% of the total study area account for about 35% of the non-methane hydrocarbon emissions.

Appendicies are included which list emission rates by vegetation species, emission factors for vegetation types (associations and land use categories), and total daily emissions for each vegetation type.

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INTRODUCTION

The regional nature of pollutant episodes has been well documented in the last few years. High pollutant levels, especially O_3, have been measured in rural areas well away from significant emission sources, (Sandberg, et al., 1978), Ripperton et al., 1977). Evidence has accumulated that indicates oxidant precursors generated in urban centers can be transported into these rural regions, however it has also been shown that photooxidation of natural hydrocarbons can produce significant quantities of ozone, (Westberg, 1977). Thus it is unclear at the present time what part each of these ozone producing mechanisms plays.

In order to define the importance of the natural production of hydrocarbons in a specific region a good estimate of natural hydrocarbon emissions is essential. Early literature estimates of biogenic hydrocarbon production indicate that natural sources of oxidant precursors may be significant, (Went, 1960). However, recent studies aimed at identifying terpene emissions in the vicinity of forested areas have found minimal amounts of these natural hydrocarbons, (Lonneman, et al., 1978).

Many rural and urban areas presently routinely exceed government air quality standards set for oxidant concentrations. As a result, large-scale control strategies aimed at local anthropogenic source emissions have been proposed. Since no adequate estimate of natural biogenic oxidant precursors is available, the potential effectiveness of the control strategies is subject to debate. (Koziar and Becker, 1977).

This report describes the procedure used to more reliably estimate the magnitude of the contribution of biogenic hydrocarbon emissions to the ambient air in the Tampa Bay/St. Petersburg area and the results of an intensive field study conducted by WSU in the Tampa/St. Petersburg area between the months of April and August, 1977.

It should be noted that the biogenic emission rates quoted in this report are not meant to be used as a direct comparison with anthropogenic emission rates. Direct comparisons are inappropriate since biogenic emissions differ fundamentally from anthropogenic emissions with respect to their chemical characteristics, emission densities and resultant ambient concentrations (Westberg, 1977; Zimmerman, 1977).

OBJECTIVES

The research program described in this report was initiated in February 1977, by Region IV of the Environmental Protection Agency, with the following objectives:

1. To develop and quantify emission rates for the dominant species of the following natural hydrocarbon sources in the Tampa/St. Petersburg area:

    a. Decaying vegetation in the coastal intertidal areas
    b. Dominant grass of the marine grass beds
    c. Production of hydrocarbons from the surface waters of Tampa Bay
    d. Forest type group of Oak-Gum-Cypress
    e. Forest type group of Long-Leaf Pine
    f. Improved pastures
    g. Palmetto
    h. Dominant Mangrove species
    i. Native grass (unimproved pastures)
    j. Citrus trees
    k. Representative shrubs
    l. Forest type group of Oak, Hickory
    m. Representative row crops

2. To identify and quantify the emission rate of each major hydrocarbon peak for each vegetative type and to group the emissions into the four chemical classes of:

    a. methane
    b. paraffins
    c. olefins
    d. aromatics

3. To develop April-August biogenic emission factors for each 1.5 x 1.5 km grid section within the approximately 61 by 80 km study area which included Tampa and St. Petersburg, Florida.

1. METHODOLOGY

This section briefly describes the techniques used for collecting emission rate samples from vegetation, soil-pasture and water surfaces. Details of the sample analysis, instrument calibration, and emission rate quantitation are also discussed.

1.1 SAMPLING METHODOLOGY

The technique used to determine the emission rates from vegetation, soil leaf-litter and surface water has been described in detail elsewhere (Zimmerman, 1979).

The method can be classified as a semi-static enclosure technique. Figure 1.1-a illustrates the equipment and procedure involved in collecting an emission sample from vegetation.

A common indoor-outdoor type thermometer is used to monitor ambient air temperatures and bag air temperatures simultaneously during sampling. Before the bag is placed around a branch the "outdoor" temperature sensor is placed along the branch. If sampling occurrs in bright sunlight the sensor is placed so that it is not in the direct incident light (i.e. it is placed below a leaf or branch for shade). The "indoor" thermometer is hung in the shade on a nearby limb.

Next, sample, evacuation and zero air lines are placed along the branch. Lines used for zero air and for sampling are connected to a sample manifold

VEGETATION EMISSION SAMPLE COLLECTION SYSTEM

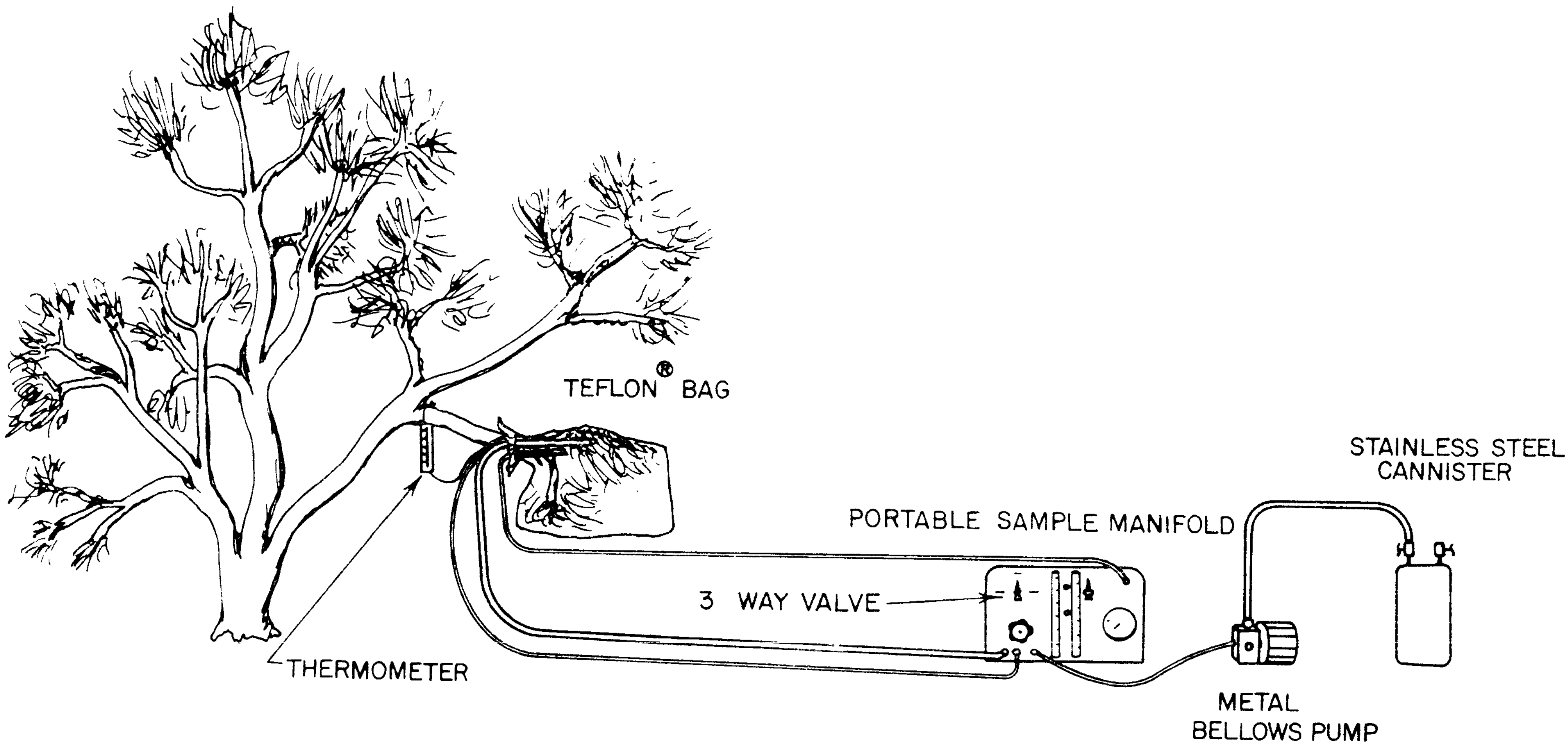


Figure 1.1-a

equipped to regulate zero air pressure, zero air and sample flow rates (Figure 1.1-b).

A large Teflon bag, (1m x 1.2m) with a capacity of approximately 120 ℓ (open at one end), is then carefully placed over the branch. The bag is sealed at its base by wrapping it with a strip of Velcro® sewn so that the "fuzzy" side and the "hook" side face opposite directions.

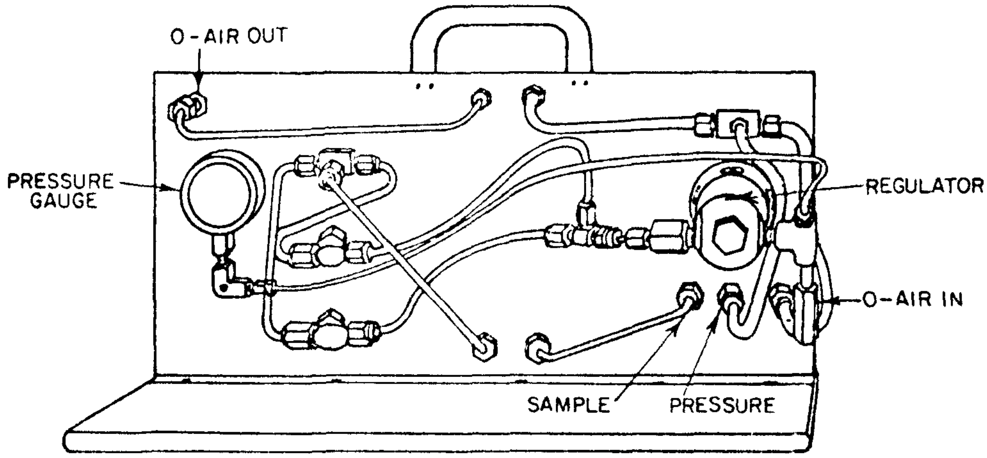
As much ambient air as practical (without damaging the vegetation) is quickly removed from the bag, and a sample of the air is pumped via a 12 volt metal-bellows pump into a 6.6 liter electropolished stainless steel canister. This is the "background sample." It contains the contribution to the bag from hydrocarbons present in ambient air at the time of sampling plus emissions from the branch. After the background sample is collected the bag is quickly inflated with zero air at the rate of 10 liters/minute for six minutes. The zero air has a CO_2 content of approximately 365 ppm and no hydrocarbons.

Next the emission rate sample is collected at approximately 2 liters per minute, while zero air continues to flow into the enclosure at 2 liters per minute. The total enclosure time is less than 15 minutes.

Leaf litter and pasture samples are collected in a similar manner except that the enclosure technique utilizes a sealing ring and stainless steel bag collar, Figure 1.1-c. To collect a pasture sample the sealing ring is driven into the soil to act as a seal and the bag collar is placed in the center of the sealing ring. After the collar and ring are placed, the Teflon bag is attached to the collar by means of a wide elastic strap. The remainder of the sample collection procedure is identical to that for vegetation.

FIGURE 1.1-b

PORTABLE SAMPLE MANIFOLD



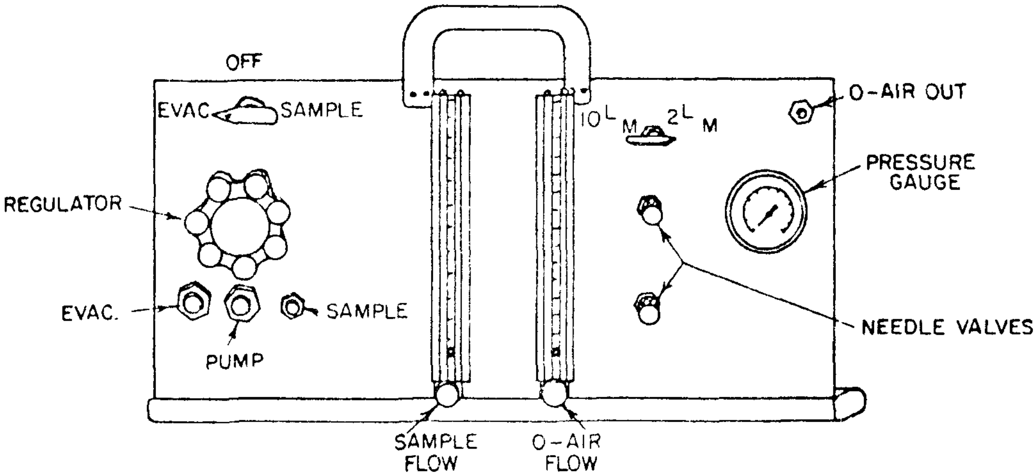
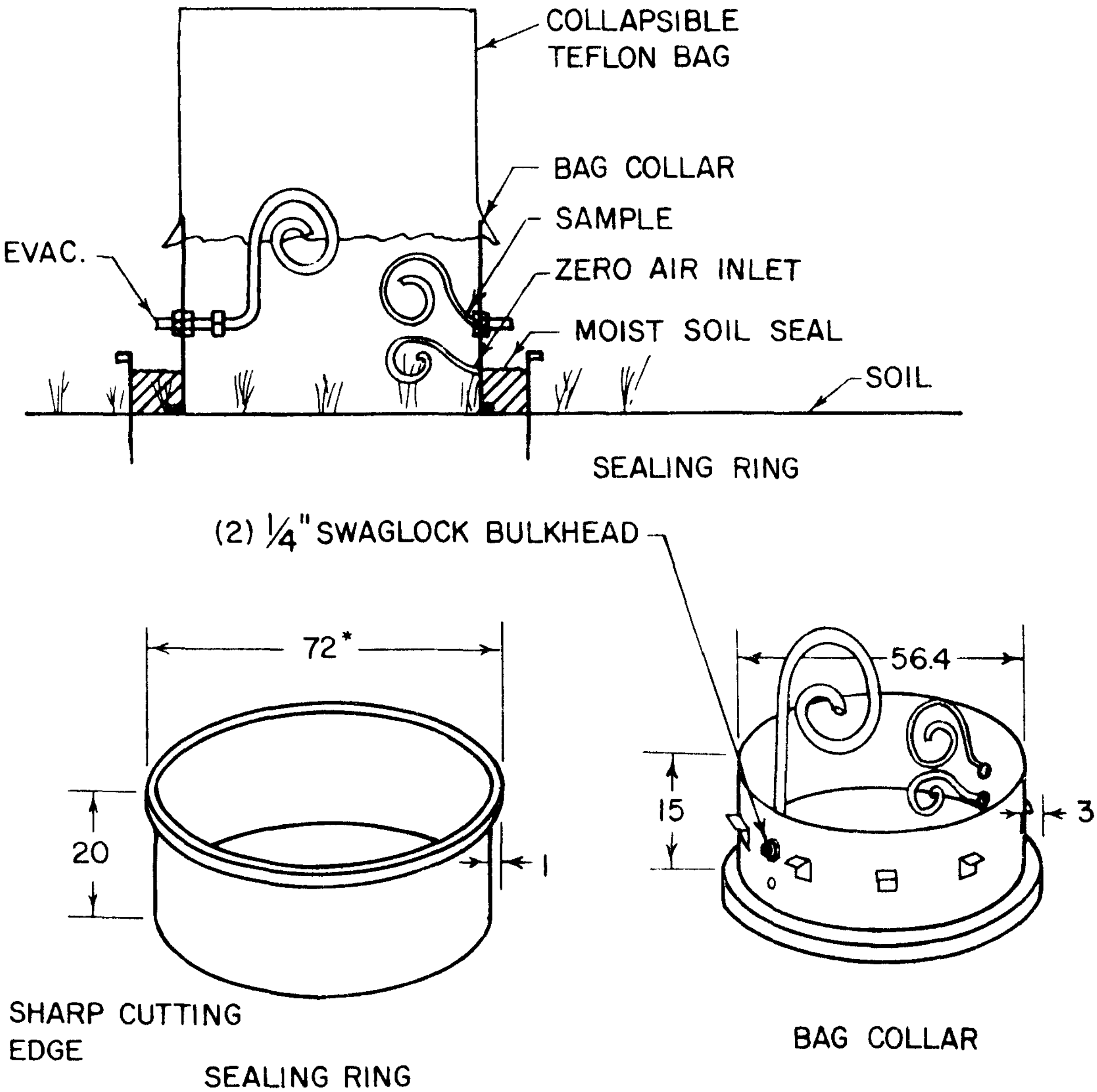


Figure 1.1-c

SOIL LEAF-LITTER SAMPLING SYSTEM



*all dimensions in centimeters

To collect samples from Tampa Bay, the Gulf of Mexico and from fresh water, a floatation ring made of two water-ski belts sewn together is strapped around the bag collar, Figure 1.1-d. The standard sample collection procedure is then followed. For many of the samples which utilize the bag collar, virtually all of the ambient air can be removed from the bag. This, therefore, eliminates the need to collect a background sample.

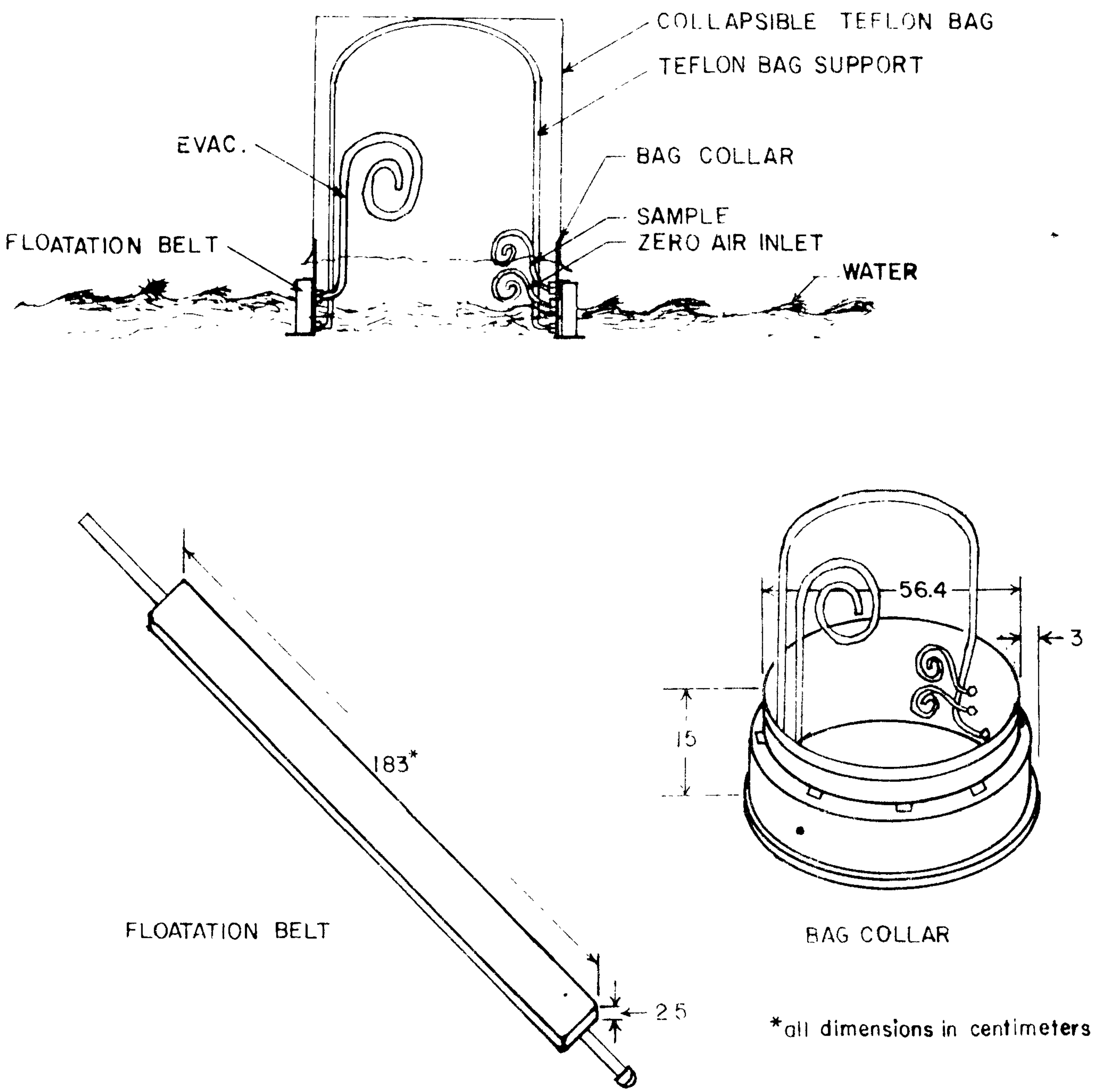
Periodic sample blanks are collected to insure the integrity of the sampling equipment and analytical procedures. The sample blanks are collected using the identical procedures as those used to collect vegetation samples, except no vegetation is enclosed.

The net emission from the vegetation, pasture leaf litter or surface water enclosed is equal to the difference between the hydrocarbon content of the bag after enclosure, as represented by the background sample, and the hydrocarbon content of the bag after the addition of zero air, as represented by the emission rate sample. This net emission is converted to an emission rate by dividing by a unit of time and a unit of foliage or area.

For vegetation samples, leaf dry weight of the branch enclosed (leaf biomass) was used as a unit of foliage. Therefore, the raw emission rates for vegetation are given in micrograms hydrocarbon (HC) emission per gram leaf biomass per hour (μg/g/hr). Leaf biomass was determined by clipping the branch at the point of enclosure, separating the leaves and drying them in an oven at 70°C until they reached a constant weight. For the pasture, marine, and aquatic samples and some row crops (flat samples) the emission rates were calculated in terms of μg/unit surface area covered/unit time ($\mu g/m^2/hr$). The emission rates for most of the flat sample categories were small. Since the samples included emissions from any vegetation enclosed

Figure 1.1-d

SURFACE WATER SAMPLING SYSTEM



(i.e. grass or phytoplankton) as well as from the substrate itself (soil or water) it was felt that the results would be more meaningful if wide ranges of pasture row crops and water conditions were sampled and emissions were related directly to ground or water surface area.

Throughout this report the emission rates reported are in terms of μg of each hydrocarbon compound. A conversion factor to micrograms carbon can be calculated from the ratio of the molecular weight of the hydrocarbon to the molecular weight minus the weight of the hydrogen atoms. Thus for the terpenes and isoprene the ratio is 0.88; therefore, μg hydrocarbon x 0.88 = μg carbon.

Figure 1.1-e shows the formula for calculating emission rates. This formula was applied to the determination of each individual hydrocarbon emission rate, as well as to each major hydrocarbon group. As the formula shows, the emission rates for vegetation were measured in terms of micrograms emission/unit time/unit leaf biomass. This emission rate was then converted to an emission factor or flux estimate by multiplying by a leaf biomass/unit ground area factor. For "flat samples" no conversion was necessary.

Figure 1.1-f illustrates the field data format used when collecting emission rate samples. Sample variables were recorded so that correlations with trends in emission rates might be determined at a later date. If the vegetation species sampled was not known, leaves were taken to local experts for positive identification.

1.2 ANALYTICAL METHODOLOGY

Columns and operating conditions are shown in Table 1.2-a. Methane, Ethylene, Ethane and Acetylene quantitation was determined using column Number 1. Column Number 2 was used for the analysis of C_2 - C_6 hydrocar-

Figure 1.1-e Emission rate formula

$$ER = \frac{C_{ss}\ (Zv + Ve) - C_{sb}\ Ve}{(Sa)\ (\Delta T_1)}$$

where:

C_{ss}: ($\mu g/m^3$) equals the TNMOC measured for the emission sample

C_{sb}: ($\mu g/m^3$) equals the TNMOC measured for the background sample

Zv: (m^3) equals the total volume of zero air put into the enclosure

Sa: (g) equals the dry weight of the leaves (leaf biomass)

ΔT_1: (min) equals the total emission time. This is the time interval between the background sample and the emission sample.

Ve: (M^3) equals the dead volume of the bag when collapsed around the branch = $\frac{ZV}{C_{sb}'/C_{ss}')-1}$

C_{sb}' and C_{ss}' are equal to the concentration of a non-emitted tracer in the background and sample respectively. For this study acetylene was used since it was not found to be an emission product.

Note: Hydrocarbon emissions were calculated in terms of μg hydrocarbon (μg). To convert to μg carbon (μgC) for terpenes and isoprene, multiply by 0.88 (see text).

bons. The Durapak low-k column (Column #3) was used for the routine analysis of C_4 - C_{12} hydrocarbons. In addition, each major species which was sampled extensively was also analyzed on the SE-30 glass capillary column (#5). This column gives better separation for purposes of peak identification; however, it was not known at the time that field sampling was performed if oxygenates would elute from the column in quantifiable peaks.

Samples of each major vegetation type were also sent to Pullman for analysis via gas chromatograph-mass spectrometer (GC-MS) to confirm the tentative field identification of the major hydrocarbons. The analysis showed that most of the tentative field identifications were correct.

1.2.1 Standardization

Each GC was standardized daily. A specially prepared standard certified by Scott Laboratories Inc., was used. The standard contained 0.299 ppm methane, 0.202 ppm ethylene, 0.213 ppm acetylene and 0.204 ppm neo-hexane. For the light hydrocarbon and heavy hydrocarbon G.C.'s 500 ml of the standard was introduced into the freeze-out loop and the area response to neo-hexane as determined by the Perkin Elmer PEP-1 Mini-computer was calculated as follows: 500 ml of 0.204 ppm neo-hexane = 359ng, (compound). Therefore the response factor is equal to 359ng/peak area of standard. The reproducibility of the injection procedure was better than one percent. The response factors for each instrument remained constant throughout the study period. The quantitation of ethane, ethylene, acetylene and methane was calculated on an individual concentration/peak height basis using the same Scott standard. This was done because we were operating five GC's and only four computer interfaces were available.

Figure 1.1-f. Field data format

Date 4-28 Sample # 151 Can # 169 Background 87 Emission

Location West U.S.F. Campus along Fowler Barom --------

Sample Type: Slash Pine

Enclosure: Teflon Bag number E

Site description: Sandy soil grassy, dry, Pine Oak Forest type, open canopy

Weather, general: clear, hot, some wind

Weather, site filtered sunlight Cloud cover 0% Ha (ambient air temp.) 27°C

Wind: direction SW speed 2-7 mph gust 15 mph

Vegetation: describe type, age, physiological state. 30' tall, moss on limbs 10" D.B.H. 20 years old growth fair, some frost damage.

Litter: Type pine needles

Incorporation ----- Depth -----

Soil: Moisture dry ph ----- Temp. -----

Describe sandy, grass understory.

Time at encl. T_0 1311, Time End Bkgd. T_1 1317 Start flush, T_2 1317

End flush, T_3 1323, Start purge, T_4 1323 Start sample, T_5 1323

End Sample, T_6 1326 Sample rate l/min. 2.1

Flush flow rate ZF(l/min.) 10 Purge flow rate Zp(l/min) 2.0

Encloses sample temp. 29°C Can pressure 10 psig

COMMENTS: Ve estimated at 30 liters collected by Don Stearns

$\Delta T_1 = 9$, $\Delta T_2 = 6$, $\Delta T_3 = 3$, Zv = 0.066

Table 1.2-a. HYDROCARBON ANALYSIS CONDITIONS

Compound	Instrument	Operating Conditions
Ethylene Ethane Acetylene Methane	P.E. 3920 Isothermal FID GC.	1. Column: 10' x 1/8" OD Porapak Q Carrier: He 80 psig, 7 ml/min. Hydrogen: 22 psig Compressed Air: 50 psig Oven: 65°C (30°C for CH_4) Total Run Time: 10 min. Sample Size: 100ml (5ml for CH_4)
Light Hydrocarbon C_2-C_6	P.E. 3920 Temp. Prog. FID GC and/or HP 5711 A Temp. Prog. FID GC with Dual Electrometer Option.	2. Column: 20' x 1/16" OD Durapak N-Octane Carrier: He 90 psig, 6 ml/min Hydrogen: 40 psig Compressed Air: 50 psig Oven: -70°C to 65°C Delay time: 4 min Program rate: 16°/min. Total Run Time: 40 min. Sample size: 500ml
Heavy Hydrocarbon and Oxygenates C_4-C_{12}	P.E. 3920 and/or P.E. 990 Temp. Prog. FID GC.	3. Column: 10' x 1/8" Durapak Low-K carbowax 400 Carrier: He 90 psig, 8 ml/min. Hydrogen: 40 psig Compressed air: 50 psig Oven: -20 to 100°C Delay Time: 2 min. Program Rate: 8°/min. Total Run Time: 20 min Sample size: 500ml
Heavy Hydrocarbon C_4-C_{12}	P.E..3920 Temp. Prog. FID GC and/or 990 Temp. Prog. FID GC.	4. Column: 200' SCOT OV-101, 10' x 1/16" OD Durapak Low-K, Carbowax 400 precolumn Carrier: He 90 psig, 5 ml/min Hydrogen: 40 psig Compressed Air: 50 psig Oven: 0°C to 100°C Temp. Prog. Delay Time: 6 min. Program rate: 6°/min Total Run Time: 60 min. Sample size: 500ml
		5. Column: 30 m SE 30 Glass Capillary Carrier: He 90 psig, 1 ml/min. Oven: -30 to 80°C Temp. Prog. Delay Time: 8 min. Program rate: 4°/min Total Run Time: 50 min. Sample size: 500 ml

A qualitative standard was used to determine the retention time of C_2 - C_{12} compounds for identification purposes. The standard was made by injecting microliter amounts of liquid samples of each compound shown in Table 1.2.2-a and 1.2.2-b into an evacuated 25 ℓ glass carbouy. The container was then pressurized to about 5 psig with clean air. This mixture was run periodically to monitor column separation performance and elution time. In addition, WSU maintains a large file of the relative retention times of a wide variety of compounds for different column types. If a large peak was noted which was not present in the routine qualitative standard, its identity was tentatively made with the aide of these files. A few of the unknown compounds which were present for many vegetation samples but did not match the retention time of the known standards were determined via GC-MS analysis upon our return to the Pullman laboratory. Some compounds could not be identified. These unknowns were numbered and then retention times were recorded so that future identification might be possible.

1.2.2 Quantitation

The light hydrocarbon and heavy hydrocarbon GC's were interfaced with a Perkin Elmer PEP-1 Mini Computer. The computer listed the peak areas and retention times of each peak analyzed. The chromatograms were also recorded on strip charts.

For each sample, emission rates were determined for the major hydrocarbon groups of paraffins, olefins and aromatics. In addition emission rates of methane and of each of the major hydrocarbon peaks which was greater than five percent of the non-methane hydrocarbon total (TNMHC) were quantified for each sample.

For most vegetation types the chromatogram consisted of five or six major hydrocarbon components plus as many as one hundred very small peaks. It was

Table 1.2.2-a ROUTINE LIGHT HYDROCARBON STANDARDS

Compound
*Ethane
+Ethylene
+Acetylene
*Propane
+Propene
*Isobutane
*n-Butane
*2,2-Dimethylpropane
+Propyne
+I-Butene
+IsoButene
+2-Methylbutene
+trans-2-Butene
*n-Pentane
*Clyclopentane
+1-Pentene
*2,2-Dimethylbutane
*2-Methylpentane
+Trans-2-Pentene
+3-Methyl-1-Butene
*3-Methylpentane
*cis-2-Pentane
*Methylcyclopentane
*n-Hexane
+Isoprene
*Cyclohexane

* Paraffins
\+ Olefins
\- Aromatics

Table 1.2.2-b ROUTINE HEAVY HYDROCARBON STANDARDS

	Class
2,3-DimethylButane	Parrafins
2-MethylPentane	
3-MethylPentane	
n-Hexane	
2,4-DimethylPentane	
2,3-DimethylPentane	
3-MethylHexane	
n-Hentane	
2,2,4-TrimethylPentane	
2,4-DimethylHexane	
2,5-DimethylHexane	
2,3,4-TrimethylPentane	
Toluene	-
3-MethylHextane	
n-Octane	
2,2,5-TrimethylHexane	
EthylBenzene	Aromatics
p-Xylene	
m-Xylene	
o-Xylene	
Styrene	
α-Pinene	+
β-Pinene	+
n-Nonane	*
IsopropylBenzene	Aromatics
n-PropylBenzene	
1-Ethyl-2-MethylBenzene	
1,3,5-TrimethylBenzene	
Myrcene	+
1,2,4-TrimethylBenzene	-
n-Decane	*
Δ^3-Carene	+
TerButylBenzene	-
d-Limonene	+
β-Phellanderene	+
Sec-ButylBenzene	-
Terpinolene	+
1,2-DiethylBenzene	Aromatics
1,3-DiethylBenzene	
1,4-DiethylBenzene	
n-ButylBenzene	
n-Undecane	*

*Parafins
+Olefins
-Aromatics

Note: All small peaks which eluted within the arrows were assumed to belong in the class named. Exceptions include those marked. Also, all large peaks were specifically identified by matching the elution time with known qualitative standards. This list only includes the compounds in the qualitative standard which was run periodically in order to verify column performance (See text).

thus impractical to attempt to identify each component and to calculate its emission rate. The following scheme was therefore used to quantify the emission components into their respective hydrocarbon groups:

TNMHC: The total of the light hydrocarbon analysis to (and including) propane plus the total of the heavy hydrocarbon analysis. If large peaks which eluted after propane were noted in the light hydrocarbon analysis, they were identified by matching their retention times with the known standards and each was grouped into its appropriate class. Usually, however there were virtually no peaks which eluted after propane on the light hydrocarbon analysis. All of the peaks which eluted after propane also eluted in the early part of the heavy hydrocarbon analysis. Although the peaks were not separated sufficiently for peak identification purposes, the TNMHC calculated by adding the individual light hydrocarbon peaks to the non-overlapping heavy hydrocarbon peak total matched the TNMHC calculated from the total of the light hydrocarbons to (and including) propane plus the total of the heavy hydrocarbons. Since the second procedure facilitated the speed of data reduction, it was used in this study to calculate TNMHC.

Paraffins: The total of the paraffins in the light hydrocarbon analysis to propane plus all of the peaks from the heavy hydrocarbon analysis which eluted before ethyl benzene, plus n-nonane and n-decane, (except for isoprene, benzene and toluene). While it was recognized that ethylene and acetylene were olefins, ethylene emissions were very small and no acetylene emission from vegetation was ever noted.

Olefins: The sum of all of of the terpenes plus isoprene.

Aromatics: Everything which eluted after n-octane with the exceptions of n-nonane, n-decane and the terpenes.

The light and heavy qualitative hydrocarbon standards which were used to establish elution order are listed in order of increasing retention times in Table 1.2.2-a and 1.2.2-b.

Some peaks which appeared in each chromatogram were subsequently determined by gas chromatographic-mass spectrometric analysis to be the result of column bleed. These peaks were then omitted. Broad tailing peaks were consistently associated with specific sample groups such as Bay and Gulf samples. These peaks, which occurred at specific elution times, were most likely due to the presence of sulfur compounds, however they could also have been caused by oxygenated compounds. It is also possible that the peaks were column bleed components caused by something in the samples. Since the character of the compounds responsible for these tailing peaks could not be determined, their areas were subtracted from the nonmethane hydrocarbon total (TNMHC) for each chromatogram.

Early in the sampling program the G.C. analysis was allowed to continue until the expected elution time of the C_{15} compounds. Since no quantifiable peaks occurred after approximately C_{12}, and since the analytical procedure was the primary bottleneck in the sampling program, subsequent chromatograms were terminated at $\sim C_{12}$.

After the analysis was complete the sample canisters were recycled by purging with clean dry air at 10 liters per minute. At the same time the "cans" were heated to 70°C. This treatment continued for approximately 12 hours. The cans were then evacuated to a pressure of 30 microns or lower prior to being reused for sampling. Blank analysis of the can contents confirmed that the procedure did an excellent job of cleaning. Testing at WSU also indicated that this treatment tends to minimize adsorption losses of hydrocarbons stored in cans. Samples stored for several days have shown no significant shift in hydrocarbon content.

2. EMISSION RATE ALGORITHMS

Field data indicated changes in emission rates with temperature and light, although, other factors also seemed to significantly affect emission rates. These variables could include site specific variables such as soil fertility, plant moisture, weather, individual genetic variability, location of the sample on the tree, various pathologic conditions such as disease or injury and the age of the vegetation.

In order to more clearly estimate the effects of temperature and light on emission rates, a laboratory research program headed by Dr. D. T. Tingey, EPA Corvallis, was conducted utilizing specially designed environmentally controlled chambers. Whole plants were placed inside the chambers and the selected variable of plant temperature or light was changed while other conditions remained constant. The reports on experiments completed for Live Oak, an isoprene emitter, and for Slash Pine, a terpene emitter, indicated that there is a positive relationship between temperature and emission rates (Tingey, et al., 1978a,b). For terpene emissions no light dependency could be detected. Terpene emissions increased exponentially with temperature. The log of isoprene emissions varied with temperature and light according to a four parameter logistic function. However, light was saturating for isoprene emissions at fairly low intensities. The study quantified the relationships between leaf temperature and terpene emissions at any light level, between isoprene emissions and leaf temperature at various light levels and between isoprene emissions and light at various temperatures. Although the isoprene comparisons seem to be the same, laboratory results were different between the two sets of experiments. This variability could reflect the differing genetic backgrounds of the plants or the different pre-conditioning of the plants used in each experiment (Tingey, personal communication). In either case the data indicates the difficulty in trying to establish one emission rate algorithm to describe the variation of isoprene emissions with temperature and light.

2.1 RAW DATA CORRECTION FACTORS

The results of Tingey experiments were used to standardize field data to constant temperature and light conditions. No "average" emission rate algorithm which combined the results of the two isoprene experiments was available; therefore, for purposes of this emission inventory we have assumed that changes in isoprene emission rate with temperature for Live Oak would be similar to other isoprene emitters and have selected one of the emission rate algorithms for varying temperature at a light intensity of 800 $\mu E/m^2/sec$, (Tingey, et al., 1978a., Table 3). This algorithm was chosen because it indicated that additional increases in light intensity would not further increase isoprene emissions (i.e. isoprene emissions were saturated with respect to light). Additionally it was assumed that light intensity would be saturating for isoprene emissions from field samples during the daylight hours. We have also assumed that the change in non-methane hydrocarbon emission rates with temperature for all vegetation types (except for isoprene emissions) would be similar to Slash Pine (Tingey, et al., 1978b, Figure 4-a). Since the field data was collected over a range of temperatures a correction factor was used to standardize the hydrocarbon emissions to specified conditions of saturating light and a leaf temperature of 30°C. Figure 2.1-a shows the emission rate algorithms used to calculate the respective hydrocarbon emissions. The emission rate correction factors are equal to the result of the emission rate algorithm at 30°C divided by the result of the emission rate algorithm for the bag temperature of the field sample. This ratio is then multiplied times the field emission rate. Since the correction factors take the form of the ratio of the predicted emission rate at 30°C to the predicted emission rate at the sampling temperature, times the emission rate measured in the field, the units make no difference (note: the data in Tingey, 1978 a and b are in μg carbon). For nighttime all isoprene emissions were assumed to be zero. From energy balance calculations (Gates, 1971) it was apparent that leaf temperature and air temperature inside our enclosure during sampling were very close. The relationship between ambient air temperature, bag temperature and leaf temperature for some deciduous plants, was more difficult to estimate. The primary factors that affect this relationship are the size of the leaf, the energy absorption by the leaf, wind speed and transpiration rate (Gates, 1965). From our field measurements, it appeared that in the morning or afternoon hours or if the sunlight was filtered through foliage or shaded by clouds, bag temperatures were within 5°C of ambient air temperatures. If, however leaves were in direct sun at noon, bag temperatures and leaf temperatures could be up to 10°C warmer than ambient air temperatures.

Because bag temperature more accurately reflects leaf surface temperature, a probable controlling factor for emissions, the raw emission rates were specified in terms of bag temperature. When the emission rates based on bag temperature are standardized to an ambient temperature of 30°C,

Figure 2.1-a. Emission rate algorithms

Isoprene

$$^{+}\ln(Er) = \frac{4.88}{1 + \exp[-0.18(Ta - 25.26)]} + 0.11$$

Isoprene Temperature correction factor to 30°C:

$$Er = Er^{*}\left[\frac{34.194}{\exp\left(\frac{4.88}{1 + \exp[-0.18(Ta - 25.26)]} + 0.11\right)}\right]$$

where: Er* = Isoprene emission rate (measured)
Er = Isoprene emission rate (std. to 30°C)
Ta = Leaf temperature
34.195 = Predicted emission rate at 30°C
exp designates an exponent

Terpenes

$$^{++}\ Er = \exp[-0.332 + 0.0729(Ta)]$$

Terpene correction factor to 30°C:

$$Er = Er^{*}\ \frac{6.392}{\exp[-0.332 + 0.0729(Ta)]}$$

where: Er* = Terpene emission rate (measured)
Er = Terpene emission rate (standardize to 30°C)
Ta = Leaf temperature
6.392 = Predicted emission rate at 30°C
exp designates an exponent

+From Tingey *et al.*, 1978a.

++From Tingey *et al.*, 1978b.

there is a possibility of underestimating emission factors. For instance, the emission rate measured at a bag temperature of 35°C is necessarily lowered when standarized to a prevailing ambient condition of 30°C. Under these conditions leaf surface temperatures of unenclosed as well as the enclosed vegetation might be closer to the bag temperature than to the ambient air temperature (Gates, 1971). Therefore, when the emission rate is standarized to an ambient air temperature of 30°C, the effect is a lower emission estimate than would be expected at a corresponding leaf surface temperature of 35°C.

Although leaf temperatures may be higher than ambient temperatures for some leaves during some period of the day, it is much more difficult to estimate average diurnal leaf temperature cycles than average diurnal air temperature cycles. For this reason, in the Tampa/St. Petersburg natural emissions inventory WSU has assumed that bag temperatures equaled air temperature. It was recognized that this assumption could lead to underestimation of emission rates. This potential underestimation of emission estimates would be moderated somewhat for isoprene emitters because during periods of direct sunlight temperatures of some leaves may exceed 44°C and the leaf would then begin to physiologically shut down (Tingey, et. al., 1978a). Since isoprene emissions seem to be tied to photosynthesis (Sanadze and Kalandadze, 1966) the isoprene emission rate would be reduced for the over-heated leaves. In other words, in bright sun, leaf temperatures of some of the leaves for some broadleafed plants tend to be warmer than ambient air during some hours of the day, causing emission rates based only upon bag temperature and standardized to ambient air temperature to be too low. However, some of the leaves of a canopy may exceed a temperature of 44°C, causing a sharp decrease in isoprene emission rates. These factors, therefore, may tend to balance.

For purposes of modeling, emission rates are given for an average leaf temperature of 30°C during the daytime and 25°C at night. If emission estimates were desired for other duirnal temperature regimes, the emission algorithm correction factors could be used to adjust emission rates on an hourly basis.

Additionally, for this study it was assumed that the emission rate of an enclosed branch at a specific bag temperature would be representative of the emission rate of the whole plant if it were at the same temperature.

Samples which were collected using the bag collar were not corrected for temperature. These "flat samples" included some of the short row crops and all of the pasture (soil/leaf litter) and surface water samples. The temperature of the enclosure for these samples did not vary as greatly as for those samples using the Teflon bag enclosure. It was not known how leaf temperature, soil/water temperature or ambient air temperatures would affect the emission rates of these samples, and no experimental data was available to elucidate possible temperature relationships. Similarly, no attempt was made to standardize methane emission rates with temperature for any of the samples.

3. FIELD PROGRAM

Between the months of April and August 1977 a field sampling program was conducted to assess the hydrocarbon emission rates from biogenic sources in the Tampa/St. Petersburg study area. This section briefly discusses the selection of sampling sites. Appendix D lists the order of events for the field sampling program and discusses the typical sampling schedule.

3.1 Sampling Sites

Figure 3.1-a shows the boundaries of the study area. The area encompasses Hillsboro and Pinellis counties and includes the major cities of Tampa and St. Petersburg, Florida. Each dot on the map represents a site where emission samples were collected during the course of the April 1 to August 7, 1977 study.

As the map illustrates, the sampling sites are not evenly distributed over the study area. Sampling sites were limited by accessibility and by the number of vegetation associations (groupings of vegetation species which are normally found together) located in close proximity. Sampling sites were concentrated upon in locations which contained representative vegetation from most of the associations in the study area. These sites were sampled repeatedly over the study period. This was intended to help define the seasonal variability in emission rates. Although this data has not been statistically analysed for trends, in general, it appears that

TAMPA / ST. PETERSBURG SAMPLING SITES

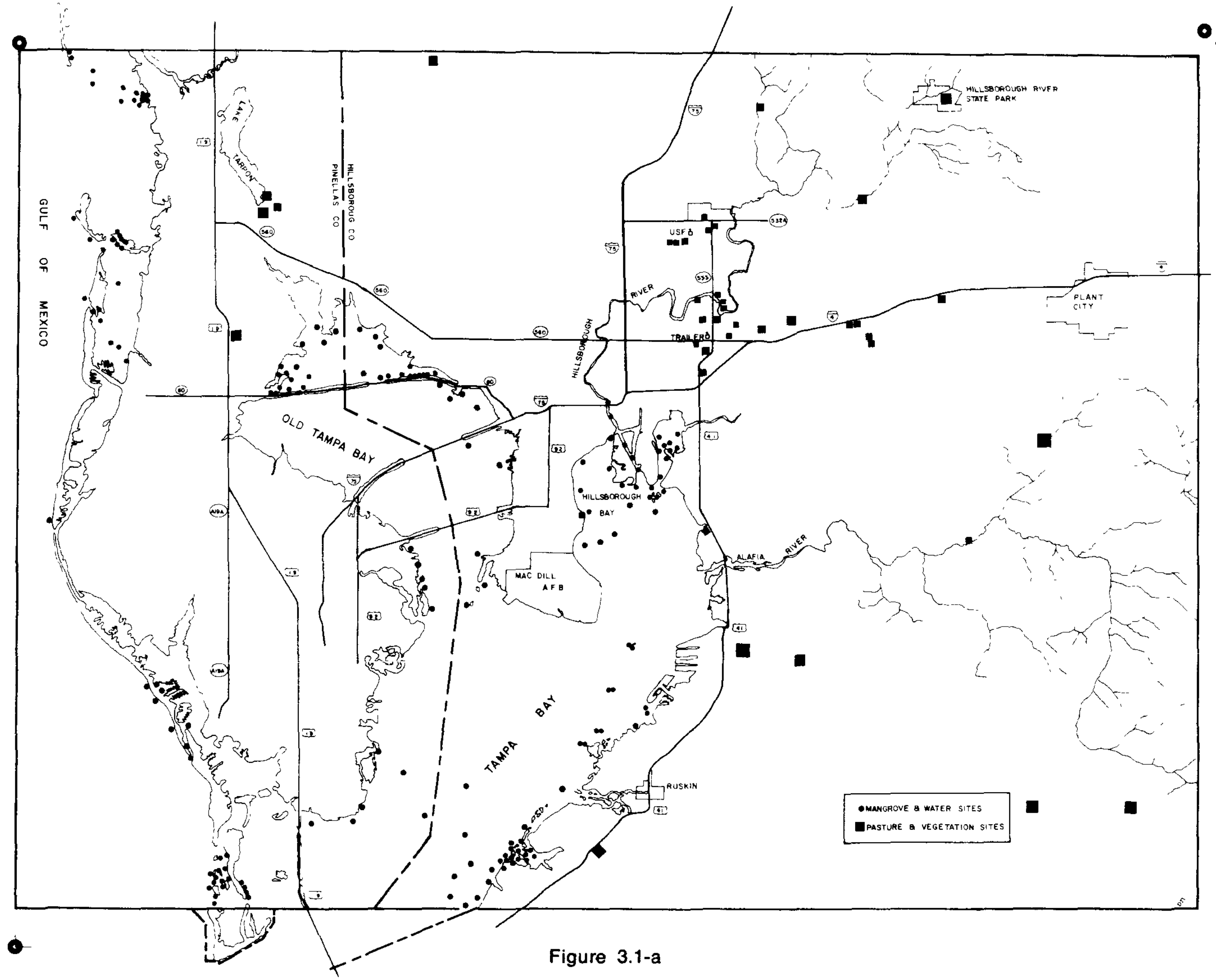


Figure 3.1-a

sampling variability (the difference between similar samples) was greater than seasonal variability.

In order to get an idea of the variability of emission rates with location, we also collected a few samples at diverse sample sites throughout the study area. This sampling scheme allowed the collection of samples from many vegetation associations daily.

The decision for WSU to sample Row Crops was made in mid-June. Row Crops were therefore sampled in June and July after the first growing season and harvest had been completed. Emission rates from these plants therefore, might not be representative of active vegetation emissions during the growing season. Recent unpublished data by WSU for experiments which measured changes in vegetation emissions throughout a year indicate that vegetation emissions are probably highest for most plants during periods of active growth.

4. LEAF BIOMASS DISTRIBUTION AND QUANTITATION

As previously explained, the emission rates of the vegetation samples were measured in terms of emission/unit time/unit leaf biomass. In order to convert this emission rate into an area wide emission factor, (emission/unit time/unit area) for each grid, it was necessary to conduct a detailed study to determine the type (plant species), quantity (biomass factors), and distribution (area coverage), of leaf biomass.

4.1 LEAF BIOMASS DISTRIBUTION

The study area primarily consisted of Hillsborough and Pinellis counties. In general, at the time that this study was conducted, Hillsborough county was mostly agricultural land closely intermixed with other vegetation communities. Many areas formerly in pine flatwoods had been converted to improved pasture with cypress heads and marshes intermixed. The pine flatwood areas remaining were located mainly in the southern half of the county or northwest of Tampa. Directly east of Tampa and five to ten miles east of Hillsborough Bay, pine and oak sandhills could be found. Wooded swamps occurred mainly in the Hillsborough River and Trout Creek drainage basins in floodplains and isolated depressions.

Nearly all of the southern half of Pinellis County was in developed land, primarily residential and urban. There was however a well-defined band of pine flatwoods running east-to-west, located south of Clearwater/Largo and North of St. Petersburg. Much of the residential land, particularly in older districts, was heavily covered in a mixture of natural and exotic trees and shrubs.

The portion of the county north of Old Tampa Bay was in pine flatwoods, sandhills, and agricultural land. Pine flatwoods were located near Sutherland Bayou and Smith Bayou. Xerophytic oak and pine were located to the east of the flatwoods area (Environmental Science and Engineering Inc., 1977).

The distribution of the vegetation types over the study area was determined primarily from Level II Land Use and Planning Maps. (Tampa Bay Regional Planning Council, 1977). These maps were developed by the U.S. Geological Survey for the Land Use and Land Cover data analysis system (LUDA), (Figure 4.1-a). The coordinates on the map in Figure 4.1-a which define the study area are: 315KmE., 3118KmN.; 396KmE., 3118KmN.; 315KmE., 3058KmN.; 396KmE., 3058KmN. The squares in the upper and lower left corners of the map designate the size of the study grids. The numbers in the grid squares represent the numbering system used to identify the location of each grid. As Figure 4.1-a shows, the coordinate system for the grids originates in the lower left-hand corner with 1-1. The first number designates the column of the grid and the second number designates its row. Therefore, the grids in column one are labeled (from bottom to top) 1-1, 1-2, 1-3 . . . 1-40 and those in row one are labeled (bottom right to left) 1-1, 2-1, 3-1 . . .54-1. Similarly the top row of grids would be labeled (right to left) 1-40, 2-40, 3-40 . . . 54-40. This makes a total of 2160 grids in the study area.

The original 1:250,000 scale Level II LUDA maps were designed to give resolution down to four hectares (10 acres) for categories of urban land, rivers, bays and estuaries and some agricultural land and 6 hectares (15 acres) for other land use categories (Anderson _et al._, 1976). Figure 4.1-b

TAMPA/ST. PETERSBURG LAND USE CATEGORIES

Figure 4.1-a

Figure 4.1-b Land Use map key

1. Urban or Built-up Land

11 Residential
12 Commerican and Services
13 Industrial
14 Transportation, Communincation, and Utilities
15 Industrial & Commercial Complexes
16 Mixed Urban or Built-up Land
17 Other Urban or Built-up Land

2. Agricultural Land

21 Cropland & Pasture
22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Hort. Areas
23 Confined Feeding Oper.
24 Other Agricultural Land
25 Cropland
26 Improved Pasture
27 Specialty farms
28 Horticultural farming

3. Rangeland

31 Herbaceous Rangeland
32 Shrub and Brush Rangeland
33 Mixed Rangeland

4. Forest Land

41 Deciduous Forest Land
42 Evergreen Forest Land
43 Mixed Forest Land
421 Planted Pine

5. Water

51 Streams and Canals
52 Lakes
53 Reservoirs
54 Bays and Estuaries
55 Gulf

6. Wetland

612 Forested Evergreen
61 Forested Wetland
621 Nonforested Wetland
6121 Mangroves

7. Barren land

71 Dry Salt Flats
72 Beaches
73 Sandy Areas other than Beaches
74 Bare Exposed Rock
75 Strip Mines, Quarries, and Gravel Pits
76 Transitional Areas
77 Mixed Barren land

8. Tundra

81 Shrub and Brush Tundra
82 Herbaceous Tundra
83 Bare Ground Tundra
84 Wet Tundra
85 Mixed Tundra

9. Perennial Snow or Ice

91 Perennial Snowfields
92 Glaciers

is a key for the numbers shown in Figure 4.1-a. Large LUDA maps are available from the Tampa Bay Planning Commission or from the State Capitol. The LUDA maps are based primarily upon land use or function in addition to ground cover. Therefore a two-hour flight by a doctoral candidate in Urban Ecology (and native of the Tampa area) in a small chartered airplane allowed for the confirmation of existing land use and stand composition information. The flight also enabled procurement of new information concerning the relationship of land use categories to vegetation types previously characterized by composition and biomass. Information from the flight was incorporated into the Land Use map shown in Figure 4.1-a.

To determine the distribution of vegetation by grid, a large LUDA Level II Map was overlaid with the grids of the study area. The percentage occupied by each land use category was then visually estimated for each grid. This technique was subjectively estimated to be accurate to within about five percent for each area in each grid. Visual area estimates compared within 6 percent of the values obtained from trial planimeter measurements of land use categories which occupied more than 20 percent of a grid. The planimeter (0.1mm resolution) WSU tested could not resolve areas smaller than 10 percent of a study grid from the 1:25,000 scale maps. WSU, therefore, chose the visual estimation technique due to its increased speed and accuracy over planimetry for these maps. The result was a set of LUDA categories and their percent area coverage for each grid of the study area. This information was then coded and stored on a computer tape.

4.2 LEAF BIOMASS QUANTITATION

This section contains a general discussion of leaf biomass quantitation. The section also contains a general description of the overall character and climate of the study area and a detailed discussion of each of the vegetation associations sampled during the course of the study. The typical species composition and the method used to estimate leaf biomass for each association has been outlined. Leaf biomass estimates were not made for the association categories of Improved Pasture, Unimproved Pasture, Tampa Bay and the Gulf of Mexico; Fresh Water Marsh or for some Row Crops. These categories were sampled using the bag collar, which enclosed $0.5m^2$ of ground. The amount of vegetation enclosed was assumed to be representative of typical conditions.

Fortunately, leaf biomass tends to be convergent in forests of widely varying growth rates, dimensions, tree density per unit area, and species composition (Lieth and Whittaker, 1975). Assuming canopy closure, leaf biomass varies more with site index than with any of the other variables, (Satoo, 1971). The figures cited for central Florida vegetation bear that out, ranging from 200 g/m^2 to 700 g/m^2, with most of the vegetation types falling within the 450 to 650 range. (Lugo and Snedaker, 1974; Bayley, 1976; Mitsch, 1975; Carter et al., 1973; Wilbur, 1975).

While some sources describing broad regional trends indicate expected leaf biomass from 800 to 1200 g/m^2 in this latitude (Satoo, 1971) (Rodin and Bazilevich, 1965), the soils and rainfall regime of the region present limitations which result in edaphic climax vegetation. Nutrient poor, excessively drained soils, poorly drained soils and fire are the major causes of edaphic climax vegetation. This successional vegetation state is also less productive and lower in leaf biomass than the classic climatic climax vegetation type. Moreover, the study area is transitional with regard to climate. Where climax communities do occur there is a mixture of humid subtropical and humid sub-boreal vegetation types (Wunderlin, 1975; Pardue, 1971; Environmental Science and Engineering, Inc., 1977). While the Tampa Bay

Region is classified as an area of Humid Continental climate (Cfa in the Koppen-Geiger Classification) it is located at the southeastern extreme of the extent of this climate designation in North America (Koppen and Geiger, 1936). In addition to the north-south temperature and moisture gradients, the central portion of the Peninsula is characterized by marked gradients from each coast to the interior. This suggests that the vegetation of the region will not fit well within categories of vegetation typical of either subtropical or sub-boreal areas.

The vegetation in the study area had also been subjected to several forms of disturbance, ranging from clear-cutting to drainage, to severe prolonged drought. This disturbance and stress had caused many of the associations in this area to remain in an early to mid-successional level. Often the climax vegetation was also stressed. Because of these factors much of the vegetation was therefore somewhat impoverished and atypical with respect to other sub-tropical areas.

Several sources were consulted regarding the composition and leaf dry weight of trees and shrubs in each of the emission categories defined for purposes of the study. These are referenced in the leaf biomass tables in the discussion of each association. Wherever possible, local sources were consulted and given preference over more general information or over sources specific to other regions. In each case the full range of biomass figures is listed in the tables. The figure deemed most representative of the vegetation type as it occurred in the study area has been denoted by double underlines. Where species-specific or site-specific information was not available, the best approximation is cited. The final figures for each association are listed in Table 4.2-a.

Table 4.2-a SUMMARY OF LEAF BIOMASS FACTORS AND PLANT ASSOCIATION CROSS-REFERENCE LISTS

Common Literature References	LUDA Land Use Categories	WSU Plant Associations	Leaf Biomass g/m^2
Mangrove swamps	6121 Mangroves	Mangroves	
		Mature	641.6
		Succession	221.5
Mixed hardwood swamps	forested wetlands	Oak-gum-cypress	
		Dome	331
		Drained	203
		Undrained	365.8
Southern mixed hardwoods, Mixed hardwood swamps, Bayheads, Moist to mesic hardwood hammocks, Hydric hammock	41 Deciduous forest, 612 Forested wetland evergreen	Hydric oak hammock	614.8
Sand hills	42 Evergreen forest	Xeric oak hammock	417
Pine flatwoods	42 Evergreen forest	Pines	662.5
--	31 Herbaceous rangeland 32 Shrub & brush rangeland	Palmetto	450
Oldfields with developing overstory	11 Residential 32 Shrub & brush rangeland	Representitive shrubs	200
--	29 Citrus groves	Citrus groves	658.3
Improved pasture	26 Pasture	Improved pasture	---
Oldfields, early stage	31 Herbaceous rangeland 32 Shrub & brush rangeland	Unimproved pasture	---
--	25 Cropland	Row crops	
		Tomatoes	8.48
		Okra	72.09

Although LUDA maps give some idea of the types of vegetation and its distribution in the study area, most leaf biomass references are given in terms of the vegetation associations shown in Table 4.2-b. The following section therefore gives a brief description, a detailed species composition list and the available leaf biomass figures for each vegetation association listed in the Table. Information used was obtained from a wide variety of sources, therefore it is not uniform with respect to detail or with respect to the method of leaf biomass determination.

4.2.1 Mangrove Swamps

Mangrove swamps occur in almost pure stands in the study area (Table 4.2.1-a). Red mangroves are the most common of the four species present and occupy the largest areas of the Tampa/St. Petersburg estuaries.

As illustrated by Table 4.2.1-b mangrove biomass is dependent upon the physiography of the area. Successional mangrove stands are considered to be less than five years old, and contain roughly one-third of the leaf biomass of mature stands. Therefore, two biomass factors were used in emission rate calculations. Where successional mangrove stands were identified, the lower biomass factor was used. In mature stands almost all of the leaf biomass is in the mangrove canopy.

Table 4.2.1-a MANGROVE SWAMP - COMMON SPECIES

Species	Common Name
Overstory -	
Avicennia germinans	Black Mangrove
Laguncularia racemosa	White Mangrove
**Rhizophora mangle*	Red Mangrove
Conocarpus erectus	Buttonwood

Table 4.2.1-a MANGROVE SWAMP - COMMON SPECIES (continued)

Understory -	
Saplings of overstory	
Bacharix halimifolia	Salt Myrtle
Iva frutescens	March Elder
Borichia frutescens	Sea Ox-eye
Ground cover -	
Distichlis spicata	Salt Grass
Batis maritima	Batis

*dominant

Table 4.2.1-b MANGROVE LEAF BIOMASS FACTORS

Type of Association	Biomass of Sample Plots	Average Biomass
Overwash	7263 kg/hectare 6946 kg/hectare	
Riverene	3810 kg/hectare 9510 kg/hectare	641.6 gm/m^2
Fringe	5934 5843 kg/hectare 7036	
Island	4990 kg/hectare	
Su :cession	2215 kg/hectare	221.5 gm/m^2

Reference: (Lugo and Snedaker, 1974)

4.2.2 Pine

The composition of this group is varied, however, the major portion of the biomass is dominated by one or two species. Often slash pine or longleaf pine occur in a closed canopy, thus limiting understory development.

Table 4.2.2-a lists the most common plant species found in the pine association. Table 4.2.2-b shows the range of needle biomass figures found for this plant association. The leaf biomass figure of 662.5 was selected because it came from the most local source and seemed to concur with the expected value based upon the climatology and physiography of the study area.

Table 4.2.2-a PINE - COMMON SPECIES

Species	Common Name
Overstory -	
*Pinus elliottii	Slash Pine
Pinus palustris	Longleaf Pine
Pinus serotina	Pond Pine
Quercus minima	Dwarf Oak
Quercus laurifolia	Laurel Oak
Quercus nigra	Water Oak
Quercus pumila	Runner Oak
Quercus geminata	Scrub-live-oak
Understory -	
*Serenoa repens (5-25% coverage)	Saw Palmetto
Myrtica cerifera	Wax Myrtle
Ilex cassine	Dahoon holly
Sambucus simponii	Elderberry
Seshenia punicea	Seshenia
Vaccinium arboreum	Sparkleberry
Viburnum rufiduluns	Black Haw
Lyonia Lucida	Fetterbush

*dominant

Table 4.2.2-a PINE - COMMON SPECIES (continued)

Species	Common Name
Rhus copallina	Winged Sumac
Rubus spp.	Blackberry
Asimina spp.	Paw-paw
Ilex glabia	Gallberry
Gaylussacia dumosa	Dwarf Huckleberry
Vaccinium myrsinites	Ground blueberry
Hypericum spp.	St. John's Wort
Ascyrum tetia.	St. John's Wort
Lyonia ferraginca	Staggerbush
Myrica pulsilla	Dwarf Wax Myrtle
Pterocaulon undulatum	Rabbit Tobacco

Table 4.2.2-b PINE LEAF BIOMASS FACTORS

Location/Type	Biomass	Source
N. Carolina		(Bernier, 1975)
Loblolly Plantation	480 g/m	
Duke 17 year Loblolly Plantation	750 g/m^2	(Arnts, *et al*, 1977)
Calhoun Experimental Forest/S. Carolina Loblolly Plantation	700 g/m^2	(Metz and Wells, 1965)
Several stands-several types/sub-boreal region	500-550 g/m^2	(Ovington, 1962)
Slash Pine Florida average	662.5 g/m^2	(Bayley, 1976)
Tampa/St. Petersburg	*662.5 g/m^2	

*Pine canopy only in plantations, or over-and-understory combined in natural stands of pine.

4.2.3 Citrus Trees

Good information is readily available for citrus groves due to their economic importance. The average leaf biomass of Florida citrus was calculated to be 658.3 g/m^2 (Bayley et al., 1976). The regression developed for California citrus and Florida citrus used by Bayley to determine leaf biomass was:

$$1.426 \times \text{age}^{0.80948} = \text{leaf biomass in kg}$$

(where 0.80948 is an exponential) (Turrell, et al. 1969)

Approximately 90% of the commercial citrus groves in the study area are planted in oranges. The remaining 10% and many abandoned groves are grapefruit. Orange groves in the study area were primarily the "Valencia" variety although some groves of the "Hamlin" variety did occur. All grapefruit groves found within the study area were "White Grapefruit." (personal communication with Dr. J. Allen, citrus experimanent station, Lake Alfred, FLA).

4.2.4 Oak-Gum-Cypress

Table 4.2.4-a lists the plant species most common to the oak-gum-cypress association.

Biomass varies with site quality, particularly with the difference in cypress domes in standing water, and cypress stands in or along flowing water courses.

The oak-gum-cypress plant association has a relatively small leaf biomass. This can be explained in terms of nutrient limitations and drainage conditions and the physiological adaptations of this type of vegetation to such conditions; the conditions can best be described as constituting a physiological drought for the vegetation. This type of broad trend has been characterized by Bazilevich, et al., (1970), for general forest types, for example:

Total Plant Biomass, by Veg. Type	g/m^2
Broadleaf forest on red and yellow soils	45,000
Broadleaf forest - swampy	40,000
Floodplain forest	25,000
Meadow - bog	20,000

Thus lower biomass is expected in seasonally undated areas.

Cypress are deciduous, therefore a seasonal fluctuation of leaf biomass exists. The values reported here are March-October averages. The minimum leaf biomass occurs in January with 10 g/m^2. Leaf and twig fall occurs in October - November and new growth begins in March. The March through October understory average is approximately 40-50 g/m^2 (Odum and Ewel, 1976). Table 4.2.4-b summarizes the leaf biomass factors for the oak-gum-cypress association.

Table 4.2.4-a OAK-GUM-CYPRESS - COMMON SPECIES

Overstory -	
Taxodium distichum (vav. nutans)	Pond Cypress
Nyssa biflora	Swamp Tupelo
Taxodium distichum	Bald Cypress
Fraxinus caroliniana	Walter Ash
Acer rubrum	Southern Red Maple
Nyssa sylvatica	Black Gum
Liquidumbar styraciflua	Sweetgum
Quercus nigra	Water Oak
Sabal palmetto	Sabal Palmetto
Carpinus caroliniana	Blue Beech
Ilex cassine	Dahoon Holly
Juniperus silicicola	Southern Red Cedar
Understory -	
Myrica cerifera	Wax Myrtle
Cephalanthus occidentalis	Buttonbush
Tyoria Lucida	Fetterbush
Salix virginiana	Virginia Willow
Ludwigia peruviana	Primrose Willow
Similax laurifolia	Bamboo Briar
Rhus toxicodendron	Poison Ivy
Itea virginica	Sweet-spires

Table 4.2.4-a OAK-GUM-CYPRESS - COMMON SPECIES (continued)

Groundcover -

Polygonum punctatum	Smartweed
Lachnanthus caroliniana	Redroot
Saururus cernuus	Lizard's tail
Rubus spp.	Blackberry
Woodwardia virginica	Virginia Chain fern
Osmunda cinnamonmea	Cinnamon Fern
Osmunda regalis	Royal Fern
Sphagnum spp.	Sphagnum Moss

Table 4.2.4-b OAK-GUM-CYPRESS LEAF BIOMASS FACTORS (g/m^2)

Location/Type	Overstory	Understory	Total
[1]Withlacooche Fla/Dome	Cypress (121), Tupelo gum (160) = 281	50	331
[2]Fahkahatchee Strand, Fla/drained	Cypress (8167.6) Total x*0.02 = 163	40	203
[2]Fahkahatchee Strand, Fla/undrained	Cypress (19,790.3 g/m^2) Total x 0.02 = 315.8 g/m^2	50	365.8

[1] Mitsch, 1975

[2] Carter, et al., 1973 and Mitsch, 1975

*0.02 is equal to the portion of the total biomass which is present as leaves (Leith, 1975).

4.2.5 Xeric Oak Hammock

The predominance of evergreen vegetation in this association (i.e. xeric evergreen oaks) is attributable to a mineral retention adaptation by the plants. The relatively low biomass reflects the impoverishment due to excessively drained sandy soils.

Table 4.2.5-a lists the most common vegetation of this association. Table 4.2.5-b shows the range of biomass estimates available for this association. A leaf biomass factor 417 g/m^2 is most appropriate for the study area since it represents the most local source of information.

Table 4.2.5-a COMMON XERIC OAK HAMMOCK SPECIES

Species	Common Name
Overstory -	
**Quercus laevis*	Turkey Oak
**Quercus virginiana*	Live Oak
**Pinus elliottii*	Slash Pine
**Pinus palustris*	Longleaf Pine
Quercus geminata	Scrub-live-oak
Quercus falcata	Southern Red Oak
Quercus laurifolia	Laurel Oak
Quercus incana	Bluejack Oak
Quercus myrtifolia	Myrtle Oak
Pinus clausa	Sand Pine
Understory -	
**Diospyros ebenaster*	Persimmon
**Myrtica cerifera*	Wax Myrtle
**Serenoa repens*	Saw Palmetto (5-25% coverage)

*dominant

Table 4.2.5-a COMMON XERIC OAK HAMMOCK SPECIES (continued)

Saplings of overstory species especially:

Quercus myrtifolia	Myrtle Oak
Quercus geminata	Scrub Oak
Bumelia sp.	Buckthorn
Lyonia ferruginea	Staggerbush
Lyonia lucida	Fetterbush

Groundcover -

Aristida Stricta	Wiregrass
Andropogon spp.	
Polygala grandiflora	Beard Grasses
Asclepias spp.	Milkweeds
Berlandiera subacaulis	Green Eyes
Opuntia spp.	Prickly Pear
Sporobolus junceus	Pinewoods Dropseed
Chrysabalanus oblongifolius	Gopher Apple
Heterotheca graminifolia	Grassy-leaf Golden Aster
Sorghastrum secudatum	Lopsided Indiangrass

Table 4.2.5-b XERIC OAK HAMMOCK LEAF BIOMASS FACTORS

Location	Type	Leaf Biomass	Source
North Florida	Upland Oak	417 g/m^2	(Odum, Brown, 1973)
Brookhaven N.Y.	45 yr. old Oak-Pine	443 g/m^2	(Whittaker and Woodwell, 1969)
Cove Forest Great Smokey Mtns.	Mixed	351 g/m^2	(Spurr, Barnes, 1973)

Best Estimate: 417 g/m^2 including understory

4.2.6 Hydric Oak Hammock

The most common species present in this association are listed in Table 4.2.6-a. Specific Biomass data for the dominant species is also included.

Leaf biomass factors for the Hydric Oak Hammock were calculated using the mean tree method and the data from Table 12.

The mean tree method (Lieth and Whittaker, 1975) involves averaging the basal area of all the trees in this association and fitting the means to a regression line of leaf biomass and the diameter at breast height (DBH)to yield average leaf biomass per tree. This is then multiplied by the tree density in terms of trees per unit area to result in the leaf biomass factor per unit area. For this vegetation type it was assumed that approximately 10% of the leaf biomass occurred in the understory. Therefore, the leaf biomass factor per unit area for the Hydric Oak Hammock plant association is approximately 615 g/m^2 (Figure 4.2.6-a).

Table 4.2.6-a COMMON HYDRIC OAK HAMMOCK SPECIES

Dominant Overstory Species (Wilbur 1975, Carter et al., 1973)

Species	Common Name	Relative Dominance (%)	Basal Area ft^2/acre	Density (trees per acre)
Quercus laurifolia	Laurel Oak	57.19	82.18	103.99
Acer rubrum	Red Maple	14.10	20.25	75.23
Nyssa biflora	Swamp Tupelo	8.11	11.65	50.89
Pinus elliotii	Slash Pine	11.66	16.75	15.49
Magnolia virginiana	Sweetbay	2.71	3.89	11.06
Liquidumbar styraciflua	Sweetgum	0.99	1.42	11.06
Ilex coriacea	Large Gallberry	0.76	1.09	11.06

Table 4.2.6-a (cont.) COMMON HYDRIC OAK HAMMOCK SPECIES

Dominant Overstory Species (Wilbur 1975, Carter *et al.*, 1973)

Species	Common Name	Relative Dominance (%)	Basal Area ft /acre	Density (per acre)
Fraxinus pennsylvanica	Green Ash	0.54	0.77	11.06
Ulmus americana	American Elm	2.33	3.35	6.64
Carya aquatica	Water Hickory	0.53	0.75	6.64
Fraxinus caroliniana	Carolina Ash	0.41	0.58	6.64
	Dominant Understory Species			
Vaccinium arboreum	Tree Sparkleberry	0.34	0.49	2.21
Salix caroliniana	Carolina Willow	0.19	0.28	2.21
Myrica cerifera	Southern Waxmyrtle	0.09	0.12	2.21
Ilex myrtifolia	Myrtle	0.09	0.12	2.21

Common Overstory Species

Species	Common Name
Quercus virginiana	Live Oak
Taxodium distichum	Bald Cypress
Sabal palmetto	Cabbage Palm
Quercus nigra	Water Oak
Persia borbonica	Red Bay
Gordonia lasianthus	Loblolly Bay
Juniperus silicicola	Southern Red Cedar
Carpinus caroliniana	Blue Beech
Cornus stricta	Stiffcornel Dogwood
Ilex coriacea	Sweet Gallberry
Ilex cassine	Dahoon Holly

Table 4.2.6-a (cont.) COMMON HYDRIC OAK HAMMOCK SPECIES

Common Understory Species	
Cephalanthus occ	Button Bush
Lyonia lucida	Fetterbush
Rhus toxicodendron	Poison Ivy
Similax Spp.	Greenbriar
Decumaiia barbara	Climbing Hydrangea
Itea virginica	Sweet-spires
Rhus copallina	Winged Sumac
Ilex myrtifolia	Myrtle-leaved Holly
Common Ground Cover	
Saururus cernuus	Lizard's Tail
Polygonum punctatum	Smartweed
Hydrocotyle spp.	Pennywort
Dyschoriste humistrate	Dyschoriste
Panicum spp.	Panicgrass
Carex spp.	Sedges
Woodwardia areolata	Neeted Chain Fern
Osmunda cinnamonea	Cinnamon Fern
Osmunda regalis	Royal Fern

Figure 4.2.6-a

Hydric oak hammock mean tree method of leaf biomass determination

The leaf biomass of an average tree is equal to the regression of the average diameter at breast height (DBH) on the average basal area (Auerbach, 1971, Pool, et al., 1974).

1. Average basal area equals:

$$\frac{\text{Total basal area}}{\text{Total number of trees}} = \frac{143.69}{318.61} = \underline{0.45 \text{ ft}^2}$$

2. Average diameter at breast height equals: $\frac{\text{Basal area} \times 4}{3.14}$ (Leith and Whittaker, 1975):

$$= \frac{0.45 \text{ ft}^2 \times 4}{3.14} = 0.75 \text{ ft} = 22,860 \text{ cm DBH}$$

3. Leaf biomass per tree is estimated from the corrected regression lines of DBH on dry leaf weight developed by Auerbach and Nelson (1975).

Average leaf biomass = 8kg/tree

4. If there are an average of 318.61 trees per acre (Table 4.2.6-a) then the total overstory leaf biomass equals:

$$8000\text{g/tree} \times 318.61 \text{ trees/acre} \times 2.171 \times 10^{-4} \text{ acre/m}^2 = \underline{553.3 \text{ g/m}^2}$$

5. Assuming roughly 10% of the total leaf biomass is understory then the total association figure equals:

$$553.3 \text{ g/m}^2 \text{ overstory} + 61.5 \text{ g/m}^2 \text{ understory} = \underline{\underline{614.8 \text{ g/m}^2}}$$

4.2.7 Representative Shrubs

The shrub species listed in Table 4.2.7-a are typical of disturbed and early successional vegetation. Shrubs which occur as understory vegetation for other plant associations are included in the appropriate association discription. Biomass estimates are shown in Table 4.2.7-a. The total leaf biomass of this association is estimated at 200 g/m^2. Approximately 90% of the leaf biomass of this vegetation type is included in overstory. (Carter *et al.*, 1973)

Table 4.2.7-a COMMON SPECIES OF REPRESENTATIVE SHRUB

Species	Common Name
Overstory - sparse small in stature	
Quercus virginiana	Live Oak
Prunus serotina	Black Cherry
Pinus elliottii	Slash Pine
Pinus palustris	Longleaf Pine
Understory -	
Prunus serotina	Black Cherry
Diospyros virginiana	Persimmon
Myrtica cerifera	Wax Myrtle
Salix caroliniana	Willow
Aster carolinianus	Aster
Ground Cover -	
Eupatorium capillifolium	Dog Fennel
Eupatorium compositifolium	
Solidago microcephala	Goldenrod
Sesbania exaltata	Sesbania
Andropogon ssp.	Beardgrasses
Paspalum notatum	Bahia Grass
Panicum spp.	Panic Grasses
Bidens pilosa	Beggars Tick

Table 4.2.7-b LEAF BIOMASS OF REPRESENTATIVE SHRUBS

Baseline data compiled by Carter, *et al.*, 1973*

Species	Avg. Diameter	Avg. Ht.	Avg. Leaf Biomass
Myrica cerifera (Wax Myrtle)	4.6cm	3.0m	405g
Salix caroliniana** (carolina willow)	7.9cm	7.4m	490g

* Field observation in the study area indicates an approximate ground coverage of 2 sq meters for wax myrtle of 5 cm DBH, and 3 square meters for willow trees/shrubs of 8 cm DBH. The understory and ground cover biomass are an additional 11%.

Thus the leaf biomass per unit area is: 200 g/m^2 for wax myrtle and 160 g/m^2 (willow). The average is 180 g/m^2. If understory and ground cover vegetation are added to this the total leaf biomass is approximately 200 g/m^2.

**Representative sample tree, not average of all trees sampled; many samples obtained during and after leaf fall.

4.2.8 Palmetto

This vegetation type is early successional and appears in areas recently disturbed by clearing or burning. Two types of Palmetto are common to the study area: Saw palmetto *Serenoa repens* and Cabbage palm *Sabal palmetto*. *Sabal palmetto* is considered to be common in the overstory of the Hydric oak hammock, and is not discussed here. Saw palmetto is by far the most common species and occupies almost pure stands in disturbed areas. Overstory and understory species are relatively insignificant to this classification.

Since Saw Palmetto is of questionable economic value, not much information concerning leaf biomass is available. The leaf biomass of Palmetto can be estimated from the range of biomass of the associations in which Saw Palmetto occurs. The range of biomass for Palmetto was estimated by WSU to be probably between that of pine flatwoods (663 g/m^2) and successional shrubs (200 g/m^2). Based upon this range and upon measurements of Palmetto leaf biomass made during field sampling, a value of 450 g/m^2 was estimated to be representative of the study area.

4.2.9 Pasture

For the categories of unimproved pasture, improved pasture and the marine samples the area enclosed was used directly in the calculation of the emission factors as discussed in Section 1.1.

Species lists for improved and unimproved pasture are shown in Table 4.2.9-a.

Table 4.2.9-a PASTURE

Species	Common Name
Overstory - sparse	
Quercus virginiana	Live Oak
Pinus palustrus	Longleaf Pine
Pinus elliottii	Slash Pine
Understory -	
Unimproved Pasture	
Eupatorium capillifolium	Dog Fennel
Eupatorium compositifolium	Dog Fennel
Solidago microcephala	Goldenrod
Andropogon spp.	Beardgrasses

Table 4.2.9-a PASTURE (continued)

Species	Common Name
Unimproved Pasture	
Paspalum notatum	Bahia grass
Panicum spp.	Panic grass
Bidens pilosa	Beggars tick
Sestania exaltata	Sestania
Improved Pasture	
Groundcover -	
Paspalum notatum	Bahia grass
Cynodon dactylon	Bermuda grass
Digitaria sanguinalis	Crabgrass
Axonopus affinis	Carpetgrass
Trifolium spp.	Clover
Spobolus poirettii	Smutgrass

4.2.10 Row Crops

Row crops in the Tampa/St. Petersburg study area include tomatoes, strawberries, beans, squash, okra, melons, peppers, cucumbers and cabbage (Florida Agricultural Statistics, 1977).

Crop yields often average 30,000 lbs./acre for tomatoes, the major row crop, and 8,000 lbs./acre for okra. High yields can be attained even in these sandy leached soils, with the application of large amounts of fertilizer. Two crops per year are often attained. The primary growing seasons are March-July and October-January, although cold-weather crops such as cabbage may be growing all year. All categories of row crops which were sampled, except okra and tomatoes, used the same sample collecting procedure as for pasture samples. For each tomato and okra sample, one entire plant was enclosed. The plant emissions were sampled and then the plant was clipped and the leaves were separated and dried. Leaf biomass factors were obtained by multiplying the average planting density (plants/m^2) by the average of the dry leaf weights of the plants sampled. Therefore, for tomatoes this is equal to: 1.73 plants/m^2 x 4.9g dry wt leaves/plant = 8.48g/m^2. For okra the leaf biomass factor is: 8.9 plants/m^2 x 8.1g dry wt leaves = 72.09g/m^2. This comparatively low leaf biomass accounts for a small part of the productivity. If for example the crop yield is added, the fruit plus leaf biomass becomes:

Tomato

3,000 lbs. fruit/acre = 3363g/m^2 x 0.10g dry wt/g wet wt. = 1634.3
leaves = 8.48
total g/m^2 = 1643

Okra

8,000 lbs. fruit/acre = 4360g/m^2 x 0.25g dry wt/g wet wt. = 1090 g/m^2
leaves = 72.09
1162 g/m^2

The total biomass figures are comparable with productivity values for Wisconsin hay and corn yields and are somewhat higher than the 600-920 g/m^2 reported for row crops in Tennessee (Lieth and Whittaker, 1975).

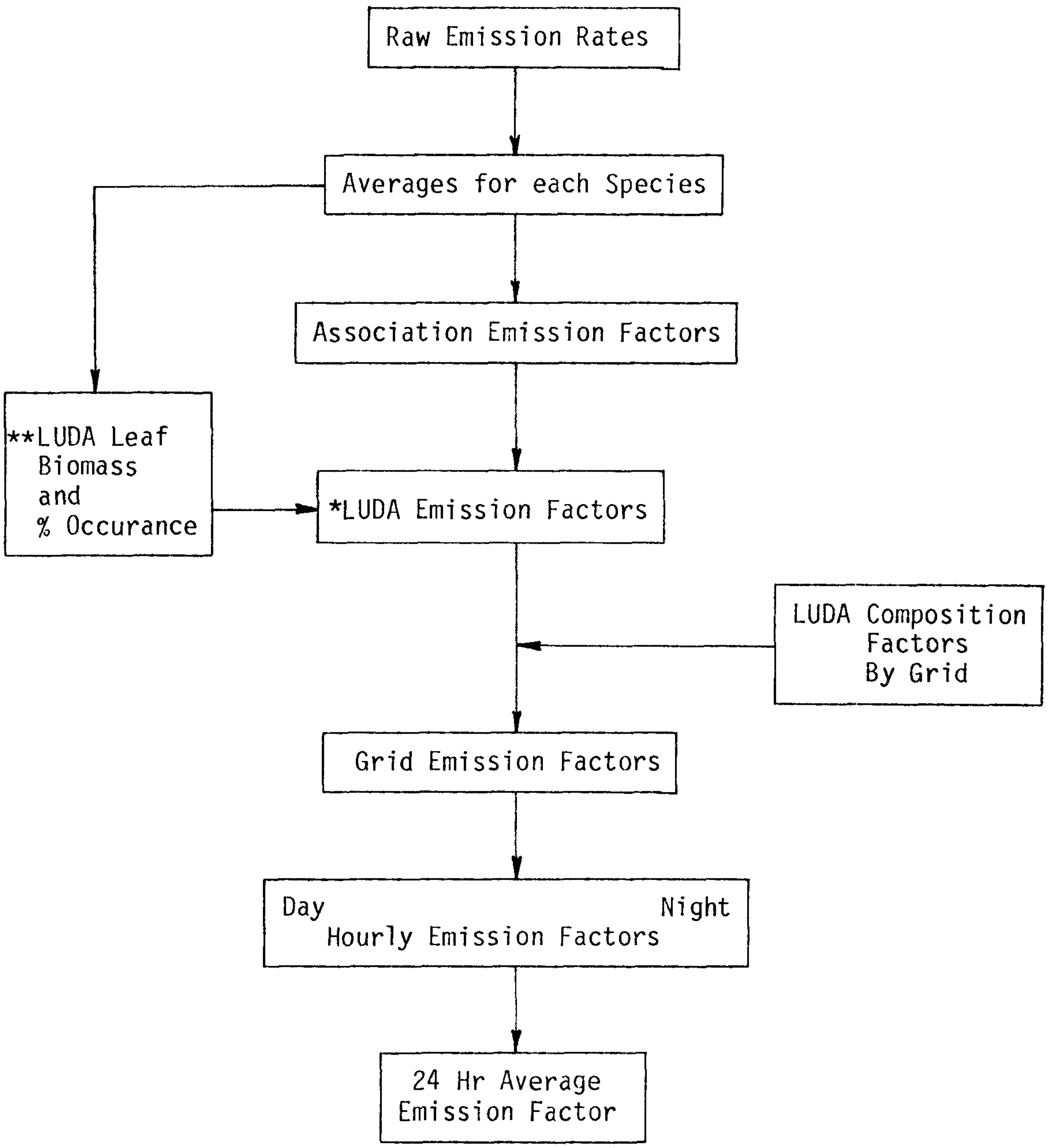
Conversion factors from yield to g/m^2 dry weight for okra and tomatoes were obtained from Dr. D. Bienz, Professor of Horticulture at WSU. All other information concerning crops, plant spacing, growing season and yields was obtained from Dr. J. Montelaro, Professor and Extension Vegetable Specialist, Vegetable Crops Department, University of Florida at Gainesville.

5. DEVELOPMENT OF EMISSION INVENTORY

The previous sections have described the background work which was necessary in order to develop a detailed estimate of natural hydrocarbon emissions for the Tampa/St. Petersburg area. The following section will describe the collation of the basic sets of information into an emission estimate.

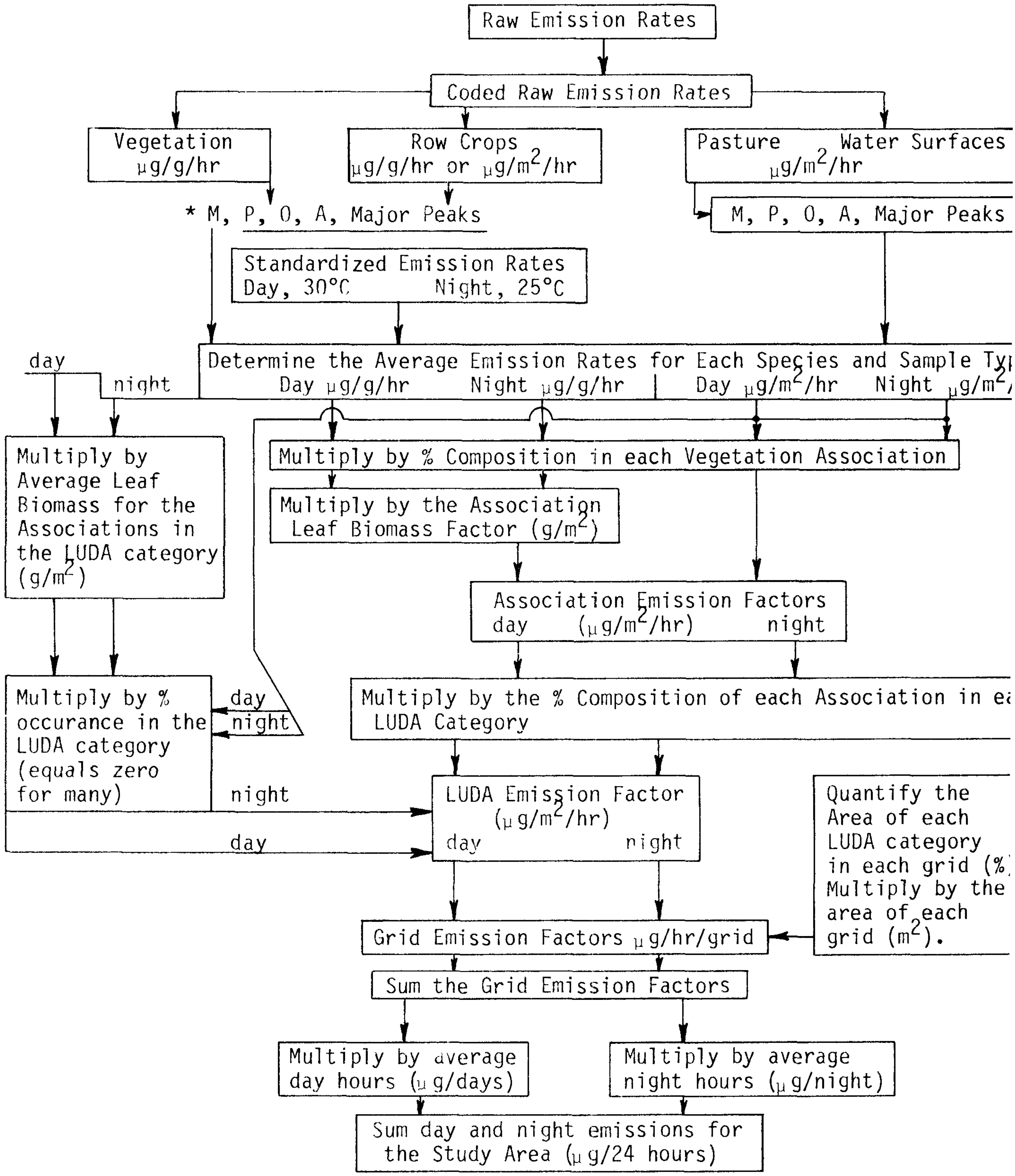
Figure 5-a is a generalized schematic outline of the methodology used to develop an inventory of the natural hydrocarbon emissions by grid. Basically it involves calculating average emission rates for each vegetation species and sample type collected during the field study. These average emission rates are then grouped into vegetation associations. The vegetation associations are multiplied by their leaf biomass factors and grouped into land use categories compatible with the LUDA map designations. In addition, LUDA categories may contain certain species/sample types that do not occur in associations. For example, ornamental shrubs like oleander occur in the residential LUDA category but in none of the associations. Some of these additional species' emissions are measured in terms of $\mu g/g$ leaf biomass/hour (eg. oleander). These are then converted to $\mu g/m^2/hr$. These LUDA emission factors are then multiplied times the percent composition of each LUDA category in each grid. The individual grid emissions can then be totaled for day and night emissions to get a daily emission rate (24 hrs). Figure 5-b is a detailed schematic of the procedures used to arrive at hourly emission

Figure 5-a. Simplified Schematic of Natural Emission Inventory Proceedure for the Tampa/St. Petersburg Study Area.



*LUDA = Land Use and Land Cover Data Analysis System
**This route was used only for species which occurred in LUDA Category, but were not present in any Association (see text).

Figure 5-b. Detailed Schematic of Proceedure Used to Compile Tampa/ St. Petersburg Natural Hydrocarbon Emission Inventory.



*M=methane, P=Parafins, O=Oefins, and A=Aromatics.

factors by grid and summary emission factors for the entire study area from the raw emission rates. The following section describes the elements which are illustrated in each step of this schematic.

5.1 SUMMARY OF AVAILABLE DATA

We have discussed the following elements of the emission inventory data:

1. Field sampling program. The program was conducted between April and August 1977. Emission rates were measured for various species during all types of weather which occurred during the study period. Repetitive diurnal samples were collected twice for species representative of each vegetation association. Samples were analyzed within 24 hours of collection. Emission rates were quantified in terms of methane(M), paraffins(P), olefins(O), aromatics(A), total nonmethane hydrocarbons(TNMHC) and for each major hydrocarbon peak.
2. Emission rate algorithms. It was known that all emissions were responsive to temperature and that only isoprene emissions seemed sensitive to light. Algorithms generated in the EPA-Corvallis laboratory for Slash Pine and for Live Oak were used to standardize field data. It was assumed that all nonmethane non-isoprene emission rates for vegetation would be similar to slash pine emission algorithms, that all isoprene emission rates would be similar to one of the Live Oak isoprene emission algorithms and that light was saturating for isoprene emissions in the daytime.
3. The determination of the distribution and quantitation of leaf biomass. This part of the study was based upon land use and land

cover maps, personal observations in the study area, extensive search of the available literature and limited field measurements. The leaf biomass factors were estimated for each of the vegetation associations in the study area. Land use definitions were used to estimate the distribution of associations and species within LUDA categories. LUDA maps were used to estimate the distribution and types of leaf biomass in each grid.

From the above data a detailed natural emission inventory for each grid in the study area was constructed using the following steps.

5.2 STEP 1: CODING OF RAW EMISSION RATES

The variables which were recorded during the collection of each sample and which were thought to be important in describing and predicting differences in emission rates were stored on a Washington State University computer tape along with the raw emission rate data for each sample. This was done so that relationships between emission rates and sample variables might become clearer. The raw emission rate data is stored in the following format:

1. Columns 1-3 contain the sample number. Numbers range from 001 to 631.
2. Columns 4-6 contain the vegetation species or vegetation category. Numbers range from 001 thru 950. The first digit corresponds to the broad vegetation type of the sample. The second digit corresponds to the genus of the sample in that type, and the third digit represents the species. For example, 001 and 011 are both mangrove however, they are separate genera and species. Numbers 101 and 102 represent two species of pines. Table 5.1-a lists the species codes and the sample types to which they correspond.

Table 5.1-a VEGETATION SPECIES/SAMPLE CATEGORY CODES

Code	Category
001	Black Mangrove
011	White Mangrove
021	Red Mangrove
101	Slash Pine
102	Longleaf Pine
103	Sand Pine
104	Southern Red Pine
601	Australian Pine
201	Laurel Oak
202	Water Oak
203	Turkey Oak
204	Live Oak
205	Southern Red Oak
206	Bluejack Oak
207	Myrtle Oak
208	Willow Oak
301	Saw Palmetto
311	Sabal Palmetto
401	Wax Myrtle
411	Elderberry
421	Dwarf Huckleberry
431	Groundsel Bush
441	Persimmon
451	Dahoon Holly
461	Red Bay
471	Red Mulberry
481	Sweet Acacia
491	Viburnum
492	Oleander
501	Oranges
511	Grapefruit
111	Pond Cypress
112	Bald Cypress
611	Sweetgum
621	American Elm
631	Carolina Ash
641	Willow
651	Red Maple
671	Hickory
700	Mixed grasses
701	Bahia
711	Bermuda
721	Clover
731	Pensicola
741	Sawgrass
801	Tomatoes
811	Strawberries
821	Beans
831	Watermellon
841	Okra
901	Grass mudflat (marine) 0"-2" water
902	Grass mudflat (2"-12")
903	Grass mudflat (12"-2')
904	Grass mudflat (2'-5')
905	Sandy Bottom (>5')
911	Decaying marine algae
912	Decaying maring grass
913	Decaying mixed veg.
921	Mudflat no grass exposed 0"-2"
922	Mudflat (2"-12")
923	Mudflat (12"-2')
924	Mudflat (2'-5')
925	Mudflat (>5')
931	Sandy Beach
941	Fresh water marsh (0"-2")
942	Fresh water marsh (>12")
943	Fresh water marsh Hyacinth
944	Fresh water marsh Waterlilly
950	Oyster Beds

3. Columns 7-10 contain the location of the sample within the study grid. The digits correspond to the grid coordinates.

4. Column 11 is a one-digit code which defines the person who collected the sample. This was done so that any trends in data related to sampling technique could be noted. 1 = Don Stearns, 2 = Phil Sweany, 3 = Pat Zimmerman.

5. Columns 12-16 represent the date in the format; Month, Day, Day, Year, Year.

6. Columns 17-18 represent the time at which the sample was collected in hours from 01-24.

7. Columns 19-21 contain the number of the canister in which the sample was collected from 001-999. This was recorded so that any anomalous emission rate trends corresponding to a specific sample container could be determined.

8. Column 22 contains a subjective estimation of the sunlight conditions where 0 is dark, 1 is dusk or overcast, 2 is partly cloudy or shady, 3 is filtered sunlight or early morning or late afternoon sunlight, and 4 is the direct noonday sunlight.

9. Column 23 contains a subjective estimation of the illumination of the enclosed branch or "bag sunlight" using the same scale as item 8.

10. Column 24 describes the rain, cloud, and moisture conditions during the time of collection of the sample:

Code	Cloud Cover	Soil	Leaves
0	<50%	dry	dry
1	<50%	dry	wet
2	<50%	damp	dry
3	<50%	wet	wet
4	Raining during sample		
5	>50%	dry	dry
6	>50%	dry	wet
7	>50%	damp	dry
8	>50%	damp	dry
9	>50%	Raining during sample	

11. Columns 25 and 26 describe the wind conditions during the collection of the sample:

Column 25		Column 26	
Code	Direction	Code	Direction
0	N	0	calm
1	E	1	0-7 mph
2	S	2	7-15
4	W	3	10-20
5	NE	4	20-30
6	NW	5	30-40
7	SE	6	40-50
8	SW	7	Too windy for good sample
9	calm/variable		

12. Column number 27 contains a code from 0-9 which is a subjective evaluation of the health of the plant being sampled:

Code	Age	Health
0	dead	---
1	mature	stagnant
2	medium	poor
3	medium	good
4	young	poor
5	young	good
6	sapling	poor
7	sapling	good
8&9	does not apply (refers to "flat samples")	

13. Columns 28 and 29 contain the temperature of the ambient air at the time that the sample was collected in °C.

14. Columns 30-31 contain the temperature of the air in the enclosure at the end of the sample period in °C.

15. Columns 32 and 33 are blank.

16. Column 34 contains a letter code from a to z which describes the time between the collection of the sample and its analysis:

Code	Time
a	<2 hours
b-t	2-20 hours
u-y	2-6 days
z	>7 days

17. The total length of time that the vegetation sampled was enclosed is coded in column 35:

Code	Time (minutes)	Code	Time	Code	Time
A	10	I	18	R	27
B	11	J	19	S	28
C	12	K	20	T	29
D	13	L	21	U	30
E	14	M	22	V	31

Code	Time (minutes)	Code	Time	Code	Time
F	15	N	23	W	32
G	16	O	24	X	33
H	17	P	25	Y	34
		Q	26	Z	35

18. Column 36 is a subjective evaluation of reliability of the emission rate results where zero is least reliable and 9 is most reliable. This number was assigned by allocating a possible six points to quantitation of the analytical results and three points to collection of the sample. Caution must be exercised when attempting to interpret reliability factors, for if one of the components is low and the other is high, the reliability could appear to be "average" when in fact, it would be very low. Samples which were obviously contaminated or invalid due to sampling or analytical difficulties have been deleted.

19-27 Columns 37-80 contain the coded emission rates for the various components of the sample. The emission rate values are four digit numbers where the first three digits represent the value and the fourth digit represents the position of the decimal point. For example, a value of 2342 would be equal to an emission rate of 23.4. Negative emission rates sometimes occurred for some components of some species. Negative emission rates imply that an uptake occurs. Negative emission rates occur when the amount of hydrocarbons in the background sample (C_{sb} X Ve) is greater than the amount of hydrocarbons in the emission rate sample (C_{ss} (Zv + Ve)). If the dead volume (Ve) is overestimated an apparently negative emission rate can occur. This could easily happen for sweet gums in which very high background values sometimes occur.

However, in most cases the negative values appear to be representative of actual conditions. For negative emission rates the minus sign is considered as a first digit for placement of the decimal. Therefore, values of -202 and -200 would equal -2.0 and -.020 respectively. The identities of the emission rate components are as follows:

Item#	Column	Description
19	37-40	Methane
20	41-44	Total non-methane hydrocarbons
21	45-48	Paraffins
22	49-52	Olefins
23	53-56	Aromatics
24	57-62	*Major Peak No. 1
25	63-68	Major Peak No. 2
26	69-74	Major Peak No. 3
27	75-80	Major Peak No. 4

*The "major peaks" may not be present for all samples.

The emission rate of each major peak is preceded by a two character code which identifies the peak as follows:

Code	Identity	Code	Identity
1. DL	d-Limonene	14. 17	unknown 17
2. AP	α-Pinene	15. 18	unknown 18
3. 3C	Δ^3-Carene	16. 20	unknown 20
4. BP	β-Pinene	17. 21	unknown 21
5. 9A	unknown 29-A	18. 22	unknown 22
6. 6A	unknown 26-A	19. 23	unknown 23
7. 1A	unknown 21-A	20. 24	unknown 24
8. MY	Myrcene	21. 25	unknown 25
9. TP	Terpinolene	22. 26	unknown 26
10. 0A	unknown 10-A	23. 27	unknown 27
11. UT	unknown terpenes	24. 28	unknown 28
12. IS	Isoprene	25. 29	unknown 29
13. 16	unknown 16		

5.3 STEP 2: DETERMINATION OF SPECIES EMISSION RATES

Since no change in non-isoprene emission rates with light intensity were apparent from the field data or the Tingey, et al., 1978b report, All raw nonmethane, non-isoprene emission rates for all vegetation samples (except some row crops), including those collected during the daytime and during the nighttime vegetation were standardized to 30°C for day and 25°C for night. All of the non-methane emission rates of isoprene emitters which were sampled during the daylight were standardized to 30°C for day. WSU's diurnal samples of isoprene emitters and Tingey et al., 1978a indicate that no isoprene is emitted in the dark. However, all of the other non-methane non-isoprene emissions from the isoprene emitters were standardized to day and to night.

Because of this scheme, emission samples were used in the day and in the night averages for all non-isoprene emissions. Therefore, the summation of N (number of samples used in each average) for all of the species in Appendix A will result in roughly twice the number of samples that were actually collected. Flat samples were not corrected for temperature. The emission rates of each species/emission category was then averaged (Appendix A). The variability of the average species emission rates in Appendix A is expressed as a Standard Deviation Error of the Mean(SD).

5.4 STEP 3: DETERMINATION OF ASSOCIATION EMISSION FACTORS

The estimated species/sample type composition for each association, as determined in Section 4, is shown in Table 5.4-a. Wherever each association occurred in the study area it was assumed to consist of the same species in the same proportions. The name of the association is shown in the first column followed by the code letter used to designate it on the computer tape. The "species code" column lists the species sample/type included in each association as defined in Table 5.1-a. The "multiplication factor" column

Table 5.4-a ASSOCIATION SPECIES/SAMPLE TYPE COMPOSITION FACTORS FOR TAMPA/ST. PETERSBURG, FLORIDA

ASSOCIATION	ASSN CODE	SPECIES CODE	MULTI FACTOR
Mangrove	A	001	32.11
		011	96.11
		021	512.88
		901	0.10
		902	0.40
		922	0.40
		923	0.10
Pine	B	101	331.25
		102	198.75
		201	66.25
		301	33.13
		491	33.13
		700	1.00
Citrus	C	501	592.47
		511	65.83
		711	0.25
		721	0.25
		731	0.25
		700	0.25
Oak-Gum-Cypress Domes	D	112	198.6
		651	16.55
		202	33.10
		611	33.10
		311	16.55
		451	6.62
		401	6.62
		641	19.86
		941	0.10
		741	0.90

WSU ASSN	ASSN CODE	SPECIES CODE	MULTI FACTOR
Drained Stand	E	112	121.88
		651	20.30
		202	20.30
		611	20.30
		311	12.18
		451	8.12
		401	8.12
		641	12.18
		941	0.10
		741	0.90
Undrained Stand	F	112	256.06
		651	18.29
		202	21.95
		611	18.29
		311	14.63
		451	7.32
		401	7.32
		641	21.95
		941	0.20
		942	0.20
		741	0.60
Xeric Oak	G	203	125.10
		204	137.61
		101	58.38
		102	41.70
		201	8.34
		206	8.34
		207	8.34
		103	8.34
		441	8.34
		401	8.34
		301	4.17
		700	1.00

Table 5.4-a ASSOCIATION SPECIES/SAMPLE TYPE COMPOSITION FACTORS FOR TAMPA/ST. PETERSBURG, FLORIDA (continued)

WSU ASSN	ASSN CODE	SPECIES CODE	MULTI FACTOR	WSU ASSN	ASSN CODE	SPECIES CODE	MULTI FACTOR
Hydric	H	201	325.84	Palmetto	J	301	450
Oak		651	98.37			700	1.0
		101	73.78				
		611	30.74	Improved	K	700	0.20
		621	12.30	Pasture		701	0.10
		671	12.30			711	0.10
		631	12.30			721	0.10
		401	6.15			731	0.45
		112	6.15			741	0.05
		311	6.15				
		204	6.15	Unimproved	L	700	0.45
		202	6.15	Pasture		701	0.10
		461	6.15			711	0.10
		451	6.15			721	0.05
		700	0.70			731	0.10
		741	0.30			741	0.20
Represent-	I	204	10	Crops	M	801	4.24
ative Shrub		101	6			811	0.10
		102	4			821	0.35
		401	51			841	3.60
		641	46				
		441	51				
		411	10				
		421	10				
		451	4				
		461	4				
		491	4				
		701	0.30				
		790	0.70				

lists emission multiplication factors determined by multiplying the association leaf biomass shown in Table 4.2-a times the estimated percent composition by species. Where identical species were not sampled, substitutions of species which were sampled and which were believed to have similar emission rates were made. For flat categories (surface water, pastures, etc.) the multiplication factor represents the percent of the ground in the association covered by the specific "flat sample" type. Therefore, each association contains leaf biomass factors multiplied by relative occurrance for canopy vegetation and percent ground cover factors for flat sample categories. Therefore, for each association, overstory, understory and soil/litter emissions are accounted for. The multiplication factors were then multiplied times the average emission rates for each respective species/sample type in Appendix A and the products were summed to give an emission factor ($\mu g/m^2/hr$) for each association. Since each sample emission rate consisted of TNMHC, M, P, O, A and major peaks for day and for night a computer was used to manipulate the data.

Appendix B lists the association emission rates and the variance (S^2) for each. The standard deviation is equal to the square root of the variance. The variance was chosen because it is easier to manipulate statistically for later use in estimating the overall variability of the final emission estimate. The association variance was calculated with the assumption that all samples were independent.

5.5 Step 4: DEVELOPMENT OF LUDA EMISSION ESTIMATES

Since the most detailed spatial characterization of the vegetation in the study area was based upon land use and land cover categories, it was necessary to estimate the composition of land use categories in terms of the vegetation associations and species present. Some vegetation species sampled (notably ornamentals) which were not normally included in association categories, were present in LUDA categories (such as the "residential" category). Therefore, the development of LUDA categories includes the emission rates of associations weighted by their relative percent ground cover, plus emission rates of individual vegetation species. Since species emission rates are in μg/g/hr, to convert to μg/m^2/hr emission factors the species emission rates were multiplied by the average leaf biomass of the LUDA category. This was determined from the average leaf biomass of each association in the LUDA category multiplied by its relative occurrance. The determination of association and species contributions to each LUDA category were based upon the definition of each LUDA category (Anderson, et al., 1976), association species composition (Section 4), and upon direct field observation in the study area.

Table 5.5-a outlines the information which was used for computer development of LUDA emission rates. The "map no." column refers to the numbers used to designate each LUDA category on the LUDA map (Figure 4.1-a). The column marked "ASSN Multiplication Factor" is derived from the percentage of each association in the LUDA category (1.00=100%) or the multiplication factor for individual species. As can be seen from Table 5.5-a, the LUDA category for "residential" does not add up to 100 percent. This is because this LUDA category includes species as well as associations. Therefore, for species whose emission rates were measured in μg/g/hr, the association multiplication factor is equal to the average species emission rate multiplied by the average LUDA leaf biomass times the relative percent occurrance. Other categories which do not add up to 1.00 (100%) include LUDA#52 "Lakes." In this case

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES

Map #	LUDA Category	ASSN CODE	WSU ASSN	SPECIES CODE	ASSN Multi. Factor
11	Residential	B	Pine	X	0.08
		G	Xeric Oak	X	0.08
		I	Shrubs	X	0.02
		*X	X	701	0.40
		X	X	481	14.04
		X	X	491	14.04
		X	X	492	17.55
		X	X	601	17.55
		X	X	471	7.02
		X	X	431	7.02
21	Cropland	M	Cropland	X	0.50
	Pasture	L	Unimproved Pasture	X	0.50
22	Orchards Nurseries Vineyards Misc.	SAME AS RESIDENTIAL			
24	Agriculture Land	M	Cropland	X	0.50
		K	Imp. Pasture	X	0.45
		L	Unimp. Pasture	X	0.05
25	Cropland	M	Crops	X	1.00
26	Pasture	K	Imp. Pasture	X	0.85
		F	Cypress Domes	X	0.10
		B	Pine	X	0.05
27	Specialty Farms	X	X	912	1.00
28	Horticulture Farms	SAME AS RESIDENTIAL			
29	Groves	C	Citrus	X	1.00

* X means "not applicable"

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES (continued)

Map #	LUDA Category	WSU ASSN CODE	WSU ASSN	SPECIES CODE	ASSN Multi. Factor
31	Herbaceous	J	Palmetto	X	0.10
	Rangeland	B	Pine	X	0.10
		D	Cypress	X	.04
		E	Cypress	X	.03
		F	Cypress	X	.03
		L	Unimp. Pasture	X	0.70
32	Shrubs	J	Palmetto	X	0.10
	Brush	I	Shrubs	X	0.20
	Rangeland	L	Unimp. Pasture	X	0.70
33	Mixed	J	Palmetto	X	0.08
	Rangeland	B	Pine	X	0.07
		D	Cypress	X	0.03
		E	Cypress	X	0.02
		F	Cypress	X	0.02
		I	Shrubs	X	0.08
		L	Unimp. Pasture	X	0.70
41	Deciduous	G	Xeric Oak	X	0.08
	Forest	H	Hydric Oak	X	0.20
42	Evergreen	B	Pines	X	0.60
	Forest	G	Xeric Oak	X	0.40
421	Planted	X	X	101	596.25
	Pine	X	X	102	66.25
43	Mixed Forest	Average 41 and 42			
51	Streams	X	X	941	0.10
	Canals	X	X	942	0.90
		X	X	943	0.40
		X	X	944	0.10

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES (continued)

Map #	LUDA Category	WSU ASSN CODE	WSU ASSN	SPECIES CODE	ASSN Multi. Factor
52	Lakes	X	X	941	0.10
		X	X	942	0.90
		X	X	943	0.20
		X	X	944	0.10
53	Reservoirs	X	X	941	0.10
		X	X	942	0.90
		X	X	943	0.20
		X	X	944	0.10
54	Bays	X	X	901	0.07
	Estuaries	X	X	902	0.13
		X	X	903	0.20
		X	X	904	0.10
		X	X	921	0.05
		X	X	922	0.05
		X	X	923	0.10
		X	X	924	0.20
		X	X	925	0.10
		X	X	911	0.05
		X	X	912	0.20
		X	X	913	0.10
		X	X	950	0.20
55	Gulf of Mexico	X	X	901	0.05
		X	X	902	0.15
		X	X	903	0.20
		X	X	904	0.10
		X	X	905	0.20
		X	X	921	0.02
		X	X	922	0.03
		X	X	923	0.15
		X	X	924	0.05
		X	X	925	0.05
		X	X	911	0.05
		X	X	912	0.10
		X	X	193	0.05
		X	X	950	0.10

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES (continued)

Map #	LUDA Category	WSU ASSN CODE	WSU ASSN	SPECIES CODE	ASSN Multi. Factor
61	Deciduous Forested Wetland	D	Cypress Dome	X	1.00
612	Forested Evergreen Wetland	D	Cypress	X	0.30
		E	Cypress		0.20
		F	Cypress		0.50
6121	Mangroves	A	Mangroves	X	1.00
621	Non Forested Wetland	X	X	741	0.10
		X	X	941	0.10
		X	X	942	0.90
		X	X	943	0.40
		X	X	944	0.10
71	Dry Salt Flats			931	1.00
72	Beaches	X	X	913	0.07
				911	0.07
				912	0.07
73	Sandy Non Beaches	X	X	931	1.00
74	Barren Rock	--	--	--	0
75	Strip Mines	X	X	931	1.00
76	Transitional Barren Land	X	X	931	1.00
77	Mixed Barren Land	X	X	931	1.00

100% of the lake is covered with water (Species sample type codes 941 and 942). Additionally, approximately 30% of the surfaces of lakes were estimated to be covered by aquatic plants (ES&ET, 1974). Appendix C lists the emision rates and their variances for each LUDA category.

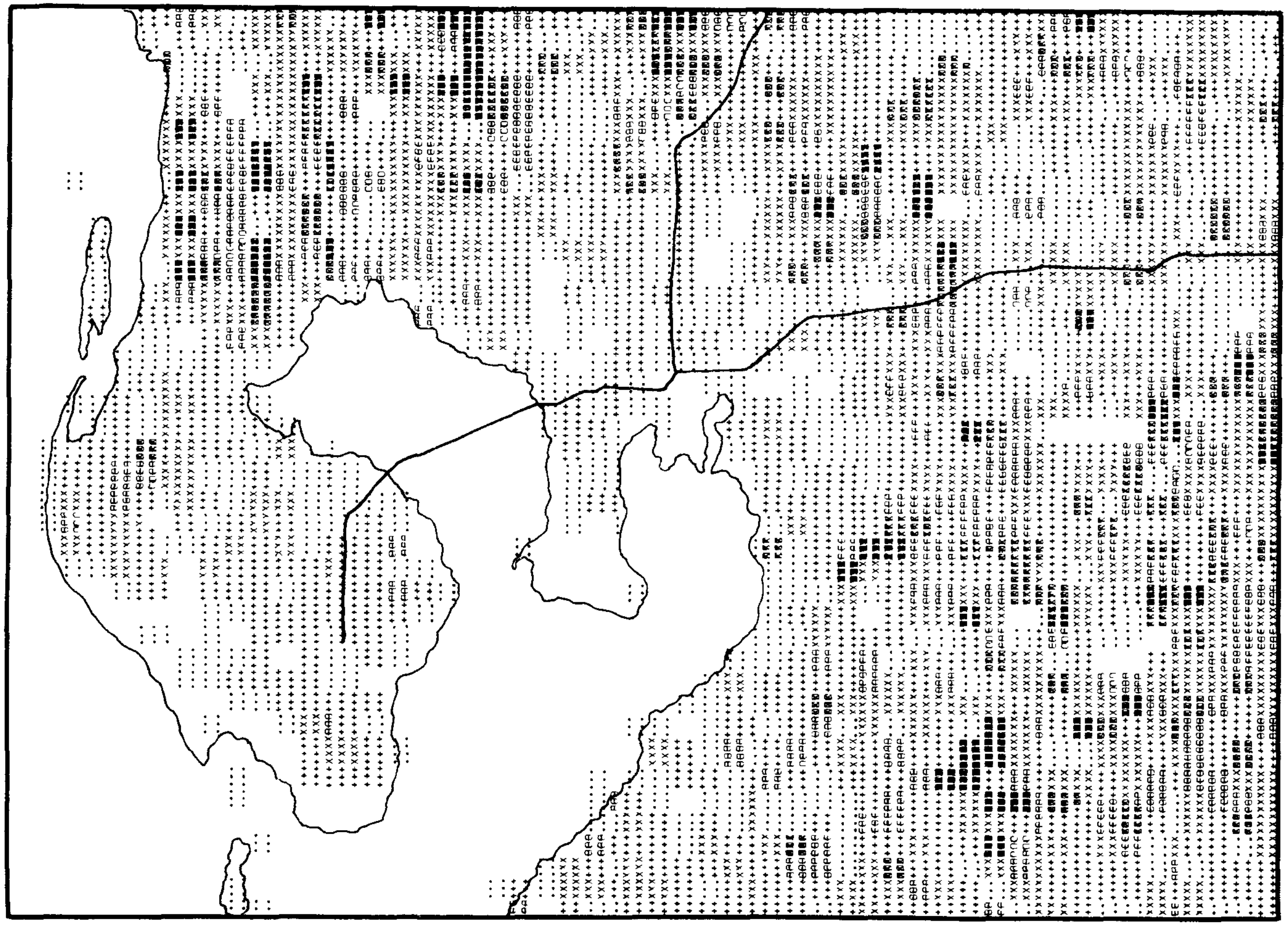
5.6 STEP 5 DETERMINATION OF GRID EMISSION RATES FOR THE STUDY AREA

Land use categories for each grid in the study area were estimated from a LUDA map, as previously described. The grid number and its associated LUDA composition in % grid area were then coded into the computer. Next, for each grid, the emission rates for each LUDA category ($\mu g/m^2/hr$) were multiplied by their percent occurrance in the grid and by the area of the grid (m^2) for day and for night. The results were hourly emission rates for each grid for daytime at a temperature of 30°C and for nighttime at a temperature of 25°C. These hourly emission rates were then used to prepare daily emission density maps for the study area. To prepare the maps each day (24 hours) was assumed to consist of 12 hours of the daytime emission rate plus 12 hours of the nighttime emission rate for each grid.

The emission densities of each grid for methane, TNMHC, paraffins, olefins and aromatics were then plotted separately on an x-y coordinate system by computer with the aid of Symmap, a packaged data presentation (Dudnik, 1971). Figures 5.6-a through 5.6-e illustrate the emission density maps. It should be noted that separate ranges were selected for methane emissions and TNMHC emissions. Emission ranges for paraffins, olefins and aromatics are identical to facilitate emission density comparisons. The maps clearly illustrate that the primary biogenic emissions are olefins and that these tend to occur in forested regions. It can be seen that grid emission densities are fairly low with a maximum TNMHC emission of approximately 88 $mg/m^2/$ day (24 hours). This is equivalent to an average flux of 3,667 $\mu g/m^2/hr$.

TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY

TOTAL NONMETHANE HYDROCARBON (TNMHC)



KEY ($mg/m^2/day$)

0-13
13-25
25-38
38-50
50-63
63-76
76-88

Figure 5.6-a

TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY

METHANE

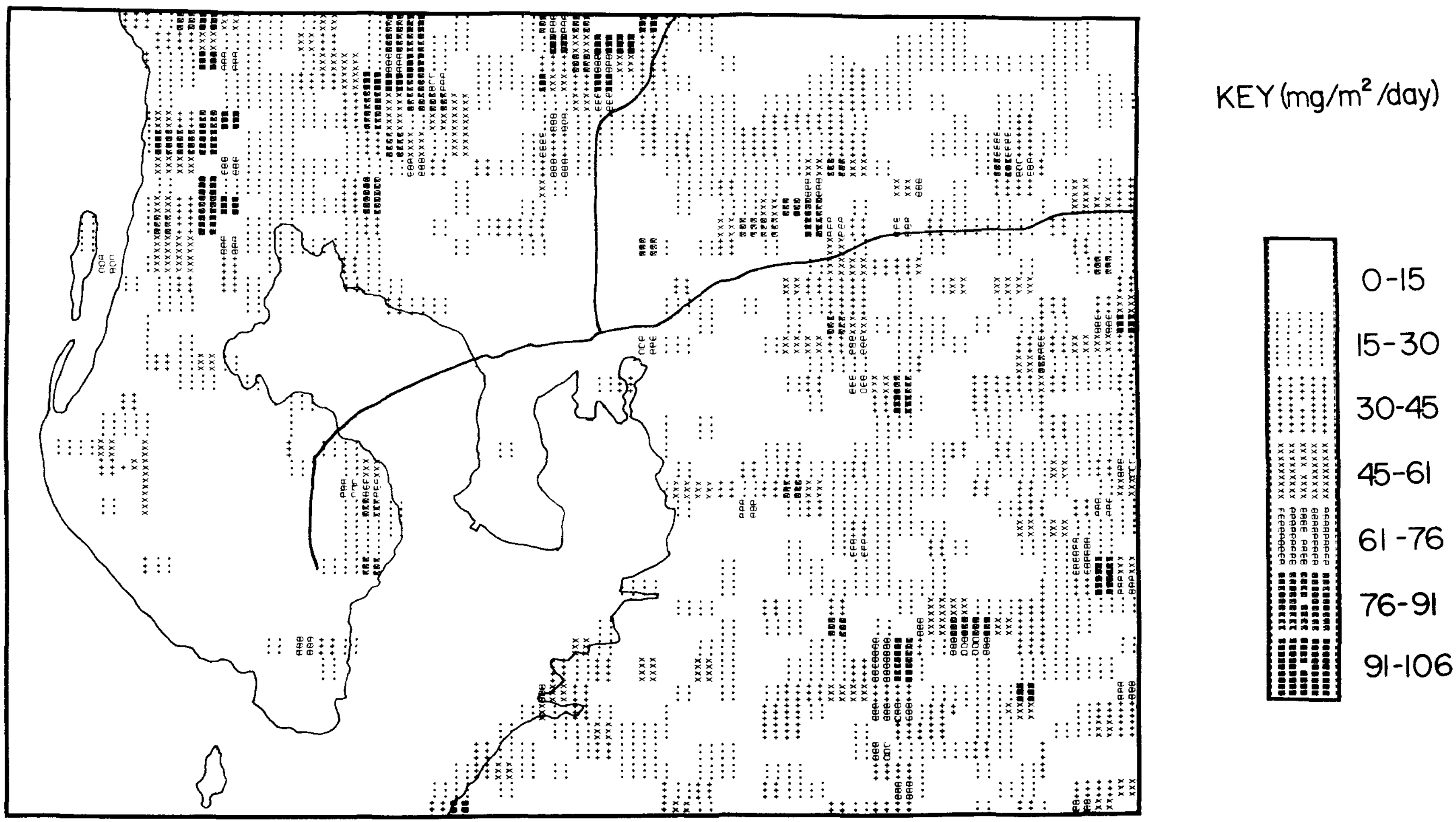
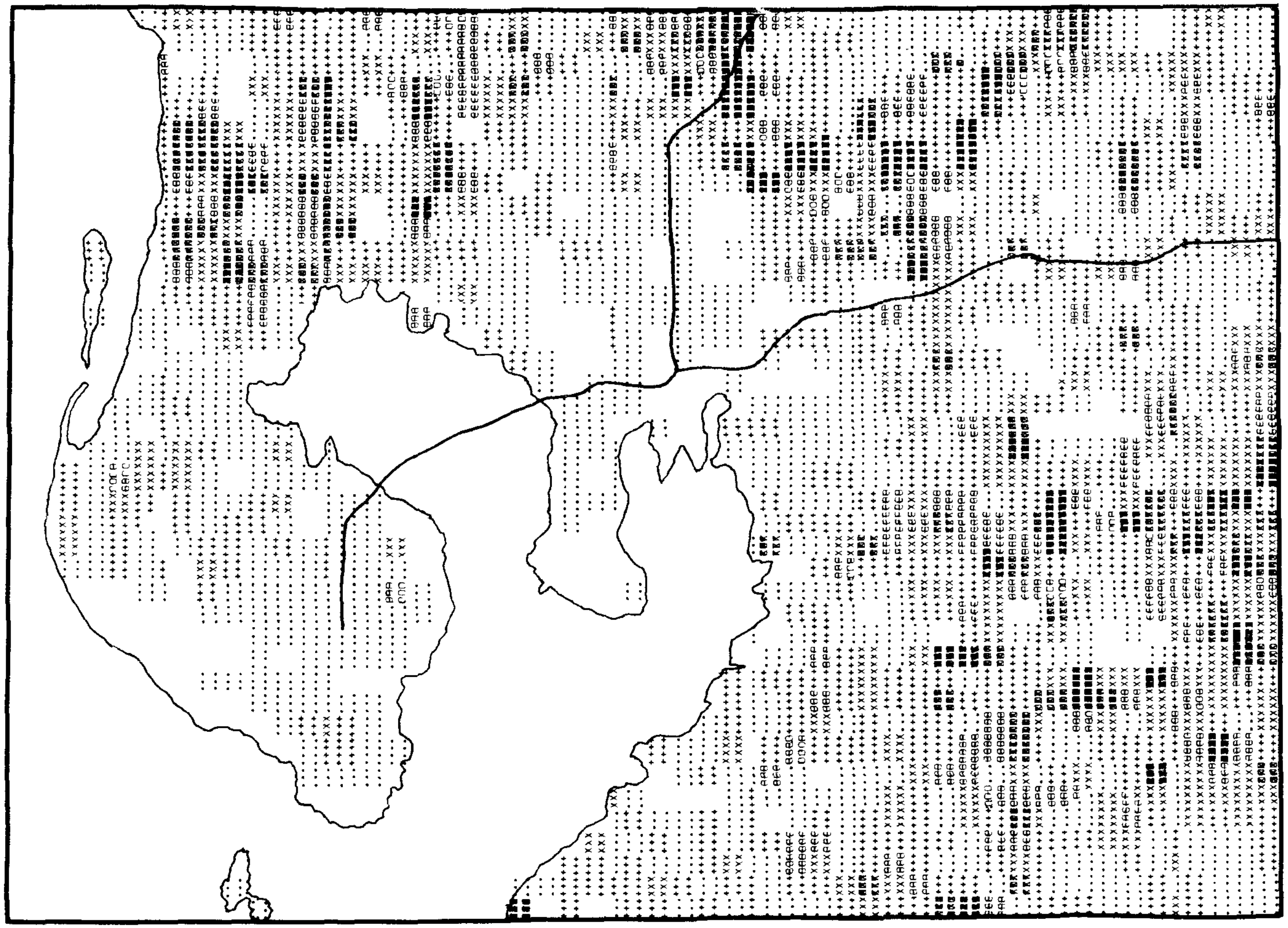


Figure 5.6-b

TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY
OLEFINS



OLEFINS
PARAFFINS
AROMATICS

KEY (mg/m²/day)

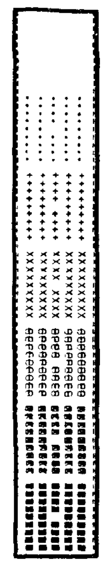


Figure 5.6-c

TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY

PARAFFINS

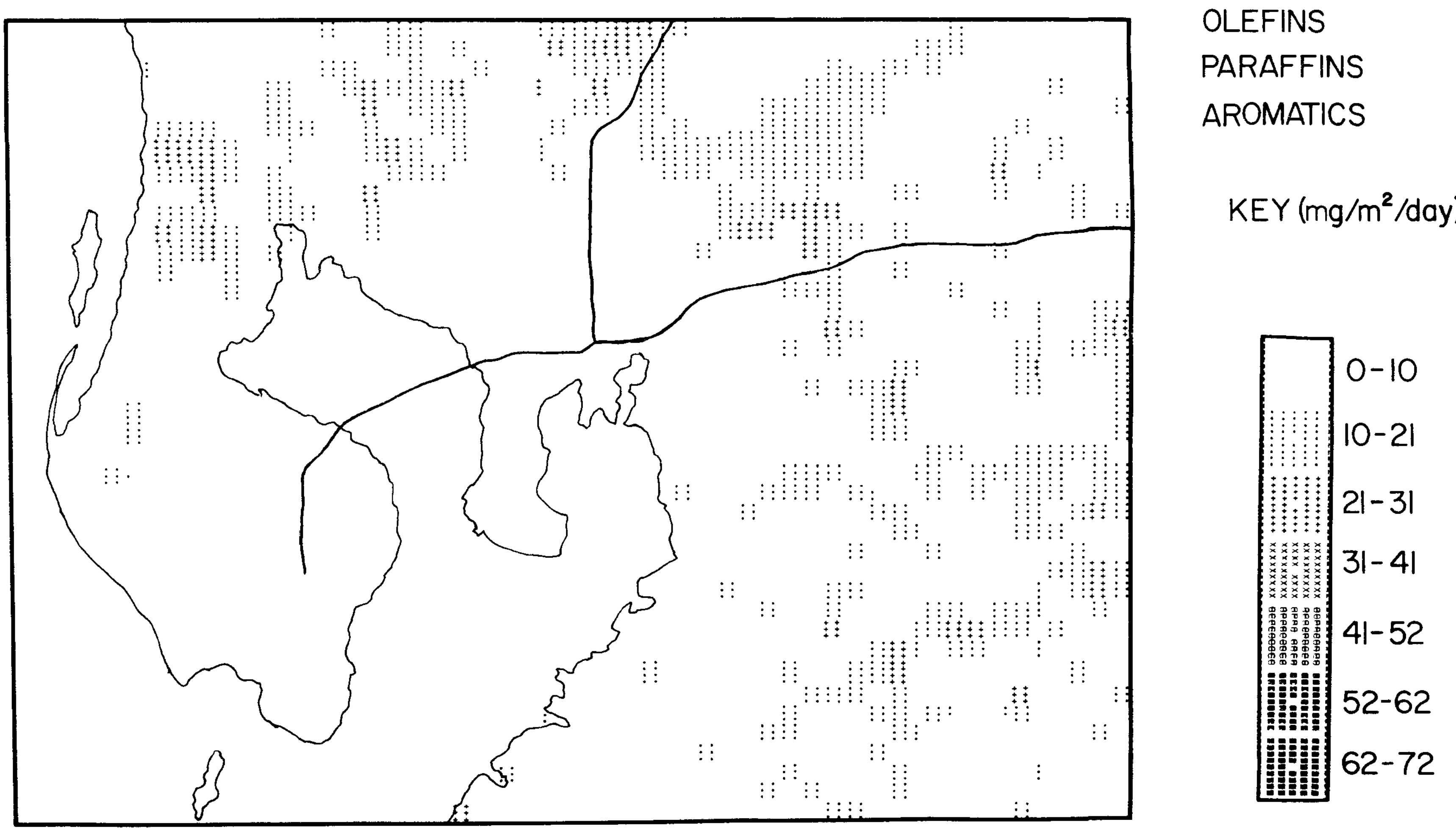


Figure 5.6-d

TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY
AROMATICS

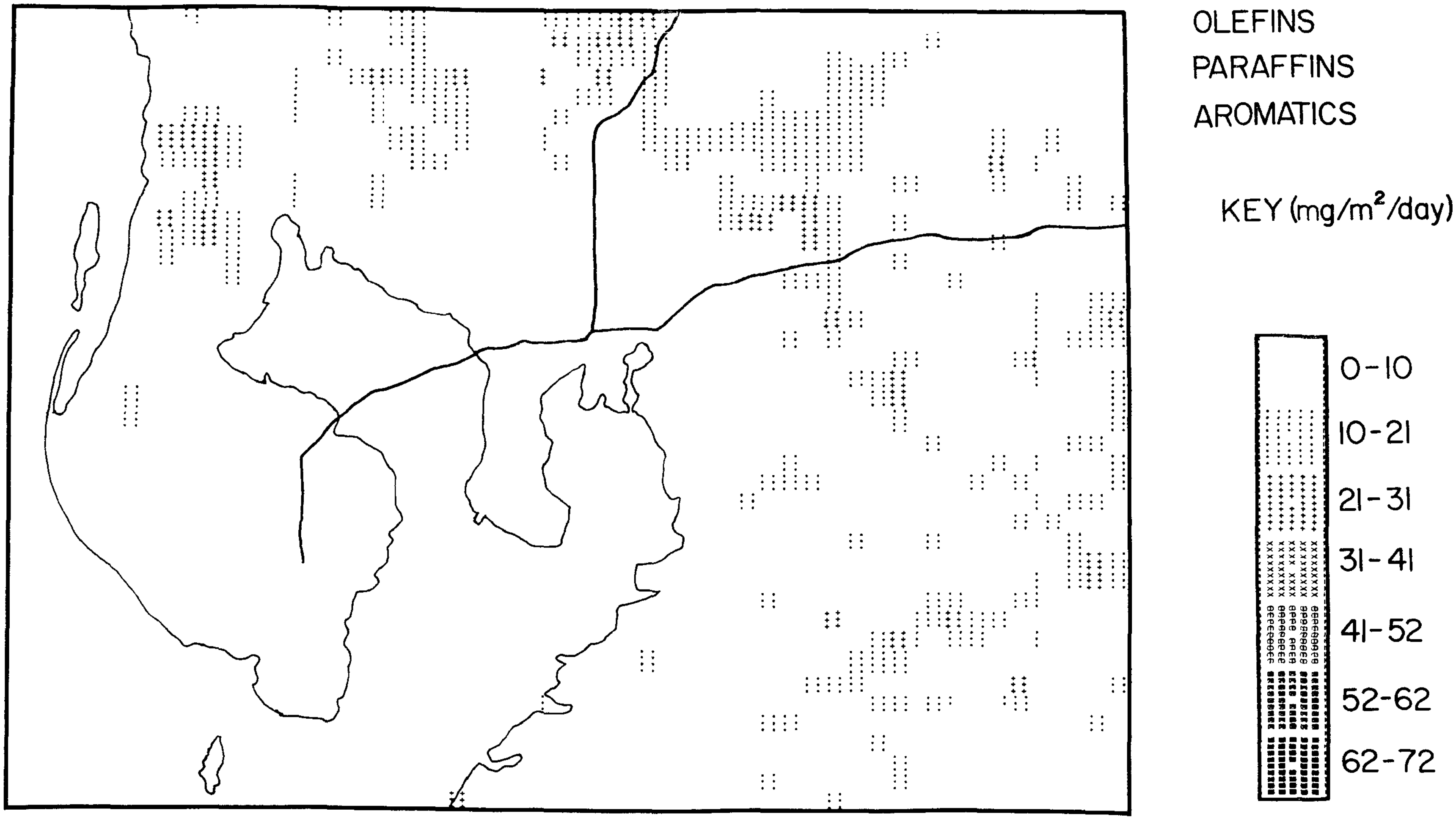


Figure 5.6-e

The emission rates have also been calculated in terms of TNMHC, paraffins, olefins, aromatics, methane and for each major peak for each grid, and stored on a computer tape. The sum of the components does not add up exactly to the TNMHC due to errors in rounding introduced by the computer format (Section 5.2).

The separate grid emission rates have been summed for the day and the night data to result in an estimated hourly flux rate of each hydrocarbon component for the total study area for day and for night (Table 5.6-a). A rough approximation of the total average daily emission rate for the study area over the study period has been made (Table 5.6-b). This estimate is based upon the assumption of a 12-hour 30°C average daytime and 12-hour 25°C average night. More complex temperature regimes could be accommodated using the Tingey et al., emission rate algorithms for isoprene and the terpenes (Tingey, et al. 1978a&b). However, due to the uncertainty of the appropriateness of applying these algorithms to non-related species it is doubtful that the emission estimates could be improved at this time. The total daily (24 hours) emissions from each major vegetation type has also been summed over the entire study are using the same scheme (Table 5.6-c). A detailed tabulation of the total area occupied by each LUDA category and its percent of the study area is given in Appendix D.

Although arithmetic means were used to calculate the variability, it has been reported that a better estimate of raw data variability might result if the geometric mean were calculated instead of the arithmetic mean, since the data by Tingey, et al. 1978a&b, indicate that emission rates are log normally distributed. In this case the arithmetic mean and standard deviation would over estimate the actual sample variability. WSU chose to use the arithmetic mean and standard deviation since it is easier to manipulate statistically

Table 5.6-a AVERAGE HOURLY DAYTIME (30°C) AND NIGHTTIME (25°C) EMISSIONS FOR THE 81 X 60 km TAMPA/ST. PETERSBURG STUDY AREA

Compound	Daytime Emission Factor (μg/hr)	Daytime Standard Deviation	Nighttime Emission Factor (μg/hr)	Nighttime Standard Deviation
TNMHC	8.6×10^{12}	1.7×10^{11}	4.5×10^{12}	1.1×10^{11}
Paraffins	1.6×10^{12}	2.3×10^{10}	1.2×10^{12}	1.6×10^{10}
Olefins	5.6×10^{12}	1.5×10^{11}	2.3×10^{12}	1.0×10^{11}
Aromatics	1.4×10^{12}	1.9×10^{10}	1.0×10^{12}	1.3×10^{10}
Methane	4.1×10^{12}	1.3×10^{11}	4.1×10^{12}	1.3×10^{11}
α-Pinene	7.4×10^{11}	1.7×10^{10}	5.6×10^{11}	1.2×10^{10}
β-Pinene	4.0×10^{11}	1.4×10^{10}	2.9×10^{11}	9.4×10^{9}
d-Limonene	1.3×10^{11}	6.3×10^{9}	8.7×10^{10}	4.4×10^{9}
Isoprene	2.4×10^{12}	3.8×10^{10}	0.0	0.0
Myrcene	4.2×10^{10}	3.2×10^{9}	3.0×10^{10}	2.2×10^{9}
Terpinolene	1.9×10^{9}	1.1×10^{8}	1.9×10^{9}	1.1×10^{8}
Unk. Terp.	-4.0×10^{9}	2.7×10^{9}	-2.1×10^{9}	1.9×10^{9}
Unk 10A	6.2×10^{8}	1.3×10^{8}	6.2×10^{8}	1.3×10^{8}
Unk 21A	4.9×10^{9}	- - - -	3.4×10^{9}	- - - -
Unk 16A	1.3×10^{9}	3.1×10^{8}	8.8×10^{8}	2.1×10^{8}
Unk 17	-3.0×10^{7}	1.5×10^{6}	-3.0×10^{7}	1.5×10^{6}
Unk 18	5.7×10^{8}	1.0×10^{8}	4.1×10^{8}	6.9×10^{7}
Unk 20	2.3×10^{8}	4.8×10^{7}	1.6×10^{8}	3.3×10^{7}
Unk 21	2.7×10^{11}	2.4×10^{10}	1.9×10^{11}	1.7×10^{10}
Unk 22	8.4×10^{10}	9.0×10^{9}	5.9×10^{10}	6.2×10^{9}
Unk 23	3.8×10^{9}	2.2×10^{8}	2.6×10^{9}	1.6×10^{8}
Unk 24	8.6×10^{11}	1.4×10^{11}	6.0×10^{11}	9.4×10^{10}
Unk 25	7.1×10^{9}	1.7×10^{9}	4.9×10^{9}	1.2×10^{9}
Unk 26	1.8×10^{9}	4.4×10^{8}	1.2×10^{9}	3.0×10^{8}
Unk 27	8.4×10^{9}	7.3×10^{8}	5.8×10^{9}	5.0×10^{8}
Unk 28	2.9×10^{9}	1.2×10^{8}	2.0×10^{9}	8.1×10^{7}
Unk 29	1.9×10^{9}	1.5×10^{8}	1.1×10^{9}	1.0×10^{8}
Δ^3-Carene	2.8×10^{11}	7.8×10^{9}	1.9×10^{11}	5.4×10^{9}
Unk 26A	3.4×10^{10}	4.6×10^{9}	2.4×10^{10}	3.2×10^{9}
Unk 29A	4.3×10^{10}	1.3×10^{9}	3.0×10^{10}	8.9×10^{8}

Table 5.6-b AVERAGE DAILY APRIL-AUGUST NATURAL EMISSION RATES FOR THE 81 X 60 km TAMPA/ST. PETERSBURG STUDY AREA (METRIC TONS)*

	Daytime		Nighttime		Daily	
Compound	12 hr Total	%	12 hr Total	%	24 hr Total	%
TNMHC	103		54		157	
Paraffins	19	18	14	27	33.6	21
Olefins	67	67	28	52	94.8	60
Aromatics	17	15	12	21	28.8	18
Methane	49	33+	49	8+	98.4	29+
Isoprene	29	28	0	0	28.8	18
α-Pinene	8.9	9	6.7	13	15.6	10
β-Pinene	4.8	5	3.5	7	8.28	5
Δ^3-Carene	3.4	3	2.3	4	5.56	4
d-Limonene	1.6	1	1.0	2	2.60	2
Myrcene	0.5	0.5	0.4	0.7	0.9	0.5

Average Daytime Flux = 1.71 $mg/m^2/hr$

Average Nighttime Flux = 0.93 $mg/m^2/hr$

Total Daily (24 hr) Average Flux = 32 $mg/m^2/day$

*Calculations assume a 12 hour day, 30°C average leaf temperature and a 12 hour night, 25°C average leaf temperature (see text).

+% of TNMHC + methane

Table 5.6-c DAILY (24 Hr) BIOGENIC EMISSIONS BY MAJOR VEGETATION TYPES**

Description	LUDA #s	Area (km^2)	% of Total Area	% of TNMHC	TNMHC (Kg/24 hr)	P (Kg/24 hr)	O (Kg/24 hr)	A (Kg/24 hr)	M (Kg/24 hr)
Residential	11,22,28	729	15	16	25,258	5,891	13,171	6,160	533
Cropland	*21(.5), 24 (.5), 25	240	5	2	3,138	917	1,771	450	1,568
Pasture-Rangeland	21(.5), 24 (.5), 26, 31, 32, 33	1243	26	19	29,691	6,127	18,849	4,620	14,715
Citrus Groves	29	286	6	22	34,925	7,743	19,534	7,686	30,933
Deciduous Forest	41, 43(.5), 61	13	<1	1	1,485	232	1,070	185	367
Evergreen Forest	42, 421, 43 (.5), 612	555	11	35	55,356	8,077	40,866	6,273	14,412
Mangroves	6121	64	1	1	1,021	585	4	432	1,565
Fresh water (aquatic)	51, 52, 53 621, 27	130	3	<1	497	211	24	263	17,435
Salt water (marine)	54, 55	1202	25	3	4,479	2,506	184	1,791	10,710
Barren areas	71-77	97	2	<1	799	360	2	439	881
Urban, Industrial & Transportation	12-17	301	6	0	0	0	0	0	0
TOTALS		4,860	100	100	156,649	32,649	95,475	28,299	93,119

*Number in parenthesis denotes fraction of preceding LUDA included in this vegetation unit. For example: 21(.5) means half of LUDA 21 is included.

**For detailed daily emission profiles of individual LUDA categories see Appendix D.

and since a log-normal distribution of the field data was not apparent when the field data were compiled. The variability of the emission estimates by grid and of the total emissions from the study area were calculated assuming that all of the emission rate data was independent. However, some of the association values used in some of the LUDA emission estimates are positively correlated since they share some of the same species/sample types. Thus, the statistical standard deviation shown in Figure 5.6-a and Appendix C underestimates the actual statistical standard deviations. The degree of underestimation is positively related to the degree of dependence between vegetation associations. A "worst case" example was calculated for the hypothetical situation where associations A and B were assumed to be independent, but had a correlation coefficient of 1 (A=B). This example indicated that the standard deviations would be underestimated by only a factor of 1.4. Since the correlation coefficient for the associations and LUDA categories is much less than one, the assumption of independence causes the underestimation of the variability to be insignificant. Additionally, WSU could not differentiate or predict the effects of other field sample variables such as soil moisture or location upon emission rates. Therefore, the actual variability in the emission inventory is probably much greater than the statistical standard deviation shown in Table 5.6-a. The standard deviations for the various hydrocarbon compounds and classes in the table indicate that the emission factor variability is less than a factor of two. It should be stressed that this only reflects the variability between the raw sample emission rates that were used in the emission inventory. Uncertainties in vegetation composition, the emissions of species not sampled and uncertainties in leaf biomass estimation are all more difficult to evaluate. Although every attempt was made to accurately evaluate each element in this inventory and to treat uncertainties conservatively, the final figures reflected in Tables 5.6-a and 5.6-b could probably differ from actual natural emissions by a factor of two. More sampling is needed to narrow this variability further. Improvements in the emission rate algorithms could be applied at a later date to increase the accuracy of these estimates. Ambient air sampling should be done in the study area and the concentrations of the natural emission products should be related to meteorological parameters to determine if they are commensurate with the emission estimates made during the course of this study. Finally, since the climatic conditions before and during the study were somewhat atypical (very cold winter preceeding a very dry summer), spot checks of emission rates should be made in future years to confirm that the emission rates measured during the course of this study are representative.

Although uncertainty in the projected emission estimates still exists, this study is the most comprehensive program of its type ever attempted. The resultant emission estimates developed as a result of this study probably are the most accurate area-wide estimates of natural hydrocarbon emissions made to date for a large heterogeneous area.

6. DESCRIPTION OF COMPUTER PROGRAMS, FILES AND TAPES

Two computer tapes were generated as a result of this study. The WSU tape contains all of the raw data, files of the refined emission factors, programs to generate those factors and emission rates by grid. The other tape submitted to Region IV, contains only the emission factors by grid.

Computer manipulations were aided by SAS, a statistical analysis computer package (Barr, et al, 1976).

6.1 EPA GRID EMISSION DATA TAPE

A computer tape of emission rates by grid was prepared according to EPA specifications and has been forwarded to Region IV. The tape is non labeled, 7-track, 556 BPI EBCDIC, even parity LRECL = 80 RECFM = FB BLK SIZE = 2400.

The tape contains the following information:

File 1: Daytime Grid Emission Rates

DSN = USER. Y6401. Emission. Grid. Daytime

File 2: Nighttime Grid Emission Rates

DSN = USER. Y6401. Emission. Grid. Nighttime

column 1-5: Grid #, character data

column 6-7: compound, character data

column 8-23: Emission rate, E notation

6.2 WSU TAMPA/ST. PETERSBURG EMISSION STUDY TAPE

The following section describes the location and format for all of the files and programs used to generate those files from the original data.

The data are stored at WSU on magnetic tape volume number CC1587. The tape is in standard labled, 1600 BPI, 9-track format. All files are in fixed block (FB) form with logical record lengths (LRECL) and block sizes (BLK SIZE) as indicated in Table 6.2-a.

6.3 DIRECTIONS FOR USE OF WSU TAMPA/ST. PETERSBURG STUDY TAPE VOLCC1587

The programs described should be put in a Wylbur or other disk library before use. They should be run in the order shown in Figure 6.3-a, although it is not required to start at the beginning. The Job Control Language (JCL) associated with each program assumes that all data sets being read exist in catalogued data sets on disk and that each data set to be written does not currently exist and will be created on disk (except the GRID emission rate data sets which are so large that it is better to write them to tape). If these written data sets are to be rewritten, the associated Data Definition (DD), card can be changed so that just the Data Set Name, (DSN) parameter and DISP = OLD need be coded. For example, the FT10F001 DD card in the program to generate the ASSN emission rates would appear as:

11GO FT10F001 DD DSN = USER. Y4313. Emission, Day ASSN, DISP = OLD

All the data sets and programs listed here are also on tape volume number CC1587. They can be accessed directly from the tape, although the unit and volume parameters must be specified since these data sets are not catalogued (the unit is UNIT = TAPE). Data sets can be written to this tape, but it is recommended that writing is done after the existing data sets on the tape. Writing over an existing file will also destroy all files after the rewritten one.

Table 6.2-a CONTENTS OF WSU TAMPA/ST. PETERSBURG EMISSION STUDY TAPE

File Number	Date Set Name	Block Count	Block Size	Logical Record Length
1	.EMISSION.RAWDATA	17	3120	80
2	6401.EMISSION.DAY	8	6400	80
3	01.EMISSION.NIGHT	8	6400	80
4	.EMISSION.DAYMEAN	65	2400	80
5	EMISSION.NIGHTMEAN	65	2400	80
6	401.EMISSION.ASSN	1	1090	10
7	.EMISSION.DAYASSN	13	2400	80
8	EMISSION.NIGHTASSN	13	2400	80
9	401.EMISSION.LUDA	1	1352	13
10	.EMISSION.DAYLUDA	32	2400	80
11	EMISSION.NIGHTLUDA	32	2400	80
12	EMISSION.AIRGRIDS	56	3120	80
13	.EMISSION.DAYGRID	1	2400	80
14	EMISSION.NIGHTGRID	1	2400	80
15	SION.GRID.DAYTIME	2160	2400	80
16	ION.GRID.NIGHTTIME	2160	2400	80
17	L.EMISSION.APRFIX	4	2400	80
18	EMISSION.APRMEANS	3	2400	80
19	.EMISSION.APRASSN	2	2400	80
20	.EMISSION.APRDATA	1	2400	80
21	.EMISSION.APRLUDA	4	2400	80
22	EMISSION.APRDATA2	1	2400	80
23	.EMISSION.APRGRID	3	2400	80
24	EMISSION.APRDATA3	1	2400	80

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)

USER. Y4313. EMISSION. RAWDATA catalogued

USER. Y6401. EMISSION. RAWDATA tape VOL=SER=CC1587 file 1

Contents: Original raw data. The original data is coded as described in Section 5.2.

USER. Y4313. EMISSION. DAY catalogued

USER. Y6401. EMISSION. DAY tape VOL=SER=CC1587 file 2

Contents: Original data corrected to a standard 30°C daytime temperature. The format of the data is the same as for original data.

USER. Y4313. EMISSION. NIGHT catalogued

USER. Y6401. EMISSION. NIGHT tape VOL=SER=CC1587 file 3

Contents: Original data corrected to a standard 25°C nighttime temperature. The format of data is the same as for the original data.

USER. Y4313. EMISSION. DAYMEAN catalogued

USER. Y6401. EMISSION. DAYMEAN tape VOL=SER=CC1587 file 4

Contents: Daytime species mean emission rates

Format:

Species	columns 1-3	
Compound	columns 4-5	character data
Rate	columns 6-15	E notation
Variance	columns 16-25	E notation

USER. Y4313. EMISSION. NIGHTMEAN catalogued

USER. Y6401. EMISSION. NIGHTMEAN tape VOL=SER=CC1587 file 5

Contents: Nighttime species mean emission rates. The format is the same as for the daytime means.

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

```
USER. Y4313. EMISSION. ASSN            catalogued

USER. Y6401. EMISSION. ASSN            tape VOL=SER=CC1587      file 6

   Contents:  ASSN factor data sorted by species

   Format: ASSN     column 1       character data
           SPECIES  columns 2-4
           FACTOR   columns 5-10


USER. Y4313. EMISSION. DAYASSN         catalogued

USER. Y6401. EMISSION. DAYASSN         tape VOL=SER=CC1587      file 7

   Contents:  Daytime ASSN emission rates

   Format:  ASSN        column 1          character data
            COMPOUND    columns 2-3       character data
            RATE        columns 4-11      hexadecimal floating point data
                                            (FORTRAN real Z form)
            VARIANCE    columns 20-27     hexadecimal floating point data


USER. Y4313. EMISSION. NIGHTASSN       catalogued

USER. Y6401. EMISSION. NIGHTASSN       tape VOL=SER=CC1587      file 8

   Contents:  Nighttime ASSN emission rates.

   Format:  the same as for the daytime ASSN rates.


USER. Y4313. EMISSION. LUDA            catalogued

USER. Y6401. EMISSION. LUDA            tape VOL=SER=CC1587      file 9

   Contents:  LUDA factor data sorted by ASSN - SPECIES

   Format:  LUDA     columns 1-4
            ASSN     column 5      character data    1st 41 records
            SPECIES  columns 5-7                     remaining records
            FACTOR   columns 8-13
```

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

USER. Y4313. EMISSION. DAY LUDA   catalogued

USER. Y6401. EMISSION. DAY LUDA   tape VOL=SER=CC1587   file 10

Contents: Daytime LUDA emission rates.

Format: LUDA	columns 1-4	
COMPOUND	columns 5-6	character data
RATE	columns 7-14	hexadecimal floating point data (FORTRAN real Z form)
VARIANCE	columns 23-30	hexadecimal floating point data

USER. Y4313. EMISSION. NIGHT LUDA   catalogued

USER. Y6401. EMISSION. NIGHT LUDA   tape VOL=SER=CC1587   file 11

Contents: Nighttime LUDA emission rates

Format: the same as for the daytime LUDA rates.

USER. Y4313. EMISSION. AIR GRIDS   catalogued

USER. Y6401. EMISSION. AIR GRIDS   tape VOL=SER=CC1587   file 12

Contents: GRID LUDA factor data.

USER. Y4313. EMISSION. DAY GRIDS   catalogued

USER. Y6401. EMISSION. DAY GRIDS   tape VOL=SER=CC1587   file 13

Contents: Daytime final total emission rates

Format: COMPOUND	columns 1-2	character data
RATE	columns 3-10	hexadecimal floating point data
VARIANCE	columns 19-26	hexadecimal floating point data

USER. Y4313. EMISSION. NIGHT GRIDS   catalogued

USER. Y6401. EMISSION. NIGHT GRIDS   tape VOL=SER=CC1587   file 14

Contents: Nighttime final total emission rates.

Format: the same as for the daytime total emission rates.

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

USER. Y6401. EMISSION. GRID. DAYTIME tape VOL=SER=CC1587 file 15

Contents: Daytime GRID emission rates.

Format:

GRID	columns 1-5	character data
COMPOUND	columns 6-7	character data
RATE	columns 8-23	E notation

USER. Y6401. EMISSION. GRID. NIGHTTIME Tape VOL=SER=CC1587 file 16

Contents: Nighttime GRID emission rates

Format: the same as for the daytime GRID rates.

WYL. SS. RAK. JOBS (APRFIX) catalogued
USER. Y6401. EMISSION. APRFIX Tape VOL=SER=CC1587 file 17

Contents: Program to correct original data for daytime and nighttime temperatures.

The EMISSION DD card defines the data set containing the original data.

The DAY DD card defines the data set which will contain the daytime corrected original emission rates.

The NIGHT DD card defines the data set which will contain the nighttime corrected original emission rates.

WYL. SS. RAK. JOBS (APRMEANS) catalogued
USER. Y6401. EMISSION. APRFIX Tape VOL=SER=CC1587 file 18

Contents: Program to determine and print specie means. Run once for day and once for night data, making the appropriate changes in the following DD cards and the TITLE statement.

The EMISSION DD card defines the data set containing the corrected day or night data.

The DAYMEAN DD defines the data set which will contain the day or night specie means.

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

WYL. SS. RAK. JOBS (APRASSN) catalogued
USER. Y6401. EMISSION. APRASSN Tape VOL=SER=CC1587 file 19

Contents: Program to generate ASSN emission rates. Run once for day and once for night data. Minor change in some DD cards are required for night data.

The FT08F001 DD card defines ASSN factor data sorted by species.
The FT09F001 DD card defines day or night species mean emission rates.
The FT10F001 DD card defines the data set which will contain the day or night ASSN emission rates.

WYL. SS. RAK. JOBS (APRDATA) catalogued
USER. Y6401. EMISSION. APRDATA Tape VOL=SER=CC1587 file 20

Contents: Program to print ASSN emission rates.

The DAYASSN DD card defines the data set containing daytime ASSN emission rates.

The NIGHTASSN DD card defines the data set containing nighttime ASSN emission rates.

WYL. SS. RAK. JOBS (APRLUDA) catalogued
USER. Y6401. EMISSION. APRLUDA Tape VOL=SER=CC1587 file 21

Contents: Program to generate LUDA emission rates. Run once for day and once for night data. Determination for LUDA's 22, 28, 43 are built in.

The FT08F001 DD card defines LUDA factor data sorted by ASSN-SPECIE.
The FT09F001 DD card defines the data set which contains day or night ASSN emission rates.

The FT10F001 DD card defines the data set which contains the day or night specie mean emission rates.

The FT11F001 DD card defines the data set which will contain the day or night LUDA emission rates. WYL. SS. RAK. JOBS (APRLUDA)

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

WYL. SS. RAK. JOBS (APRDATAZ) catalogued
USER. Y6401. EMISSION. APRDATAZ Tape VOL=SER=CC1587 file 22

Contents: Program to print LUDA emission rates

The DAYLUDA DD card defines the data set containing daytime LUDA emission rates.

The NIGHTLUDA DD card defines the data set containing nighttime LUDA emission rates.

WYL. SS. RAK. JOBS (APRGRID) catalogued
USER. Y6401. EMISSION. APRGRID Tape VOL=SER=CC1587 file 23

Contents: Program to generate GRID and TOTAL emission rates. Run once for day and once for night data.

The FT08F001 DD card defines the data set which contains the GRID factor data.

The FT09F001 DD card defines the data set which will contain the day or night GRID emission rates. The tape volume serial number will have to be supplied. If operator attempts to write on CC1587, the label will have to be changed so that previous data does not get destroyed. Note also, the night label must be different from the day label.

The FT11F001 DD card defines the data set which contains the day or night LUDA emission rates.

The FT12F001 DD card defines the data set which will contain the day or night TOTAL emission rates.

WYL. SS. RAK. JOBS (APRDATAZ) catalogued
USER. Y6401. EMISSION. APRDATAZ Tape VOL=SER=CC1587 file 24

Contents: Program to print TOTAL emission rates.

The DAYGRID DD card defines the data set containing daytime TOTAL emission rates.

The NIGHTGRID DD card defines the data set containing nighttime TOTAL emission rates.

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APPENDIX A

INTRODUCTION

This appendix contains the average emission rates for day and for night of each species/sample type used to compile the emission inventory. The "compound" column lists the compounds for which emission rates were calculated. "TNMHC" means total non-methane hydrocarbons; "Parafins", "Olefins", "Aromatics" and "Methane" are classes of compounds as described in Section 1.2.2. Other compounds such as "α-Pinene" designate major peaks. Some of those include unknowns. In these cases the peak identity (eg #21) is preceeded by UNK. The column labeled "N" designates the number of samples. In some cases N is smaller for one compound than another. This is due to analytical problems which required the omission of a sample. $\overline{X}$ designates the mean of the emission samples calculated as $(\Sigma x_1 + x_2 . . . . + x_n)/n$. SD designates the standard deviation of the emission samples, calculated as the square root of the variance. N denotes the number of samples used to calculate the mean.

The name of each species/sample type is shown above its set of emission rates followed by its scientific code and the units of measurement. μg/g/hr means micrograms emission per gram leaf biomass dry wt per hour. The heading $\mu g/m^2/hr$ means micrograms emissions per square meter surface per hour.

Emission rates for row crops were collected in June and July after harvest. These emission rates therefore do not include fruit and may not be representative of actual emissions during the growing season.

For "wet" categories such as "grassy mudflat (Marine) 0"-2" water 901," the title designates an an area of salt water where marine grass occurred that had a water depth of from 0" to 2" during the time that the samples were collected. Similarly, category 905 designates samples collected over an area where the bottom was sandy and the water depth was greater than five feet. Categories 901 to 931 designate salt water areas, while 941-944 designate fresh water samples. Category 950 is a sample collected while the tide was out on an oyster bed.

APPENDIX A

Emission Rate Means by Species Standardized
to 30°C (day) and 25°C (night)

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Name: Black Mangrove 001 (μg/g/hr)						
TNMHC	3	1.344	0.426	3	0.932	0.294
Paraffins	3	0.429	0.082	3	0.298	0.057
Olefins	3	0	0	3	0	0
Aromatics	3	0.917	0.475	3	0.638	0.331
Methane	3	-0.301	0.225	3	-0.301	0.225
Name: White Mangrove 011 (μg/g/hr)						
TNMHC	18	1.172	0.701	18	0.814	0.488
Paraffins	18	0.692	0.519	18	0.480	0.361
Olefins	18	0	0	18	0	0
Aromatics	18	0.480	0.301	18	0.333	0.208
Methane	18	1.514	3.369	18	1.514	3.369
Name: Red Mangrove 021 (μg/g/hr)						
TNMHC	16	1.000	0.744	16	0.695	0.516
Paraffins	16	0.596	0.552	16	0.414	0.384
Olefins	16	0.006	0.020	16	0.004	0.016
Aromatics	16	0.400	0.376	16	0.278	0.252
Methane	15	1.361	1.371			
Name: Slash Pine 101 (μg/g/hr)						
TNMHC	16	4.069	3.884	16	2.824	2.696
Paraffins	16	0.566	0.608	16	0.393	0.424
Olefins	16	3.216	3.536	16	2.235	2.456
Aromatics	16	0.287	0.312	16	0.200	0.216
Methane	16	0.816	0.952	16	0.816	0.952
α-Pinene	16	0.966	1.008	16	0.670	0.700
β-Pinene	16	0.900	1.648	16	0.625	1.144
d-Limonene	16	0.291	0.432	16	0.202	0.300
Δ^3-Carene	16	0.462	0.976	16	0.301	0.676

	Day			Night		
Compound	N	$\bar{X}$	SD	N	$\bar{X}$	SD
			Name: Longleaf Pine 102 (μg/g/hr)			
TNMHC	29	7.265	11.680	29	5.048	8.121
Paraffins	28	0.802	1.005	28	0.557	0.698
Olefins	28	5.894	11.424	28	4.091	7.921
Aromatics	28	0.384	0.444	28	0.266	0.307
Methane	28	0.321	0.639	28	0.321	0.693
α-Pinene	29	2.416	5.175	29	1.679	3.597
β-Pinene	29	2.871	5.945	29	1.993	4.125
d-Limonene	29	0.087	0.226	29	0.060	0.156
Myrcene	29	0.001	0.005	29	0.001	0.003
Δ^3-Carene	29	0.176	0.716	29	0.122	4.971
			Name: Sand Pine 103 (μg/g/hr)			
TNMHC	4	13.558	16.558	4	9.428	11.518
Paraffins	4	1.516	0.908	4	1.052	0.628
Olefins	4	11.650	15.388	4	8.088	10.684
Aromatics	4	0.386	0.456	4	0.268	0.316
Methane	4	1.575	2.626	4	1.575	2.626
α-Pinene	4	4.783	6.284	4	3.315	4.354
β-Pinene	4	6.188	9.184	4	4.302	6.388
			Name: Southern Red Pine 104 (μg/g/hr)			
TNMHC	1	2.910	---	1	2.020	---
Paraffins	1	1.560	---	1	1.090	---
Olefins	1	0.067	---	1	0.047	---
Aromatics	1	1.290	---	1	0.894	---
Methane	1	0.325	---	1	0.325	---
α-Pinene	1	0.068	---	1	0.047	---

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
			Name: Cypress 112 (μg/g/hr)			
TNMHC	20	14.159	9.816	20	9.838	6.816
Paraffins	20	3.214	3.318	20	2.232	2.303
Olefins	20	8.486	9.942	20	5.902	6.923
Aromatics	20	2.448	2.419	20	1.701	1.677
Methane	20	3.230	5.765	20	3.230	5.765
α -Pinene	20	4.362	7.231	20	3.032	5.018
β -Pinene	20	0.058	0.165	20	0.040	0.116
d -Limonene	20	0.272	0.452	20	0.189	0.313
Myrcene	20	0.282	0.783	20	0.196	0.541
Unk Terp.	20	0.278	1.243	20	0.193	0.863
Unk #22	20	0.072	0.322	20	0.050	0.224
Unk #27	20	0.145	0.648	20	0.100	0.447
Δ^3-Carene	20	2.810	4.571	20	1.949	3.180
			Name: Laurel Oak 201 (μg/g/hr)			
TNMHC	10	12.633	13.753	12	1.609	2.562
Paraffins	10	1.405	1.940	12	0.872	1.244
Olefins	10	10.174	10.705	12	0.111	0.704
Aromatics	10	1.034	1.224	12	0.622	0.800
Methane	9	1.988	1.563	11	1.703	1.547
α-Pinene	10	0.022	0.071	12	0.013	0.045
Isoprene	10	9.996	10.120	12	0	0
			Name: Water Oak 202 (μg/g/hr)			
TNMHC	3	26.683	22.680	3	2.054	1.991
Paraffins	3	1.236	0.667	3	0.857	0.461
Olefins	3	23.797	20.134	3	0.061	0.162
Aromatics	3	1.626	2.138	3	1.129	1.485
Methane	3	-1.427	14.903	3	-1.427	14.903
Isoprene	3	23.713	19.913	3	0	0

	Day			Night		
Compound	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Name: Turkey Oak 203 (μg/g hr)						
TNMHC	7	26.500	19.104	7	2.126	2.602
Paraffins	7	1.215	1.258	7	0.844	0.873
Olefins	7	24.213	17.572	7	0.550	1.030
Aromatics	7	1.040	1.178	7	0.722	0.818
Methane	7	1.095	1.925	7	1.095	1.925
α-Pinene	7	0.373	0.649	7	0.258	0.449
β-Pinene	7	0.152	0.266	7	0.106	0.185
Isoprene	7	23.434	17.418	7	0	0
Name: Live Oak 204 (μg/g hr)						
TNMHC	18	10.789	7.701	21	1.362	1.379
Paraffins	18	0.695	0.603	21	0.439	0.408
Olefins	18	9.440	7.413	21	0.505	1.406
Aromatics	18	0.654	0.595	21	0.419	0.393
Methane	18	0.998	2.931	21	0.824	2.738
α-Pinene	18	0.054	0.209	21	0.140	0.506
β-Pinene	18	0.061	0.229	21	0.175	0.642
Isoprene	18	9.083	7.662	21	0	0
Unk #29	18	0.081	0.187	21	0.048	0.121
Name: Bluejack Oak 206 (μg/g hr)						
TNMHC	7	56.411	56.749	7	8.659	8.482
Paraffins	7	6.862	6.855	7	4.767	4.766
Olefins	7	44.193	45.113	7	0.170	0.208
Aromatics	7	5.317	6.133	7	3.696	4.272
Methane	5	0.737	2.850	5	0.737	2.850
Isoprene	7	43.909	44.833	7	0	0

Compound	Day N	Day $\overline{X}$	Day SD	Night N	Night $\overline{X}$	Night SD
Name: Myrtle Oak 207 (μg/g/hr)						
TNMHC	1	17.200	---	1	1.800	---
Paraffins	1	1.310	---	1	0.912	---
Olefins	1	14.800	---	1	0.120	---
Aromatics	1	1.080	---	1	0.750	---
Methane	1	3.060	---	1	3.060	---
Isoprene	1	14.60	---	1	0	0
Name: Willow Oak 208 (μg/g/hr)						
TNMHC	1	32.600	---	1	1.120	---
Paraffins	1	1.010	---	1	0.704	---
Olefins	1	31.000	---	1	0	0
Aromatics	1	0.624	---	1	0.433	---
Methane	1	7.120	---	1	7.120	---
Isoprene	1	31.000	---	1	0	0
Name: Saw Palmetto 301 (μg/g/hr)						
TNMHC	35	11.547	17.932	36	2.040	2.142
Paraffins	35	1.300	2.121	36	0.888	1.449
Olefins	35	8.667	14.447	36	0.048	0.131
Aromatics	35	1.590	2.581	36	1.101	1.771
Methane	32	2.323	4.264	33	2.258	4.213
α-Pinene	35	-0.006	0.037	36	-0.004	0.027
Isoprene	35	8.595	14.349	36	0	0
Unk #18	35	0.014	0.081	36	0.009	0.055
Unk #20	35	0.007	0.039	36	0.004	0.027
Unk #22	35	0.308	1.289	36	0.208	0.884
Name: Sabal Palmetto 311 (μg/g/hr)						
TNMHC	12	7.452	3.977	14	1.861	3.289
Paraffins	11	1.266	2.941	13	0.803	1.864
Olefins	11	4.916	2.542	13	0.023	0.064
Aromatics	11	0.786	1.330	13	0.498	0.851
Methane	12	0.641	1.259	14	0.552	1.180
Isoprene	12	4.470	2.842	14	0	0

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
			Name: Wax Myrtle 401 (μg/g/hr)			
TNMHC	9	7.477	5.395	9	5.191	3.745
Paraffins	9	0.754	0.555	9	0.523	0.385
Olefins	9	6.287	4.816	9	4.371	3.350
Aromatics	9	0.426	0.525	9	0.296	0.364
Methane	8	2.060	4.278	8	2.060	4.278
α-Pinene	9	0.635	0.517	9	0.441	0.359
β-Pinene	9	0.294	0.883	9	0.204	0.613
d-Limonene	9	0.047	0.142	9	0.033	0.099
Unk #21	9	0.007	0.020	9	0.005	0.014
Unk #22	9	0.010	0.029	9	0	0
Unk #23	9	0.224	0.673	9	0.157	0.470
Unk #27	9	0.119	0.317	9	0.082	0.220
Unk #28	9	0.254	0.363	9	0.176	0.252
Δ^3-Carene	9	0.109	0.294	9	0.076	0.204
Unk #26-A	9	0.133	0.338	9	0.092	0.234
Unk #29-A	9	3.707	3.984	9	0.257	2.760
			Name: Elderberry 411 (μg/g/hr)			
TNMHC	5	4.800	3.062	5	3.332	2.125
Paraffins	5	2.790	1.243	5	1.936	0.864
Olefins	5	-0.032	0.072	5	-0.022	0.049
Aromatics	5	2.039	2.000	5	1.416	1.387
Methane	5	6.352	11.619	5	6.352	11.619
			Name: Groundsel Bush 431 (μg/g/hr)			
TNMHC	2	2.540	1.414	2	1.765	0.983
Paraffins	2	0.564	0.352	2	0.392	0.245
Olefins	2	1.700	0.792	2	1.180	0.552
Aromatics	2	0.276	0.271	2	0.191	0.188
Methane	0	---	---	0	---	---
α-Pinene	2	1.131	0.564	2	0.789	0.397

Compound	Day N	Day $\overline{X}$	Day SD	Night N	Night $\overline{X}$	Night SD
Name: Persimmon 441 (μg/g/hr)						
TNMHC	17	2.892	2.065	17	2.007	1.435
Paraffins	17	1.702	1.414	17	1.182	0.982
Olefins	17	-0.025	0.180	17	-0.018	0.126
Aromatics	17	1.217	0.895	17	0.846	0.621
Methane	17	0.076	1.001	17	0.076	1.001
α-Pinene	17	-0.036	0.161	17	-0.025	0.112
β-Pinene	17	0.003	0.011	17	0.002	0.008
Name: Dahoon Holly 451 (μg/g/hr)						
TNMHC	3	2.750	1.401	3	1.911	0.968
Paraffins	3	1.477	0.768	3	1.024	0.531
Olefins	3	0	0	3	0	0
Aromatics	3	1.278	0.748	3	0.886	0.518
Methane	2	0.804	0.057	2	0.804	0.057
Name: Red Bay 461 (μg/g/hr)						
TNMHC	2	2.003	1.976	2	1.391	1.371
Paraffins	2	0.457	0.179	2	0.317	0.124
Olefins	2	1.180	1.669	2	0.820	1.160
Aromatics	2	0.369	0.131	2	0.256	0.091
Methane	2	0.066	0.334	2	0.066	0.334
α-Pinene	2	0.304	0.429	2	0.211	0.298
β-Pinene	2	0.195	0.275	2	0.135	0.191
Unk #29-A	2	0.575	0.813	2	0.400	0.564
Name: Red Mulberry 471 (μg/g/hr)						
TNMHC	3	8.230	5.148	3	5.730	3.588
Paraffins	3	4.911	3.900	3	3.413	2.709
Olefins	3	1.163	2.164	3	0.807	1.502
Aromatics	3	2.167	0.598	3	1.507	0.417
Methane	2	-2.200	1.414	2	-2.200	1.414

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
			Name: Sweet Acacia 481 (μg/g/hr)			
TNMHC	3	5.850	3.702	3	4.063	2.568
Paraffins	3	0.576	0.252	3	0.400	0.174
Olefins	3	4.707	3.421	3	3.271	2.375
Aromatics	3	0.570	0.313	3	0.396	0.217
Methane	3	2.295	5.502	3	2.295	5.502
α-Pinene	3	3.762	2.781	3	2.614	1.931
β-Pinene	3	0.414	0.391	3	0.288	0.271
d-Limonene	3	0.201	0.182	3	0.140	0.126
Myrcene	3	0.093	0.161	3	0.064	0.111
Unk #21	3	0.180	0.312	3	0.125	0.217
			Name: Viburnum 491 (μg/g/hr)			
TNMHC	1	2.680	---	1	1.860	---
Paraffins	1	1.340	---	1	0.930	---
Olefins	1	0.214	---	1	0.149	---
Aromatics	1	1.120	---	1	0.781	---
Methane	1	-0.100	---	1	-0.100	---
Unk #21-A	1	0.221	---	1	0.154	---
			Name: Oleander 492 (g/g/hr)			
TNMHC	1	20.000	---	1	13.900	---
Paraffins	1	6.940	---	1	4.820	---
Olefins	0	0	---	0	0	---
Aromatics	1	13.200	---	1	9.160	---
Methane	1	1.450	---	1	1.450	---

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Name: Oranges 501 (μg/g/hr)						
TNMHC	29	9.334	15.442	29	6.484	10.722
Paraffins	29	1.857	2.094	29	1.288	1.451
Olefins	29	5.540	13.981	29	3.848	9.711
Aromatics	29	1.949	1.744	29	1.353	1.211
Methane	26	6.407	12.151	26	6.407	12.151
d-Limonene	29	0.187	0.572	29	0.130	0.397
Unk #21	29	0.044	0.178	29	0.030	0.123
Unk #22	29	0.404	0.857	29	0.281	0.595
Unk #24	29	5.065	13.217	29	3.517	9.178
Name: Grapefruit 511 (μg/g/hr)						
TNMHC	16	4.274	3.680	16	2.963	2.544
Paraffins	16	2.077	2.047	16	1.442	1.420
Olefins	16	0.628	1.603	16	0.437	1.113
Aromatics	16	1.568	1.464	16	1.089	1.017
Methane	14	7.238	10.010	14	7.238	10.010
α-Pinene	16	0.475	1.262	16	0.330	0.877
Unk #16	16	0.068	0.270	16	0.047	0.188
Unk #21	16	0.014	0.055	16	0.010	0.038
Unk #24	16	0.005	0.022	16	0.004	0.015
Unk #25	16	0.378	1.513	16	0.263	1.050
Unk #26	16	0.096	0.383	16	0.066	0.265
Δ^3-Carene	16	0.003	0.012	16	0.002	0.099
Name: Australian Pine 601 (μg/g/hr)						
TNMHC	1	10.200	---	1	0.625	---
Paraffins	1	0.599	---	1	0.416	---
Olefins	1	9.380	---	1	0.083	---
Aromatics	1	0.162	---	1	0.113	---
Methane	1	0.579	---	1	0.579	---
Isoprene	1	9.260	---	1	0	---

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
			Name: Sweetgum 611 (μg/g hr)			
TNMHC	17	60.852	99.553	17	35.822	69.175
Paraffins	17	3.046	3.549	17	2.116	2.472
Olefins	17	54.908	95.292	17	31.812	65.481
Aromatics	17	3.423	4.791	17	2.372	3.323
Methane	16	-0.082	1.040	16	-0.082	1.040
α-Pinene	18	-1.366	31.837	18	-0.934	22.062
β-Pinene	18	-0.377	2.423	18	-0.262	1.682
d-Limonene	18	1.219	2.427	18	0.847	1.686
Isoprene	18	8.463	10.237	18	0	0
Myrcene	18	2.461	10.442	18	1.711	7.260
Unk Terp.	18	-1.889	8.014	18	-1.278	5.421
Unk #21	18	22.189	81.165	18	14.933	57.500
Δ^3-Carene	18	4.290	13.408	18	2.978	9.318
Unk #26-A	18	3.283	15.438	18	2.278	10.704
			Name: American Elm 621 (μg/g hr)			
TNMHC	1	3.920	---	1	2.720	---
Paraffins	1	1.960	---	1	1.360	---
Olefins	1	0	---	1	0	---
Aromatics	1	1.960	---	1	1.360	---
Methane	1	0.016	---	1	0.016	---
			Name: Carolina Ash 631 (μg/g hr)			
TNMHC	1	0.546	---	1	0.379	---
Paraffins	1	0.173	---	1	0.120	---
Olefins	1	0	---	1	0	---
Aromatics	1	0.374	---	1	0.260	---
Methane	1	2.590	---	1	2.590	---

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
			Name: Willow 641 (μg/g/hr)			
TNMHC	7	22.143	12.440	8	4.944	5.484
Paraffins	7	4.776	5.601	8	2.911	3.766
Olefins	7	14.326	9.727	8	0.096	0.132
Aromatics	7	3.056	2.808	8	1.938	1.882
Methane	7	4.801	6.015	8	4.076	5.934
Isoprene	8	12.399	10.338	9	0	0
			Name: Red Maple 651 (μg/g/hr)			
TNMHC	9	6.457	4.097	9	4.486	2.848
Paraffins	9	0.883	0.800	9	0.613	0.556
Olefins	9	3.473	3.542	9	2.411	2.600
Aromatics	9	2.104	1.533	9	1.461	1.065
Methane	9	2.998	3.197	9	2.998	3.197
α-Pinene	9	0.033	0.100	9	0.023	0.069
Unk #21	9	2.267	2.774	9	1.574	1.927
Δ^3-Carene	9	0.458	0.911	9	0.317	0.631
			Name: Hickory 671 (μg/g/hr)			
TNMHC	4	3.188	2.142	4	2.213	1.486
Paraffins	4	1.548	1.407	4	1.074	0.974
Olefins	4	-0.375	0.750	4	-0.250	0.500
Aromatics	4	2.015	1.040	4	1.398	0.721
Methane	4	9.346	18.843	4	9.346	18.843
α-Pinene	4	-0.575	1.150	4	-0.400	0.800
β-Pinene	4	-0.078	0.155	4	-0.055	0.110
d-Limonene	4	0.255	0.510	4	0.177	0.354
Unk #22	4	0.112	0.137	4	0.078	0.095
Δ^3-Carene	4	0.640	0.128	4	0.045	0.089

	Day			Night		
Compound	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Name: Mixed Grass 700 (μg/m²/hr)						
TNMHC	24	190.050	237.128	24	190.050	237.128
Paraffins	24	75.254	49.203	24	75.254	49.203
Olefins	24	71.671	212.237	24	71.671	212.237
Aromatics	24	43.154	34.335	24	43.154	34.335
Methane	24	292.450	205.674	24	292.450	205.674
α-Pinene	24	56.198	161.256	24	56.198	161.256
β-Pinene	24	8.674	30.250	24	8.674	30.250
d-Limonene	24	0.104	5.993	24	0.104	5.993
Unk Terp.	24	1.008	4.940	24	1.008	4.940
Unk #24	24	2.246	11.002	24	2.246	11.002
Δ^3-Carene	24	1.649	5.145	24	1.649	5.145
Name: Bahia 701 (μg/m²/hr)						
TNMHC	4	53.650	9.863	4	53.650	9.863
Paraffins	4	24.875	7.999	4	24.875	7.999
Olefins	4	0	0	4	0	0
Aromatics	4	28.775	13.470	4	28.775	13.470
Methane	4	147.000	61.395	4	147.000	61.395
Name: Bermuda 711 (μg/m²/hr)						
TNMHC	4	163.250	40.302	4	163.250	40.302
Paraffins	4	68.525	45.856	4	68.525	45.856
Olefins	4	19.000	41.608	4	19.000	41.608
Aromatics	4	75.800	34.466	4	75.800	34.466
Methane	4	207.425	261.388	4	207.425	261.388
α-Pinene	4	3.215	6.250	4	3.215	6.250
Δ^3-Carene	4	10.625	21.250	4	10.625	21.250

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
			Name: Clover 721 ($\mu g/m^2/hr$)			
TNMHC	3	153.00	14.107	3	153.00	14.107
Paraffins	3	97.467	11.707	3	97.467	11.707
Olefins	3	11.573	5.368	3	11.573	5.368
Aromatics	3	44.400	6.636	3	44.400	6.636
Methane	3	150.633	66.821	3	150.633	66.821
			Name: Pensicola 731 ($\mu g/m^2/hr$)			
TNMHC	59	144.336	91.039	59	144.336	91.039
Paraffins	59	79.490	47.513	59	79.490	47.513
Olefins	59	13.190	65.896	59	13.190	65.896
Aromatics	59	51.678	23.986	59	51.678	23.986
Methane	59	280.831	175.591	59	280.831	175.591
α-Pinene	59	10.050	58.437	59	10.050	58.437
β-Pinene	59	2.448	10.314	59	2.448	10.314
			Name: Sawgrass 741 ($\mu g/m^2/hr$)			
TNMHC	6	391.717	476.865	6	391.717	476.865
Paraffins	6	70.383	18.578	6	70.383	18.578
Olefins	6	292.500	456.430	6	292.500	456.430
Aromatics	6	28.505	11.720	6	28.505	11.720
Methane	6	313.200	215.211	6	313.200	215.211
α-Pinene	6	242.333	378.023	6	242.333	378.023
β-Pinene	6	39.167	61.568	6	39.167	61.568

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Name: Tomatoes 801 (μg/g/hr)						
TNMHC	6	48.083	24.619	6	33.400	17.081
Paraffins	6	7.555	5.648	6	5.243	3.910
Olefins	6	31.355	19.473	6	21.745	13.508
Aromatics	6	9.278	13.152	6	6.443	9.133
Methane	7	4.127	15.142	7	4.127	15.141
d-Limonene	7	15.301	11.865	7	10.636	8.247
Myrcene	7	0.129	0.341	7	0.900	0.2370
Unk #21	7	5.543	4.445	7	3.850	3.087
Unk #23	7	1.207	1.121	7	0.840	0.7793
Δ^3-Carene	7	3.930	2.820	7	2.728	1.960
Name: Strawberries 811 (μg/m^2/hr)						
TNMHC	2	419.000	420.021	2	290.800	291.611
Paraffins	2	360.55	406.516	2	250.400	282.277
Olefins	2	0	0	2	0	0
Aromatics	2	58.350	13.647	2	40.550	9.405
Methane	2	174.000	83.439	2	174.000	83.439
Name: Beans 821 (μg/m^2/hr)						
TNMHC	10	1565.100	1053.640	10	264.390	182.476
Paraffins	10	296.700	220.010	10	205.970	152.631
Olefins	10	1172.800	850.750	10	-8.690	23.668
Aromatics	10	95.420	44.720	10	66.300	31.083
Methane	8	669.880	36.470	8	669.875	36.471
Isoprene	10	1184.100	835.440	10	0	0
Name: Okra 841 (μg/g/hr)						
TNMHC	6	9.847	11.495	6	6.840	7.979
Paraffins	6	5.593	6.664	6	3.886	4.630
Olefins	6	0	0	6	0	0
Aromatics	6	4.250	4.979	6	2.953	3.463
Methane	6	0.849	2.427	6	0.849	2.427

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Name: Grassy Mudflat (Marine) 0"-2" Water 901 (μg/m²/hr)						
TNMHC	7	206.371	250.511	7	206.371	250.511
Paraffins	7	148.443	208.617	7	148.443	208.617
Olefins	7	0	0	7	0	0
Aromatics	7	57.943	44.785	7	57.943	44.785
Methane	7	352.429	178.100	7	352.429	178.100
Name: Grassy Mudflat (2"-12") 902 (μg/m²/hr)						
TNMHC	11	77.927	39.459	11	77.927	39.459
Paraffins	11	36.855	13.310	11	36.855	13.310
Olefins	11	0	0	11	0	0
Aromatics	11	41.091	29.167	11	41.091	29.167
Methane	11	186.200	107.170	11	186.200	107.170
Name: Grassy Mudflat (12"-2') 903 (μg/m²/hr)						
TNMHC	4	79.300	39.125	4	79.300	39.125
Paraffins	4	45.050	22.000	4	45.050	22.000
Olefins	4	0	0	4	0	0
Aromatics	4	34.325	18.421	4	34.325	18.421
Methane	4	143.250	18.283	4	143.250	18.283
Name: Grassy Mudflat (2'-5') 904 (μg/m²/hr)						
TNMHC	10	123.650	57.479	10	123.650	57.479
Paraffins	10	69.130	46.001	10	69.130	46.001
Olefins	10	0	0	10	0	0
Aromatics	10	54.610	22.180	10	54.610	22.180
Methane	10	201.110	225.747	10	201.110	225.747
Name: Sandy Bottom (>5') 905 (μg/m²/hr)						
TNMHC	15	89.540	50.143	15	89.540	50.143
Paraffins	15	50.153	33.033	15	50.153	33.033
Olefins	15	0	0	15	0	0
Aromatics	15	39.329	21.175	15	39.329	21.175
Methane	15	281.200	284.621	15	281.200	284.621

Compound	Day N	Day $\overline{X}$	Day SD	Night N	Night $\overline{X}$	Night SD
Name: Decaying Marine Algae 911 ($\mu g/m^2/hr$)						
TNMHC	2	209.500	126.572	2	209.500	126.572
Paraffins	2	50.800	29.557	2	50.800	29.557
Olefins	2	127.500	180.312	2	127.500	180.312
Aromatics	2	31.400	23.193	2	31.400	23.193
Methane	2	433.000	69.296	2	433.000	69.296
α-Pinene	2	32.650	46.174	2	32.650	46.174
Myrcene	2	31.000	43.841	2	31.000	43.841
Terpinolene	2	31.000	43.841	2	31.000	43.841
Name: Decaying Marine Grass 912 ($\mu g/m^2/hr$)						
TNMHC	5	87.200	20.027	5	87.200	20.027
Paraffins	5	54.520	19.467	5	54.520	19.467
Olefins	5	0	0	5	0	0
Aromatics	5	32.720	12.138	5	32.720	12.138
Methane	4	375.750	136.170	4	375.750	136.170
Name: Decaying Mixed Vegetation 913 ($\mu g/m^2/hr$)						
TNMHC	11	96.100	15.056	11	96.100	49.935
Paraffins	11	49.700	5.721	11	49.700	18.973
Olefins	11	0	0	11	0	0
Aromatics	11	46.373	10.655	11	46.373	35.338
Methane	10	380.300	72.605	10	380.300	229.598
Name: Mudflat No Grass 0-2" H_2O 921 ($\mu g/m^2/hr$)						
TNMHC	1	215.000	---	1	215.000	---
Paraffins	1	119.000	---	1	119.000	---
Olefins	1	0	---	1	0	---
Aromatics	1	96.900	---	1	96.900	---
Methane	1	80.800	---	1	80.800	---

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Name: Mudflat 2"-12" 922 (μg/m²/hr)						
TNMHC	4	85.575	11.481	4	85.575	11.481
Paraffins	4	43.050	10.573	4	43.050	10.573
Olefins	4	0	0	4	0	0
Aromatics	4	42.500	6.472	4	42.500	6.472
Methane	4	151.475	58.066	4	151.475	58.066
Name: Mudflat 12"-2' 923 (μg/m²/hr)						
TNMHC	2	105.550	812.470	2	105.550	812.470
Paraffins	2	66.250	56.215	2	66.250	56.215
Olefins	2	0	0	2	0	0
Aromatics	2	39.300	25.032	2	39.300	25.032
Methane	2	124.750	59.751	2	124.750	59.751
Name: Mudflat 2'-5' 924 (μg/m²/hr)						
TNMHC	22	136.582	125.379	22	136.582	125.379
Paraffins	22	79.746	72.120	22	79.746	72.120
Olefins	22	0	0	22	0	0
Aromatics	22	56.900	55.955	22	56.900	55.955
Methane	22	271.973	219.996	22	271.973	219.996
Unk #10-A	23	1.339	6.422	23	1.339	6.422
Unk #22	23	0.373	1.787	23	0.373	1.787
Name: Mudflat >5' 925 (μg/m²/hr)						
TNMHC	48	149.423	141.883	48	149.423	141.883
Paraffins	48	79.179	73.237	48	79.179	73.237
Olefins	48	0	0	48	0	0
Aromatics	48	70.279	75.114	48	70.279	75.114
Methane	48	305.417	247.450	48	305.417	247.450
Unk #10-A	48	4.063	28.146	48	4.063	28.146
Unk #22	48	1.412	9.786	48	1.412	9.786
Unk #23	48	0.005	0.032	48	0.005	0.032
Unk #24	48	0.444	3.074	48	0.444	3.074

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
		Name: Sandy Beach 931 (μg/m^2/hr)				
TNMHC	1	349.000	---	1	349.000	---
Paraffins	1	157.000	---	1	157.000	---
Olefins	1	0	---	1	0	---
Aromatics	1	192.000	---	1	192.000	---
Methane	1	380.000	---	1	380.000	---
		Name: Fresh H_2O Marsh (o"-2") 941 (μg/m^2/hr)				
TNMHC	4	74.670	23.900	4	74.670	23.900
Paraffins	4	49.870	23.860	4	49.870	23.860
Olefins	4	0	0	4	0	0
Aromatics	4	24.820	1.310	4	24.820	1.310
Methane	3	2940.330	2456.340	3	2940.330	2456.340
Unk. #17	4	-0.650	1.300		-0.650	1.300
Unk. #18	4	1.850	3.690		1.850	3.690
		Name: Fresh Water Marsh (>12") 942 (μg/m^2/hr)				
TNMHC	3	120.100	44.950	3	120.100	44.950
Paraffins	3	48.530	14.180	3	48.530	14.180
Olefins	3	0	0	3	0	0
Aromatics	3	71.430	44.440	3	71.430	44.440
Methane	3	1432.330	1811.420	3	1432.330	1811.420
		Name: Fresh Water Marsh (hyacinth) 943 (μg/m^2/hr)				
TNMHC	2	69.650	8.410	2	69.650	8.410
Paraffins	2	26.850	15.490	2	26.850	15.490
Olefins	2	0	0	2	0	0
Aromatics	2	42.800	7.070	2	42.800	7.070
Methane	2	1792.500	1269.260	2	1792.500	1269.260

	Day			Night		
Compound	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Name: Fresh Water Marsh (Waterlilly) 944 (μg/m²/hr)						
TNMHC	2	164.000	15.600	2	164.000	15.600
Paraffins	2	94.600	14.600	2	94.600	14.600
Olefins	2	0	0	2	0	0
Aromatics	2	69.500	0.800	2	69.500	0.800
Methane	2	36950.000	29769.200	2	36950.000	29769.200
Name: Oyster Beds 950 (μg/m²/hr)						
TNMHC	1	50.400	---	1	50.400	---
Paraffins	1	32.800	---	1	32.800	---
Olefins	1	0	---	1	0	---
Aromatics	1	17.600	---	1	17.600	---
Methane	1	323.000	---	1	323.000	---

APPENDIX B

INTRODUCTION

This appendix contains the emission factors (ER) and variances (S^2) for each vegetation association during a 30°C day and a 25°C night. S^2 was calculated by multiplying the variance of each species/sample type times the square of its association multiplication factor and summing these for each association. This procedure carries the implicit assumption that the mean emission rates in Appendix A are independently related.

Since a change in one species/sample type emission rate value in Appendix A will not affect the emission rates of any of the other species/sample types, this assumption seems valid. The "name" designates the computer letter code and the association type. All emission factors are in micrograms per meter squared ground surface per hour ($\mu g/m^2/hr$).

Association Emission Factors ($\mu g/m^2/hr$)

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: Assn. A Mangrove				
TNMHC	765.266	150551.0	561.323	73002.6
Paraffins	439.131	83182.7	321.487	40567.2
Olefins	3.109	118.9	2.180	57.4
Aromatics	323.738	38429.5	238.036	18563.0
Methane	1017.190	600835.0	1017.190	600835.0
Name: Assn. B Pine				
TNMHC	4289.950	8287360.0	2364.540	3499180.0
Paraffins	602.553	104704.0	434.125	50472.7
Olefins	3276.390	7303520.0	1638.970	3188770.0
Aromatics	372.757	33513.0	265.746	166333.2
Methane	821.851	190969.0	810.816	190278.0
α-Pinene	857.510	1196080.0	612.619	590904.0
β-Pinene	877.476	1694520.0	611.880	817258.0
d-Limonene	113.827	22492.5	79.075	10847.7
Isoprene	946.987	675435.0	0.000	0.0
Myrcene	0.158	0.720	0.110	0.349
Unk. Terpenes	1.008	24.4	1.008	24.4
21A	7.322	0.0	5.102	0.0
18	0.452	7.165	0.306	3.361
20	0.217	1.644	0.146	0.771
22	10.188	1824.2	6.881	856.8
24	2.246	121.1	2.246	121.1
Δ^3-Carene	189.733	124492.0	132.201	60042.5
Name: Assn. C Citrus				
TNMHC	5974.090	83781200.0	4199.180	40399500.0
Paraffins	1317.130	1558510.0	938.209	748416.0
Olefins	3352.490	68638800.0	233.742	33109700.0
Aromatics	1311.640	63.838	927.057	519264.0
Methane	4505.220	52289100.0	4505.220	52289100.0
α-Pinene	48.626	8745.0	39.061	5168.5
β-Pinene	2.780	63.838	2.780	63.8
d-Limonene	111.528	114893.0	77.638	55394.7
Myrcene	0.750	2.250	0.750	2.250
Unk. Terpenes	0.252	1.525	0.252	1.525
16	4.444	315.9	3.091	152.8
21	26.808	11151.0	18.629	5348.9
22	239.299	257860.0	166.247	124261.0
24	3001.780	61323300.0	2084.520	29570000.0
25	24.890	9915.2	17.280	4775.6
26	6.295	634.0	4.361	304.3
Δ^3-Carene	3.269	30.530	3.207	30.2

Association Emission Factors ($\mu g/m^2/hr$)

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: Assn. D Oak, Gum, Cypress (Domes)				
TNMHC	6807.000	15479100.0	3817.460	7280810.0
Paraffins	993.542	464183.0	701.483	223343.0
Olefins	5018.710	14504500.0	2561.450	6758540.0
Aromatics	801.235	265039.0	560.589	127612.0
Methane	1341.940	1671330.0	1326.060	1670900.0
α-Pinene	1043.900	3289920.0	792.606	1641350.0
β-Pinene	36.196	10634.7	35.908	6716.5
d-Limonene	94.761	14562.2	65.819	7019.8
Isoprene	1385.170	593605.0	0.000	0.0
Myrcene	137.484	143666.0	95.460	69381.8
Unk. Terpenes	-7.315	131337.0	-3.972	61584.2
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136
21	772.050	7219980.0	520.262	3623100.0
22	14.364	4090.2	9.945	1960.3
23	1.486	19.870	1.037	9.681
27	29.484	16475.4	20.406	7890.5
28	1.681	5.763	1.167	2.782
Δ^3-Carene	708.361	1021560.0	491.185	493595.0
26A	109.550	2610890.0	76.014	125559.0
29A	25.392	701.3	17.552	336.4
Name: Assn. E Oak, Gum, Cypress (Drained)				
TNMHC	4436.090	22368.0	2558.580	2857170.0
Paraffins	656.341	175404.0	470.771	84457.7
Olefins	3250.500	5566120.0	1714.980	2649760.0
Aromatics	532.140	100605.0	375.322	48471.1
Methane	1089.060	693824.0	1079.140	693653.0
α-Pinene	727.460	1309660.0	572.453	689577.0
β-Pinene	37.026	5954.3	36.484	4460.6
d-Limonene	58.308	5478.2	40.500	2640.8
Isoprene	858.588	223638.0	0.000	0.0
Myrcene	84.318	54037.0	58.545	26096.5
Unk. Terpenes	-4.486	49399.6	-2.436	23163.6
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136
21	496.530	2718010.0	335.068	1363900.0
22	8.849	1538.5	6.127	737.3
23	1.822	29.9	1.272	14.6
27	18.565	6201.8	12.849	2970.2
28	2.062	8.670	1.432	4.186
Δ^3-Carene	439.521	384498.0	304.762	185780.0
26A	67.728	98208.4	46.994	47229.0
29A	30.623	1048.6	21.207	503.4

Association Emission Factors ($\mu g/m^2/hr$)

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: Assn. G Xeric Oak (cont'd)				
26A	1.112	7.936	0.771	3.802
29A	30.916	1103.8	21.450	530.0
Name: Assn. H Hydric Oak				
TNMHC	7840.610	29779300.0	2766.440	5389160.0
Paraffins	884.093	423365.0	599.801	176145.0
Olefins	6134.830	21004600.0	1623.350	4239210.0
Aromatics	827.685	205562.0	553.785	90707.4
Methane	1514.730	454815.0	1415.780	449422.0
α-Pinene	177.712	992150.0	157.866	489501.0
β-Pinene	75.448	21159.0	58.636	10620.9
d-Limonene	64.132	6642.2	44.561	3212.3
Isoprene	3822.670	10992600.0	0.000	0.0
Myrcene	77.386	103022.0	53.798	49809.0
Unk. Terpenes	-55.652	60754.9	-37.393	27812.1
21	905.165	6299780.0	613.810	3159910.0
22	1.883	6.785	1.308	3.261
23	1.380	17.149	0.964	8.355
24	1.572	59.339	1.572	59.3
27	1.619	19.592	1.122	9.393
28	1.561	4.974	1.084	2.401
29	0.497	1.322	0.296	0.557
Δ^3-Carene	230.902	183916.0	160.513	88775.7
26A	101.740	225185.0	70.594	108293.0
29A	26.598	625.8	18.437	300.5
Name: Assn. I Representative Shrubs				
TNMHC	1983.460	454221.0	881.610	136414.0
Paraffins	487.518	74267.0	337.796	34446.4
Olefins	1170.920	290744.0	314.846	52772.5
Aromatics	324.857	21731.4	228.701	10227.4
Methane	724.839	202707.0	689.748	200567.0
α-Pinene	87.072	13976.4	73.517	13360.6
β-Pinene	39.497	3147.7	30.598	1788.3
d-Limonene	4.581	77.6	3.204	46.5
Isoprene	661.230	232071.0	0.000	0.0
Myrcene	0.003	0.0003	0.002	0.0001
Unk. Terpenes	0.706	11.956	0.706	11.956
21	0.334	1.006	0.232	0.486
22	0.499	2.238	0.346	1.075
23	1.144	1179.3	7.992	574.6
24	1.572	59.3	1.572	59.3
27	6.059	261.1	4.204	125.8

Association Emission Factors ($\mu g/m^2/hr$)

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: Assn. I Representative Shrubs (cont'd)				
28	12.949	342.0	8.991	165.1
29	0.808	3.496	0.480	1.472
Δ^3-Carene	10.180	279.8	7.421	141.8
26A	6.803	296.8	4.714	142.2
29A	193.329	41319.6	133.986	19838.0
Name: Assn. J Palmetto				
TNMHC	5387.500	65180200.0	1108.000	2055920.0
Paraffins	660.250	913063.0	475.075	427671.0
Olefins	3971.820	42489000.0	93.207	48514.9
Aromatics	758.649	1350030.0	538.600	636016.0
Methane	1337.750	3723750.0	1308.500	3636670.0
α-Pinene	53.371	26280.1	54.200	26144.0
β-Pinene	8.674	915.0	8.674	915.0
d-Limonene	0.104	35.9	0.104	35.9
Isoprene	3867.750	41694700.0	0.000	0.0
Unk. Terpenes	1.008	24.4	1.008	24.4
18	6.147	1321.9	4.150	620.0
20	2.944	303.3	1.988	142.2
22	138.375	336555.0	93.465	158071.0
24	2.246	121.1	2.246	121.1
Δ^3-Carene	1.649	26.5	1.649	26.5
Name: Assn. K Improved Pasture				
TNMHC	159.505	4515.2	159.505	4515.2
Paraffins	73.426	570.9	73.426	570.9
Olefins	37.952	3219.2	37.952	3219.2
Aromatics	48.208	178.1	48.208	178.1
Methane	251.000	8816.4	251.000	8816.4
α-Pinene	28.190	2091.6	28.190	2091.6
β-Pinene	4.795	67.6	4.795	67.6
Myrcene	0.300	0.360	0.300	0.360
Unk. Terpenes	0.202	0.976	0.202	0.976
24	0.449	4.844	0.449	4.844
Δ^3-Carene	1.392	5.575	1.392	5.575
Name: Assn. L Unimproved Pasture				
TNMHC	207.605	20583.2	207.605	20583.2
Paraffins	70.100	548.3	70.100	548.3
Olefins	94.549	17513.4	94.549	17513.4
Aromatics	42.962	263.8	42.962	263.8
Methane	265.270	11458.9	265.270	11458.9
α-Pinene	75.068	11015.6	75.068	11015.6

Association Emission Factors ($\mu g/m^2/hr$)

Compound	Day ER	Day S^2	Night ER	Night S^2
		Name: Assn. L Unimproved Pasture (cont'd)		
α-Pinene	11.982	338.0	11.982	338.0
β-Limonene	0.283	7.495	0.283	7.495
Myrcene	0.300	0.360	0.300	0.360
Unk. Terpenes	0.454	4.941	0.454	4.941
24	1.011	24.5	1.011	24.5
Δ^3-Carene	1.804	9.876	1.804	9.876
		Name: Assn. M Crops		
TNMHC	828.956	150347.0	287.860	11004.3
Paraffins	192.063	8731.4	133.360	4203.8
Olefins	543.474	95482.5	89.136	3349.5
Aromatics	93.871	3678.3	65.209	1774.3
Methane	272.418	4431.1	272.418	4431.1
d-Limonene	64.872	2531.2	45.114	1223.8
Isoprene	414.400	85504.9	0.000	0.0
Myrcene	0.547	2.1	0.380	1.0
21	23.502	355.2	16.324	171.3
23	5.118	22.6	3.560	10.9
Δ^3-Carene	16.663	143.0	11.567	69.1

APPENDIX C

LUDA EMISSION FACTORS

This appendix contains the day and night LUDA emission factors in $\mu g/m^2/hr$. LUDA (Land Use and Land Cover Data Analysis System) map identification codes and their general designations are given in the headings.

The variance (S^2) was calculated for each LUDA category from the variance for each species times the square of the multiplication factor summed for all species in each LUDA category, plus the variance for each association times the square of the association percent in each LUDA category, summed for all associations in the LUDA category. Symbolically, this appears as:

$$S^2 \text{ LUDA} = [S_1^2(f_1^2) + S_2^2(f_2^2). \ldots . + S_n^2(f_n^2)] = [S_a^2(f_n^2) + S_b^2(f_b^2) + S_n^2(f_n^2)]$$

where: $S_1^2(f_1^2)$ represents species variance times its squared multiplication factor. $S_a^2(f_a^2)$ represents the association variance times its squared multiplication factor. This calculation procedure assumes that all values are independent. However, it is recognized that since many associations share some species, the variances show a slight positive correlation. The correlation coefficients vary between each association depending upon the number of species shared, the predominance of the shared species in each association, and the predominance of each association in each LUDA category. The detailed statistical analysis and computer programming that would be required to evaluate the LUDA variances more accurately were beyond the scope of this project.

It should also be noted that the variances reported here can only be considered as rough estimates of the variance associated with the samples involved in the LUDA emission estimates. However, uncertainties in emission rate algorithms, temperature regimes, annual emission rate variability and many other unknown factors which may cause actual emissions to vary from the emission estimates reported here make a more detailed analysis of the sample variances superfluous.

APPENDIX C

LUDA Emission Factors
μg/m²/hr

	Day		Night	
Compound	ER	S^2	ER	S^2
Name: LUDA 0011 Residential				
TNMHC	2006.520	122974.0	878.956	32111.4
Paraffins	393.924	4680.2	279.014	2214.9
Olefins	119.772	101638.0	306.961	25277.4
Aromatics	412.204	1365.8	291.497	666.6
Methane	378.625	17725.0	367.795	1750.3
α-Pinene	163.826	10290.0	120.265	5431.7
β-Pinene	112.851	11526.2	80.900	5619.8
d-Limonene	14.538	158.4	10.104	76.9
Isoprene	753.571	52072.7	0.000	0.0
Myrcene	1.317	5.083	0.914	2.450
Unk. Terpenes	0.302	0.790	0.302	0.790
21A	3.865	0.0	2.693	0.0
18	0.041	0.046	0.028	0.022
20	0.020	0.011	0.013	0.005
21	2.603	19.271	1.809	9.310
22	1.023	11.195	0.693	5.613
23	2.439	47.374	1.703	23.1
24	0.674	3.924	0.674	3.924
27	1.291	10.049	0.896	5.053
28	2.759	13.740	1.916	6.633
29	1.051	4.377	0.625	1.843
Δ^3-Carene	20.165	83.458	14.149	402.9
26A	11.450	1.922	1.004	5.712
29A	41.139	1659.8	28.513	796.9
Name: LUDA 0021 Cropland Pasture				
TNMHC	518.281	42733.	247.732	7896.8
Paraffins	131.081	23230.	101.730	1188.0
Olefins	319.011	28249.	91.842	5215.7
Aromatics	68.417	985.5	54.086	509.5
Methane	268.884	3973.	268.844	3972.5
α-Pinene	37.534	2753.9	37.534	2753.9
β-Pinene	5.992	84.5	5.991	84.5
d-Limonene	32.578	634.7	22.698	307.6
Isoprene	207.200	21376.2	0.000	0.0
Myrcene	0.423	0.614	0.340	0.342
Unk. Terpenes	0.227	1.235	0.227	1.235
21	11.751	88.8	8.162	42.8
23	2.559	5.649	1.780	2.729
24	0.505	6.131	0.505	6.131
Δ^3-Carene	9.234	38.2	6.685	19.7

LUDA Emission Factors
$\mu g/m^2/hr$

	Day		Night	
Compound	ER	S^2	ER	S^2
Name: LUDA 0022 Orchards, Vineyards, Nurseries				
TNMHC	2006.520	122974.0	878.956	32111.4
Paraffins	393.924	4680.2	279.014	2214.9
Olefins	119.772	101638.0	306.961	25277.4
Aromatics	412.204	1365.8	291.497	666.6
Methane	378.625	17725.0	367.795	17502.8
α-Pinene	163.826	10290.0	120.265	5431.7
β-Pinene	112.851	11526.2	80.900	5619.8
d-Limonene	14.538	158.4	10.104	76.9
Isoprene	753.571	52072.7	0.000	0.0
Myrcene	1.317	5.083	0.914	2.450
Unk. Terpenes	0.302	0.790	0.302	0.790
21A	3.865	0.0	2.694	0.0
18	0.041	0.047	0.028	0.022
20	0.020	0.011	0.013	0.005
21	2.063	19.271	1.809	9.310
22	1.024	11.950	0.693	5.613
23	2.439	47.374	1.703	23.1
24	0.674	3.924	0.674	3.924
27	1.291	1.049	0.896	5.053
28	2.579	13.740	1.916	6.633
29	1.050	4.377	0.625	1.843
Δ^3-Carene	20.165	834.6	14.149	402.9
26A	1.450	11.922	1.004	5.712
29A	41.139	1659.8	28.513	796.9
Name: LUDA 0024 Agricultural Land				
TNMHC	496.636	38552.6	226.087	3716.8
Paraffins	132.578	2299.8	103.226	1167.9
Olefins	293.542	24566.3	66.374	1533.0
Aromatics	70.777	956.3	56.446	480.3
Methane	262.423	2921.8	262.423	2921.8
α-Pinene	16.439	451.1	16.439	451.1
β-Pinene	2.757	14.539	2.757	14.5
d-Limonene	2.356	633.2	22.687	306.1
Isoprene	207.200	21376.2	0.000	0.0
Myrcene	0.423	0.597	0.340	0.326
Unk. Terpenes	0.113	0.210	0.113	0.210
21	11.751	88.8	8.162	42.8
23	2.559	5.649	1.780	2.729
24	0.253	1.042	0.253	1.042
Δ^3-Carene	9.048	36.9	6.500	18.4

LUDA Emission Factors
$\mu g/m^2/hr$

	Day		Night	
Compound	ER	S^2	ER	S^2
Name: LUDA 0025 Cropland				
TNMHC	828.958	150347.0	287.860	11004.3
Paraffins	192.063	8731.3	133.360	4203.8
Olefins	543.474	95482.5	89.136	3349.5
Aromatics	93.871	3678.3	65.209	1774.3
Methane	272.418	4431.1	272.418	4431.1
d-Limonene	64.872	2531.2	45.114	1222.8
Isoprene	414.400	85504.9	0.000	0.0
Myrcene	0.547	2.094	0.380	1.100
21	23.502	355.2	16.324	171.3
23	5.118	22.6	3.560	10.9
Δ^3-Carene	16.663	143.0	11.567	69.0
Name: LUDA 0026 Pasture				
TNMHC	988.706	124478.0	630.087	59514.7
Paraffins	204.894	8117.8	163.029	4121.0
Olefins	633.166	119002.0	349.052	56831.4
Aromatics	148.717	4194.4	116.793	2087.3
Methane	459.655	33823.1	456.881	33816.3
α-Pinene	191.095	42705.9	145.424	21627.6
β-Pinene	51.304	4337.1	37.718	2124.1
d-Limonene	15.149	211.9	10.590	102.8
Isoprene	148.629	4481.8	0.000	0.0
Myrcene	11.988	767.9	8.396	370.1
Unk. Terpenes	3.885	1229.2	2.826	587.6
21A	0.366	0.0	0.255	0.0
17	-0.013	0.0007	-0.013	0.0007
18	0.060	0.023	0.052	0.014
20	0.011	0.004	0.007	0.002
21	44.736	22064.1	30.189	11071.7
22	2.360	72.6	1.625	34.7
23	0.164	0.243	0.115	0.118
24	0.494	3.802	0.494	3.802
27	3.787	273.9	2.621	131.2
28	0.186	0.070	0.129	0.034
Δ^3-Carene	91.386	14622.9	63.755	7068.1
26A	6.102	797.2	4.234	383.4
29A	2.808	8.574	1.941	4.113
Name: LUDA 0027 Specialty Farms				
TNMHC	87.200	401.1	87.200	401.1
Paraffins	54.520	378.9	54.520	378.9
Olefins	0.000	0.0	0.000	0.0
Aromatics	32.720	147.3	32.720	147.3
Methane	375.700	18540.0	375.700	18540.0

LUDA Emission Factors
μg/m²/hr

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0028 Horticultural Farms				
TNMHC	2006.520	122974.0	878.956	32111.4
Paraffins	393.924	4680.2	279.014	2214.9
Olefins	1197.720	101638.0	306.961	25277.4
Aromatics	412.204	1365.8	291.497	666.6
Methane	378.625	17725.0	367.795	17502.8
α-Pinene	163.826	10290.0	120.265	3431.7
β-Pinene	112.851	11526.2	80.900	5619.8
d-Limonene	14.538	158.4	10.104	76.9
Isoprene	753.571	52072.7	0.000	0.0
Myrcene	1.317	5.083	0.914	2.450
Unk. Terpenes	0.302	0.790	0.302	0.790
21A	3.865	0.0	2.694	0.0
18	0.041	0.046	0.028	0.022
20	0.020	0.012	0.013	0.005
21	2.063	19.3	1.809	9.310
22	1.024	11.9	0.693	5.613
23	2.439	47.4	1.703	23.1
24	0.674	3.923	0.674	3.924
27	1.291	10.5	0.896	5.053
28	2.759	13.7	1.916	6.633
29	1.051	4.377	0.625	1.843
Δ^3-Carene	20.165	834.6	14.149	402.9
26A	1.450	11.9	1.004	5.712
29A	41.139	1659.8	28.513	796.9
Name: LUDA 0029 Groves				
TNMHC	5974.090	83781200.0	4199.180	40399500.0
Paraffins	1317.130	1558510.0	938.209	748416.0
Olefins	3352.490	68638800.0	2337.420	33109700.0
Aromatics	1311.640	1077280.0	927.075	519264.0
Methane	4505.220	52289100.0	4505.220	522891.0
α-Pinene	48.626	8745.0	39.061	5168.5
β-Pinene	2.780	63.8	2.780	63.8
d-Limonene	111.528	114893.0	77.638	55394.7
Myrcene	0.750	2.250	0.750	2.250
Unk. Terpenes	0.252	1.525	0.252	1.525
16	4.444	315.9	3.090	152.8
21	26.808	11151.0	18.629	5348.9
22	239.299	257860.0	166.247	124261.0
24	3001.780	61323300.0	2084.520	29570000.0
25	24.890	9915.2	17.280	4775.6
26	6.294	634.0	4.361	304.3
Δ^3-Carene	3.269	30.5	3.207	30.2

LUDA Emission Factors
μg/m²/hr

Compound	Day ER	Day S²	Night ER	Night S²
Name: LUDA 0031 Herbaceous Rangeland				
TNMHC	1710.020	783922.0	834.917	84132.7
Paraffins	268.489	12016.8	205.846	5805.9
Olefins	1220.390	543581.0	463.762	58340.8
Aromatics	217.958	14837.7	162.950	7073.2
Methane	550.412	50488.4	543.934	49609.4
α-Pinene	244.493	27502.2	195.356	16492.4
β-Pinene	100.567	17147.0	73.888	8365.0
d-Limonene	19.903	271.1	13.889	132.8
Isoprene	593.021	425104.0	0.000	0.0
Myrcene	11.772	347.8	543.934	49609.4
Unk. Terpenes	1.191	368.1	1.068	175.1
21A	0.732	0.0	0.510	0.0
17	-0.008	0.0001	-0.008	0.0001
18	0.684	13.292	0.470	6.235
20	0.316	3.050	0.213	1.430
21	59.199	15983.9	39.919	8020.9
22	16.252	3397.8	11.001	1596.0
23	0.163	0.080	0.114	0.039
24	1.157	14.4	1.157	14.4
27	2.872	56.590	1.988	27.1
28	0.185	0.023	0.128	0.011
Δ^3-Carene	86.136	4518.2	60.227	2184.7
26A	8.244	577.9	5.721	277.9
29A	2.777	2.837	1.920	1.361
Name: LUDA 0032 Shrub & Brush Rangeland				
TNMHC	4706.690	32608300.0	1062.720	1033410.0
Paraffins	625.703	459502.0	447.619	215213.0
Olefins	3411.640	21256100.0	137.535	26368.3
Aromatics	627.189	675885.0	476.619	318417.0
Methane	1215.170	1869980.0	118.475	1826360.0
α-Pinene	60.111	13699.1	58.064	13606.4
β-Pinene	14.839	583.4	13.059	529.0
d-Limonene	0.992	21.0	0.724	19.8
Isoprene	3226.450	20856600.0	0.000	0.0
Myrcene	0.0006	0.00001	0.0004	0.00006
Unk. Terpenes	0.948	12.7	0.948	12.7
21A	0.177	0.0	0.123	0.0
18	4.918	661.0	3.320	310.0
20	2.355	151.7	1.590	71.1
21	0.067	0.040	0.046	194.3
22	110.800	168277.0	74.841	79035.7
23	2.289	47.2	1.598	23.0

LUDA Emission Factors
$\mu g/m^2/hr$

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0032 Shrub 7 Brush Rangeland (cont'd)				
24	2.111	62.9	2.111	62.9
27	1.212	10.4	0.841	5.031
28	2.590	13.7	1.798	6.604
29	0.162	0.140	0.096	0.059
Δ^3-Carene	3.355	24.4	2.803	18.9
26A	1.361	11.9	0.943	5.688
29A	38.666	1652.8	26.797	793.5
Name: LUDA 0033 Mixed Rangeland				
TNMHC	1455.950	491083.0	10.066	67.7
Paraffins	248.474	7886.3	190.730	3851.6
Olefins	1009.940	337376.0	371.668	33858.7
Aromatics	195.347	9510.8	146.890	4556.2
Methane	511.907	34540.7	504.268	33965.6
α-Pinene	194.526	16529.1	159.041	11044.5
β-Pinene	76.162	8508.8	56.777	4196.6
d-Limonene	14.398	136.1	10.066	67.7
Isoprene	50.759	272376.0	0.000	0.0
Myrcene	8.377	181.8	5.880	33965.6
Unk. Terpenes	0.949	189.9	0.878	90.9
21A	0.583	0.0	0.406	0.0
17	-0.006	0.00005	-0.006	0.00005
18	0.540	8.496	0.370	3.985
20	0.251	1.950	0.169	0.914
21	42.066	8467.8	28.366	4249.2
22	12.801	2169.9	8.664	1019.2
23	1.029	7.587	0.719	3.696
24	1.170	13.8	1.170	13.8
27	2.498	29.9	1.730	14.3
28	1.165	2.200	0.809	1.062
29	0.065	0.022	0.038	0.009
Δ^3-Carene	61.675	2262.3	43.266	1095.2
26A	6.406	308.0	4.444	148.1
29A	17.402	265.8	12.058	127.6
Name: LUDA 0041 Deciduous Forest				
TNMHC	6766.050	5955530.0	1566.530	441895.0
Paraffins	583.021	43139.4	414.970	20353.3
Olefins	5703.130	4909980.0	819.285	321585.0
Aromatics	470.809	29477.3	328.793	14063.7
Methane	876.217	190798.0	835.143	177365.0
α-Pinene	285.465	94877.6	230.086	57665.4
β-Pinene	225.108	51805.9	174.251	29980.7

LUDA Emission Factors
μg/m²/hr

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0041 Deciduous Forest (cont'd)				
d-Limonene	29.723	753.1	20.671	375.1
Isoprene	4595.070	4286410.0	0.000	0.0
Myrcene	876.217	190798.0	10.778	1992.4
Unk. Terpenes	-10.324	2445.8	-6.672	1128.1
18	0.046	0.073	0.031	0.034
20	0.022	0.017	0.015	0.008
21	181.077	251991.0	122.792	126396.0
22	1.468	18.8	1.000	8.836
23	1.773	20.9	1.238	10.168
24	2.111	79.9	2.111	79.9
27	1.116	5.253	0.774	2.528
28	2.006	6.053	1.393	2.922
29	8.992	423.7	5.349	178.4
Δ^3-Carene	75.683	10020.0	52.985	4844.3
26A	21.124	9012.5	14.736	4334.2
29A	30.053	731.5	20.848	351.2
Name: LUDA 0042 Evergreen Forest				
TNMHC	5172.930	4174540.0	1925.350	1316290.0
Paraffins	564.633	44244.6	407.980	21497.0
Olefins	4203.920	3646710.0	1230.690	1185960.0
Aromatics	376.290	17378.5	268.465	8488.8
Methane	785.746	111900.0	762.483	108347.0
α-Pinene	639.467	444387.0	466.827	222247.0
β-Pinene	631.495	622767.0	448.389	301602.0
d-Limonene	76.744	8219.1	53.324	3966.8
Isoprene	2483.460	1204830.0	0.000	0.0
Myrcene	0.108	0.264	0.075	0.128
Unk. Terpenes	1.008	12.7	1.008	12.7
21A	4.393	0.0	3.061	0.0
18	0.294	2.598	0.199	1.218
20	0.141	0.596	0.095	0.279
21	0.022	0.004	0.015	0.002
22	6.658	661.3	4.498	310.6
23	0.749	5.046	0.523	2.458
24	2.246	63.0	2.246	63.0
27	0.396	1.117	0.275	0.538
28	0.847	1.463	0.588	0.706
29	4.446	105.9	2.645	44.6
Δ^3-Carene	128.591	45483.2	89.762	21938.6
26A	0.445	1.270	0.308	0.608
29A	12.366	176.6	8.580	84.8

LUDA Emission Factors
$\mu g/m^2/hr$

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0043 Mixed Forest				
TNMHC	5969.490	2532520.0	1745.940	439545.0
Paraffins	573.827	21846.0	411.475	10462.6
Olefins	4953.520	2139170.0	1024.990	376886.0
Aromatics	423.550	11713.9	298.629	5638.1
Methane	830.981	75674.5	798.813	71427.9
α-Pinene	462.466	134816.0	348.456	69977.9
β-Pinene	428.301	168643.0	311.320	82895.6
d-Limonene	53.234	2243.0	36.998	1085.5
Isoprene	3539.270	1372810.0	0.000	0.0
Myrcene	7.806	1030.3	5.426	498.1
Unk. Terpenes	-4.658	614.625	-2.832	285.2
21A	2.196	0.0	1.531	0.0
18	0.170	0.668	0.115	0.313
20	0.081	0.153	0.055	0.072
21	90.549	62997.8	61.404	31599.1
22	4.063	170.0	2.749	79.9
23	1.261	6.479	0.880	3.156
24	2.179	35.7	2.179	35.7
27	0.756	1.593	0.525	0.767
28	1.427	1.879	0.991	0.907
29	6.719	132.4	3.997	55.8
Δ^3-Carene	102.137	13875.9	71.374	6695.7
26A	10.842	2253.4	7.522	1083.7
29A	21.210	227.0	14.714	109.0
Name: LUDA 0051 Streams, Canals				
TNMHC	159.817	1655.7	159.817	1655.7
Paraffins	68.869	209.2	68.869	209.2
Olefins	0.000	0.0	0.000	0.0
Aromatics	90.839	1607.8	90.839	1607.8
Methane	5994.600	11837700.0	5994.600	11837700.0
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136
Name: LUDA 0052 Lakes				
TNMHC	145.887	1647.2	145.887	1647.2
Paraffins	63.499	180.4	63.499	180.4
Olefins	0.000	0.0	0.000	0.0
Aromatics	82.279	1601.8	82.279	1601.8
Methane	5636.200	11644400.0	5636.200	11644400.0
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136

LUDA Emission Factors
$\mu g/m^2/hr$

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0053 Reservoirs				
TNMHC	145.887	1647.2	145.887	1647.2
Paraffins	63.499	180.4	63.499	180.4
Olefins	0.000	0.0	0.000	0.0
Aromatics	82.279	1601.8	82.279	1601.8
Methane	5636.200	11644400.0	5636.200	11644400.0
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136
Name: LUDA 0054 Bays & Estuaries				
TNMHC	168.242	1405.6	168.242	1405.6
Paraffins	94.671	571.3	94.671	571.3
Olefins	6.375	81.3	67.375	81.3
Aromatics	67.301	250.4	67.301	250.4
Methane	406.068	4745.8	406.068	4745.8
α-Pinene	1.632	5.330	1.632	5.330
Myrcene	1.550	4.805	1.550	4.805
Terpinolene	1.550	4.805	1.550	4.805
10A	0.674	9.572	0.674	9.572
22	1.134	10.4	1.134	10.4
23	0.0005	0.00001	0.0005	0.00001
24	0.044	0.094	0.044	0.094
Name: LUDA 055 Gulf				
TNMHC	134.169	675.3	134.169	675.3
Paraffins	74.213	301.4	74.213	301.4
Olefins	6.375	81.3	6.375	81.3
Aromatics	53.639	102.6	53.639	102.6
Methane	314.810	4787.8	314.810	4787.8
α-Pinene	1.632	5.330	1.632	5.330
Myrcene	1.550	4.805	1.550	4.805
Terpinolene	1.550	4.805	1.550	4.805
10A	0.270	2.084	0.270	2.084
22	0.548	2.566	0.548	2.566
23	0.0002	0.00003	0.0002	0.00003
24	0.022	0.024	0.022	0.024
Name: LUDA 0061 Deciduous Forest Wetland				
TNMHC	6807.000	15479100.0	3817.460	7280810.0
Paraffins	993.542	464183.0	701.483	223343.0
Olefins	5018.710	14504500.0	2561.450	6758540.0
Aromatics	801.235	265039.0	560.589	127612.0
Methane	1341.940	1671330.0	1326.060	1670900.0
α-Pinene	1043.900	3289920.0	792.606	1641350.0

LUDA Emission Factors
$\mu g/m^2/hr$

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0061 Deciduous Forest Wetlands (cont'd)				
α-Pinene	36.196	10634.7	35.908	6716.5
d-Limonene	94.761	14562.2	65.819	7019.8
Isoprene	1385.170	593605.0	0.000	0.0
Myrcene	137.484	143666.0	2536.145	6758540.0
Unk. Terpenes	-7.315	131337.0	-3.972	61584.2
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136
21	772.050	7219980.0	520.262	3623100.0
22	14.364	4090.2	9.945	1960.3
23	1.486	19.9	1.037	9.681
27	29.484	16475.4	20.406	7899.0
28	1.681	5.763	1.167	2.782
Δ^3-Carene	708.361	1021560.0	491.185	493595.0
26A	109.550	261089.0	76.014	125559.0
29A	25.392	701.3	17.552	336.4
Name: LUDA 0071 Dry Salt Flats				
TNMHC	349.000	0.0	349.000	0.0
Paraffins	157.000	0.0	157.000	0.0
Olefins	0.000	0.0	0.000	0.0
Aromatics	192.000	0.0	192.000	0.0
Methane	380.000	0.0	380.000	0.0
Name: LUDA 0072 Beaches				
TNMHC	303.206	92.7	303.206	92.7
Paraffins	134.881	7.901	134.881	7.901
Olefins	8.925	159.3	8.925	159.3
Aromatics	159.414	9.478	159.414	9.478
Methane	383.430	372.7	383.430	372.7
α-Pinene	2.286	10.4	2.286	10.4
Myrcene	2.170	9.418	2.170	9.418
Terpinolene	2.170	9.418	2.170	9.418
22	0.643	4.544	0.643	4.544
Name: LUDA 0073 Sand Non-Beaches				
TNMHC	349.000	0.0	349.000	0.0
Paraffins	157.000	0.0	157.000	0.0
Olefins	0.000	0.0	0.000	0.0
Aromatics	192.000	0.0	192.000	0.0
Methane	380.000	0.0	380.000	0.0

LUDA Emission Factors
$\mu g/m^2/hr$

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0074 Bare Rock				
TNMHC	0.000	0.0	0.000	0.0
Paraffins	0.000	0.0	0.000	0.0
Olefins	0.000	0.0	0.000	0.0
Aromatics	0.000	0.0	0.000	0.0
Methane	0.000	0.0	0.000	0.0
Name: LUDA 0075 Strip Mines etc.				
TNMHC	349.000	0.0	349.000	0.0
Paraffins	157.000	0.0	157.000	0.0
Olefins	0.000	0.0	0.000	0.0
Aromatics	192.000	0.0	192.000	0.0
Methane	380.000	0.0	380.000	0.0
Name: LUDA 0076 Transition				
TNMHC	349.000	0.0	349.000	0.0
Paraffins	157.000	0.0	157.000	0.0
Olefins	0.000	0.0	0.000	0.0
Aromatics	192.000	0.0	192.000	0.0
Methane	380.000	0.0	380.000	0.0
Name: LUDA 0077 Mixed Barren Land				
TNMHC	349.000	0.0	349.000	0.0
Paraffins	157.000	0.0	157.000	0.0
Olefins	0.000	0.0	0.000	0.0
Aromatics	192.000	0.0	192.000	0.0
Methane	380.000	0.0	380.000	0.0
Name: LUDA 0421 Planted Pine				
TNMHC	2907.450	5963810.0	2018.240	2873070.0
Paraffins	390.590	136662.0	271.161	65783.7
Olefins	2308.020	5013140.0	1603.650	2421690.0
Aromatics	196.709	35647.3	136.647	17228.2
Methane	507.806	323268.0	507.806	323268.0
α-Pinene	735.799	479851.0	510.840	230925.0
β-Pinene	726.948	1120640.0	504.812	540113.0
Myrcene	0.052	0.080	0.037	0.039
-Carene	287.247	339642.0	199.373	163738.0
Name: LUDA 0612 Forested Evergreen Wetland				
TNMHC	6541.230	8091040.0	2870.010	1636140.0
Paraffins	839.900	123869.0	582.862	52715.4

LUDA Emission Factors
$\mu g/m^2/hr$

Compound	Day ER	Day S^2	Night ER	Night S^2
Name: LUDA 0612 Forested Evergreen Wetland (cont'd)				
Olefins	4986.700	5842400.0	1801.960	1327970.0
Aromatics	710.833	60369.4	486.162	27008.8
Methane	1371.550	171970.0	1313.560	170583.0
α-Pinene	561.752	380081.0	428.794	187960.0
β-Pinene	223.896	73288.2	161.981	35489.4
d-Limonene	79.378	2915.2	55.145	1408.0
Isoprene	2426.390	2786120.0	0.000	0.0
Myrcene	72.629	28500.3	50.457	13777.1
Unk. Terpenes	-25.141	18225.6	-16.531	8388.3
21A	1.464	0.0	1.020	0.0
17	-0.026	0.001	-0.026	0.001
18	0.164	0.295	0.135	0.143
20	0.043	0.066	0.029	0.031
21	624.177	1696390.0	422.627	850920.0
22	7.151	198.9	4.919	94.6
23	1.185	5.028	0.828	2.450
24	1.235	19.7	1.235	19.7
27	9.402	505.5	6.507	242.1
28	1.341	1.458	0.931	0.704
29	0.248	0.330	0.148	0.139
Δ^3-Carene	348.901	79326.8	242.253	38303.4
26A	74.700	60686.5	51.832	29184.5
29A	21.708	182.5	15.035	87.6
Name: LUDA 0621 Nonforested Wetlands				
TNMHC	198.987	3929.7	198.987	3929.7
Paraffins	75.907	212.6	75.907	212.6
Olefins	29.250	2083.0	29.250	2083.0
Aromatics	93.689	1609.2	93.689	1609.2
Methane	6025.910	11838200.0	6025.910	11838200.0
α-Pinene	24.230	1429.0	24.230	1429.0
β-Pinene	3.917	37.9	3.917	37.9
17	-0.065	0.017	-0.065	0.017
18	0.185	0.136	0.185	0.136
Name: LUDA 6121 Mangroves				
TNMHC	765.266	150551.0	561.323	73002.6
Paraffins	439.131	83182.7	321.487	40567.2
Olefins	3.109	118.9	2.180	57.4
Aromatics	323.738	38429.5	238.036	18563.0
Methane	1017.190	600835.0	101.719	600835.0

APPENDIX D

INTRODUCTION

This appendix lists the daily (24 hour) emissions of each LUDA category summed over the entire study area. The total estimated area and the area % covered by each LUDA category are also listed. Area values are in units of km^2. Emission rates are in units of Kg/24 hrs.

APPENDIX D

Total Emissions By LUDA Category (kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0011 Residential	Area: 711 km^2	% of Total Area: 14.6
TNMHC	24,631	3,361
Paraffins	5,744	709
Olefins	12,844	3,041
Aromatics	6,007	385
Methane	6,371	1,602
α-Pinene	2,425	1,070
β-Pinene	1,654	1,118
d-Limonene	210	131
Isoprene	6,433	1,948
Myrcene	19	23
Unk. Terpenes	5	11
21A	56	---
21	38	46
22	14	36
23	35	72
24	12	24
27	19	34
28	40	39
29	14	21
Δ^3-Carene	293	300
26A	21	36
29A	595	423
Name: LUDA 0021 Cropland Pasture	Area: 32 km^2	% of Total Area: 0.7
TNMHC	291	85
Paraffins	88	22
Olefins	156	69 Aromatics
46 15		
Methane	204	34
α-Pinene	28	28
β-Pinene	5	5
d-Limonene	21	12
Isoprene	79	55
Myrcene	---	---
21	8	4
23	2	1
Δ^3-Carene	6	3

Total Emissions By LUDA Category
(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0022 Orchards, Vineyards, Nurseries Area: 7 km^2 % of Total: 0.1		
TNMHC	234	32
Paraffins	55	7
Olefins	122	29
Aromatics	57	4
Methane	60	15
α-Pinene	23	10
β-Pinene	16	11
d-Limonene	2	1
Isoprene	61	18
Δ^3-Carene	3	3
29A	6	4
Name: LUDA 0024 Agricultural Land Area: 6 km^2 % of Total Area: 0.1		
TNMHC	56	16
Paraffins	18	5
Olefins	28	12
Aromatics	10	3
Methane	40	6
α-Pinene	3	2
β-Limonene	4	2
Isoprene	16	11
21	2	1
Δ^3-Carene	1	1
Name: LUDA 0025 Cropland Area: 221 km^2 % of Total Area: 4.6		
TNMHC	2,964	1,066
Paraffins	864	302
Olefins	1,679	834
Aromatics	422	196
Methane	1,446	250
d-Limonene	292	163
Isoprene	1,100	776
Myrcene	2	5
21	106	61
23	23	15
Δ^3-Carene	75	39

Total Emissions By LUDA Category
(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0026 Pasture	Area: 719 km^2	% of Total: 14.8
TNMHC	13,973	3,703
Paraffins	3,176	955
Olefins	8,478	3,620
Aromatics	2,292	684
Methane	7,911	2,245
α-Pinene	2,905	2,189
β-Pinene	768	694
d-Limonene	222	153
Isoprene	1,283	578
Myrcene	176	291
Unknown terpenes	58	358
21A	5	---
18	1	2
21	648	1,571
22	34	89
23	2	5
24	9	24
27	55	174
28	3	3
Δ^3-Carene	1,339	1,271
26A	89	30
29A	41	31
Name: LUDA 0027 Specialty Farms	Area: 6 km^2	% of Total: 0.1
TNMHC	12	2
Paraffins	8	2
Olefins	0	---
Aromatics	5	1
Methane	53	14
Name: LUDA 0028 Horticultural Farms	Area: 11.4 km^2	% of Total: 0.2
TNMHC	393	54
Paraffins	92	11
Olefins	205	49
Aromatics	96	6
Methane	102	26
α-Pinene	39	17
β-Pinene	26	18
d-Limonene	3	2
Isoprene	103	31
Δ^3-Carene	5	5
29A	9	7

Total Emissions By LUDA Category
(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0029 Groves	Area: 286 km^2	% of Total: 5.9
TNMHC	34,925	38,257
Paraffins	7,743	5,214
Olefins	19,534	34,629
Aromatics	7,686	4,338
Methane	30,933	35,108
α-Pinene	301	405
β-Pinene	19	39
d-Limonene	649	1,417
Myrcene	5	7
Unknown terpenes	2	6
16	26	74
21	156	441
22	1,392	2,122
24	17,462	32,730
25	145	416
26	37	105
Δ^3-Carene	22	27
Name: LUDA 0031 Herbaceous Rangeland	Area: 503 km^2	% of Total: 10.4
TNMHC	15,364	5,625
Paraffins	2,864	806
Olefins	10,168	4,684
Aromatics	2,300	894
Methane	6,607	1,910
α-Pinene	2,655	1,266
β-Pinene	1,053	964
d-Limonene	204	121
Isoprene	3,580	3,936
Myrcene	121	137
Unknown terpenes	14	141
21A	8	---
18	7	27
20	3	13
21	598	935
22	165	427
23	2	2
24	14	32
27	29	55
28	2	1
Δ^3-Carene	884	494
26A	84	177
29A	28	12

Total Emissions By LUDA Category
(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0032	Area: 2 km^2	% of Total: 0.1
TNMHC	171	172
Paraffins	32	24
Olefins	105	137
Aromatics	34	30
Methane	71	57
α-Pinene	4	5
β-Pinene	1	1
Isoprene	96	136
22	6	15
29A	2	1
Name: LUDA 0033 Mixed Rangeland	Area: 34 km^2	% of Total: <0.1
TNMHC	9	3
Paraffins	2	<1
Olefins	6	2
Aromatics	1	<1
Methane	4	1
α-Pinene	1	<1
β-Pinene	1	<1
Isoprene	2	2
Name: LUDA 0041 Deciduous Forest	Area: 0.7 km^2	% of Total: <1
TNMHC	67	20
Paraffins	8	2
Olefins	53	19
Aromatics	6	2
Methane	14	5
α-Pinene	4	3
β-Pinene	3	2
Isoprene	37	17
21	2	5
Δ^3-Carene	1	1

Total Emissions By LUDA Category

(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0042 Evergreen Forest	**Area: 223 km^2**	**% of Total: 4.6**
TNMHC	18,974	6,264
Paraffins	2,600	685
Olefins	14,527	5,876
Aromatics	1,723	430
Methane	4,138	1,254
α-Pinene	2,957	2,182
β-Pinene	2,887	2,570
d-Limonene	348	295
Isoprene	6,638	2,934
Unknown terpenes	5	13
21A	20	---
18	1	5
22	30	83
23	3	7
24	12	30
27	2	3
28	4	4
29	19	33
Δ^3-Carene	584	694
26A	2	4
29A	56	43
Name: LUDA 0043 Mixed Forest	**Area: 2 km^2**	**% of Total: <.1 TNMHC**
167 37		
Paraffins	21	4
Olefins	129	34
Aromatics	16	3
Methane	35	8
α-Pinene	18	10
β-Pinene	16	11
d-Limonene	2	1
Isoprene	76	25
21	3	7
Δ^3-Carene	4	3
Name: LUDA 0051 Streams, Canals	**Area: 12.7 km^2**	**% of Total: 0.3**
TNMHC	49	9
Paraffins	21	3
Olefins	0	0
Aromatics	28	9
Methane	1,829	742

Total Emissions By LUDA Category

(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0052 Lakes	Area: 63 km^2	% of Total: 1.3
TNMHC	222	44
Paraffins	97	14
Olefins	0	0
Aromatics	125	43
Methane	8,658	3,668
Name: LUDA 0053 Reserviors	Area: 14 km^2	% of Total: 0.3
TNMHC	50	10
Paraffins	22	3
Olefins	0	0
Aromatics	28	10
Methane	1,933	827
Name: LUDA 0054 Bays & Estuaries	Area: 742 km^2	% of Total: 15.3
TNMHC	2,998	472
Paraffins	1,687	301
Olefins	114	114
Aromatics	1,199	199
Methane	7,236	868
α-Pinene	29	29
β-Pinene	0	0
d-Limonene	0	0
Isoprene	0	0
Myrcene	28	28
Terpinolene	28	28
10A	12	39
22	20	41
Name: LUDA 0055 Gulf	Area: 460 km^2	% of Total: 9.5
TNMHC	1,481	203
Paraffins	819	135
Olefins	70	70
Aromatics	592	79
Methane	3,474	540
α-Pinene	18	18
Myrcene	17	17
Terpinolene	17	17
10A	3	11
22	6	12

Total Emissions By LUDA Category

(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0061 Deciduous Forest Wetland Area: 11 km^2 % of Total: 0.2		
TNMHC	1,334	599
Paraffins	213	104
Olefins	952	579
Aromatics	171	79
Methane	335	203
α-Pinene	231	279
β-Pinene	9	17
d-Limonene	20	18
Isoprene	174	97
Myrcene	29	58
Unknown terpenes	-1	55
21	163	413
22	3	10
27	6	20
Δ^3-Carene	151	165
26A	23	78
29A	5	4
Name: LUDA 0071 Dry Salt Flats Area: <0.1 km^2 % of Total: <.1		
TNMHC	0	0
Paraffins	0	0
Olefins	0	0
Aromatics	0	0
Methane	0	0
Name: LUDA 0072 Beaches Area: 3 km^2 % of Total: 0.2		
TNMHC	61	1
Paraffins	27	<1
Olefins	2	2
Aromatics	32	<1
Methane	77	3
Name: LUDA 0073 Sand Non-beaches Area: 1 km^2 % of Total: <.1		
TNMHC	12	---
Paraffins	6	---
Olefins	0	---
Aromatics	7	---
Methane	13	---

Total Emissions By LUDA Category

(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0074 Bare Rock	Area: 0.7 km^2	% of Total: <1
TNMHC	0	0
Paraffins	0	0
Olefins	0	0
Aromatics	0	0
Methane	0	0
Name: LUDA 0075 Strip Mines, etc.	Area: 40 km^2	% of Total: 0.8
TNMHC	337	0
Paraffins	152	0
Olefins	0	0
Aromatics	186	0
Methane	367	0
Name: LUDA 0076 Transition	Area: 47 km^2	% of Total: 1.0
TNMHC	389	0
Paraffins	175	0
Olefins	0	0
Aromatics	214	0
Methane	424	0
Name: LUDA 0077 Mixed Barren Land	Area: <0.1 km^2	% of Total: <1
TNMHC	0	0
Paraffins	0	0
Olefins	0	0
Aromatics	0	0
Methane	0	0
Name: LUDA 0421 Planted Pine	Area: 21 km^2	% of Total: 0.4
TNMHC	1,257	758
Paraffins	169	115
Olefins	998	696
Aromatics	85	59
Methane	259	205
α-Pinene	318	215
β-Pinene	314	329
d-Limonene	78	80
Δ^3-Carene	124	181

Total Emissions By LUDA Category

(kg/24 hr)

Compound	ER	Std. Dev.
Name: LUDA 0612 Evergreen Wetland Forests	Area: 310 km^2	% of Total: 6.4
TNMHC	35,041	11,612
Paraffins	5,297	1,565
Olefins	25,276	9,970
Aromatics	4,457	1,101
Methane	9,997	2,179
α-Pinene	3,688	2,806
β-Pinene	1,437	1,228
d-Limonene	501	245
Isoprene	9,034	6,215
Myrcene	458	766
Unknown terpenes	-155	607
21A	9	0
18	1	2
21	3,898	5,924
22	45	64
23	7	10
24	9	23
27	59	102
28	8	5
29	1	3
Δ^3-Carene	2,201	1,277
26A	471	1,116
29A	137	61
Name: LUDA 0621 Non-Forested Wetland	Area: 34 km^2	% of Total: 0.7
TNMHC	164	37
Paraffins	63	8
Olefins	24	27
Aromatics	77	23
Methane	4,962	2,004
α-Pinene	20	22
β-Pinene	3	4
Name: LUDA 6121 Mangroves	Area: 64 km^2	% of Total: 1.3
TNMHC	1,021	364
Paraffins	585	271
Olefins	4	10
Aromatics	432	184
Methane	1,565	844

APPENDIX E

INTRODUCTION

This appendix outlines the order of events for the performance of this project. A sample field work schedule is also included. This information may be of importance for those interested in a more detailed interpretation of the data presented in this report or to those involved in planning similar research programs in the future.

APPENDIX E

Field Sampling Schedule

1.1 ORDER OF EVENTS

In February 1977, prior to initiation of the field program, the study area was visited by the principal investigator. During this planning trip the local air pollution control agencies were visited and informed of the impending study. Arrangements were made with the Hillsborough County Environmental Protection Commission for the location of our field laboratory. Laboratory and storage facilities were also provided. The Pinellis County Department of Environmental Management arranged a helicopter flight and a ground tour over the study area to help define the major vegetation types and to determine potential sampling sites. Land use planning maps (LUDA Maps), which defined vegetation in the study area, were obtained from the Tampa Bay Regional Planning Council.

The WSU mobile laboratory and a four-man crew arrived in Tampa on March 15, 1977. The period from March 15 to March 31 was used to optimize the analytical instrumentation and to perform the necessary checks on the sampling equipment. The field sampling program began on April 1. On April 28 and 29 the field site was visited by EPA project officers to review the sampling procedures and to discuss the sampling strategy. In June two additional personnel were added to the staff. One person had extensive experience as a laboratory assistant for the chemistry department at the University of South Florida. He therefore assisted in routine analysis, allowing other experienced WSU personnel to begin data reduction. The other person had previous experience in the air pollution field, and was a doctoral candidate in urban ecology. She was therefore assigned the task of quantitating the vegetative leaf biomass in the study area.

On June 16, 1977 the Tampa field site was visited by Ron McHenry and Carl Sova EPA Region IV, Dave Tingey EPA Corvalis, and Leslie Dunn EPA Las Vegas. The meeting was initiated so that results of the Phase I sampling program could be discussed and recommendations concerning Phase II could be made. The main points of the meeting were:

1. Mr. Dunn was to insure that all of the contractors involved in the Ozone Modeling Study including WSU would be furnished with the exact grid coordinates of the study area.

2. Based upon the results of Phase I the following re-distribution of our sample effort was recommended:

    a) Due to the large emissions from Gum trees, the Oak Gum Cypress vegetation groups were to be considered to consist primarily of Gum and Cypress.

    b) The marine samples were to be cut by 50 samples. This would allow an additional 25 samples to be distributed among other vegetation types.

    c) Ten samples were to be cut from citrus and ten samples from Mangrove vegetation types.

    d) Ten additional samples were to be made of the representative shrub group. The samples will concentrate upon Black Willow, Wax Myrtle, and Persimmon.

    e) Ten samples were to be made of freshwater marsh and wetland vegetation.

    f) Twenty five samples were to be collected of the predominate row crops available at that time, especially tomatoes and beans if possible.

    g) The Oak-Hickory group would be considered to consist primarily of Oak.

h) Some of the species sampled diurnally in Phase I would again be sampled in Phase II.

3. The problem of isolating sample variables which affect emission rates was discussed. It was pointed out that Corvalis should soon have a system of enclosed plexiglass environmentally controlled chambers for use in the project. It was decided that in order to separate the effects that the variables of illumination, temperature and soil water potential might have on emission rates, chamber studies should be performed. The vegetation type chosen for the first chamber tests was oak. Oaks were chosen because WSU sampling had shown that oaks exhibited a definite diurnal cycle of emissions. WSU had also found that the emission components of oaks were relatively simple consisting almost entirely of large amounts of Isoprene (in daylight hours), thus the analytical methodology required could be relatively simple. Rasmussen, (1970) had previously demonstrated that Isoprene production in plants was light dependent. Field samples collected during Phase I illustrated that temperature and soil moisture may also affect Isoprene production.

Phase II of the field study began on June 19 and was completed by August 1, 1977. In all, 632 natural emission samples were collected requiring over 1000 analysis for each of the heavy hydrocarbon, light hydrocarbon, methane and C_2 hydrocarbon groups.

.2 TYPICAL WORK SCHEDULE

On typical sampling days, the G.C.s were standardized at about 6 AM. Analysis of samples would then begin. Field samples were usually collected between 6 AM and 7 PM, although each week two vegetation species/sample types were sampled every 6 hours for 30 hours. At least eight vegetation samples were collected daily. Each vegetation sample required a background sample and an emission rate sample; therefore at least 16 cans had to be analyzed daily. Two days each week (usually Saturday and Sunday) twenty samples were collected from Tampa Bay and the Gulf of Mexico. The sampling schedule necessitated operation of the G.C.s on a 16 to 24-hour basis six days per week.

commerce early in the morning so that emission rate samples could be collected and returned throughout the day. Testing at WSU had indicated that minimum hydrocarbon losses would be expected even for samples stored for 24 hours.

The field schedule outlined allowed each vegetation association to be sampled approximately four times weekly. Appendix A lists the species sampled, the number of times each was sampled, and the mean and standard error of the emission rates standardized to 30°C (day) and 25°C (night) for each species. The emission rates are given in terms of the micrograms emission (compound)/g leaf biomass/hr of paraffins, olefins, aromatics, methane, TNMHC and for each major peak. "Flat samples" (bay, pasture, etc.) are in micrograms/m^2/hr.

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16. ABSTRACT
The methodology used to develop a natural hydrocarbon emission inventory for a 60 X 81 km area including Tampa and St. Petersburg, Florida is described. The inventory is based upon more than 600 emission rate samples collected from vegetation, surface water and pastures between the months of April and August, 1977. Emission rates in terms of total non methane hydrocarbons (TNMHC), paraffins, olefins, aromatics, methane, and each major emission component are presented for the major vegetation species, associations and land use categories which occurred in the study area. Hourly emission factors were calculated for each of the 2,160 1.5 km X 1.5 km grids in the study area and coded onto a computer tape.
The inventory estimates the summer biogenic emissions to approach 1025 $\mu g/m^2/hr$ or 160 metric tons/day. Isoprene is 18% of the TNMHC, α-pinene is about 10%. Evergreen forests occupy approximately 10% of the total study area and contribute about 35% of the total daily emissions.
The emissions are fairly uniform with respect to time and space, therefore, low ambient levels of the natural hydrocarbons are expected in ambient air.

17. KEY WORDS AND DOCUMENT ANALYSIS

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