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SUBJECT: DOMINANT SOIL TYPES ASSOCIATED WITH FUMIGANT APPLICATIONS
           IN OZONE NONATTAINMENT AREAS

Background

The Environmental Monitoring Branch is investigating the ability of computer simulation models to describe post-application fumigant fluxes. The primary objective is to simulate total cumulative volatilization for different application methods and fumigants for use in the volatile organic compound (VOC) program. The purpose of this memorandum is to document a procedure for determining the dominant soil types associated with fumigant use in different regions of California.

Methods

Database operations were performed using Oracle and SAS. Fumigant use records consisting of pounds of fumigant active ingredient (A.I.), and acres treated, county, meridian, township, range, and section were extracted from the 2006 pesticide use report (PUR). Data for 1,3-dichloropropene (1,3-d), methyl bromide, chloropicrin, metam sodium, and metam potassium were included, and only records for use during the May 1 through October 31, 2006 ozone season were included. Applications were also restricted to nonattainment areas (NAAs) as defined by a lookup table of county, meridian, township, range, section (COMTRS) in each NAA created for the VOC calculation program. The five NAAs are Sacramento Valley (Sacvalley), San Joaquin Valley (SJV), Southeast Desert (SE_desert), South Coast (SoCoast), and Ventura. For each COMTRS, the sum of pounds applied and acres treated were determined.

In parallel, the following surface soil information was extracted from an existing Oracle table (Troiano.layer99): soil texture class, textural subclass modifier, area of soil class within the COMTRS and COMTRS area. The soils data in Troiano.layer99 were originally obtained from

Soil Conservation Service county soil surveys (Soil Conservation Service, 1973; Soil Survey Staff, 1997). An additional variable named class_frac that describes the fraction of soil type within each COMTRS was created by dividing the acreage of each soil type within a section by the total COMTRS acreage. These sectional soil factors were then merged with the use information by COMTRS, and sections with no fumigant use were discarded. The Appendix contains a more detailed set of notes on these operations.

This resulted in a set of records for each application of each fumigant in each section containing COMTRS, soil class, fraction by acreage of this soil class within section, NAA, and both pounds of fumigant applied and acres treated during the 2006 ozone season. An application within a section would potentially be listed several times, depending on how many soil types were in that section. The pounds applied and acres treated were apportioned over the soil types using class_frac, the fraction of each soil type within the section. In other words, use within each soil type within a section was indexed in two ways: (1) the product of class_frac and pounds applied and (2) the product of class_frac and acres treated. An important methodological feature was that all soils within a section were listed if there was any fumigant use within the section, regardless of whether fumigant use actually occurred on that soil type. The available information does not enable locating individual applications on specific soil types. Thus, strictly speaking, the soil classes determined in this analysis cannot be described as those soils upon which these fumigants were applied. Rather, these soils represent the dominant soils in sections where fumigants were used.

For each fumigant within each NAA, these weighted use measures were summed by soil class (using Excel pivot table) producing a table of NAA x soil type of pounds applied and acreage treated. Subsequently we decided that pounds applied was the most important index of use and acreage was not included in the write up.

The soil classification scheme in Troiano.layer99 included modifiers such as fine sandy loam and coarse sandy loam. which resulted in 18 classes. In addition, a soil class "unknown" was assigned to sections which did not have soil mapping information. In order to further

Table 1. Soil class mapping from finer division to broader divisions. All classes are USDA/SCS soil classes.

Soil classes with finer divisions	Broader soil classes (soil textural triangle)
CLAY	clay
CLAYLOAM	clayloam
COARSESAND	sand
COARSESANDYLOAM	sandyloam
FINESAND	sand
FINESANDYLOAM	sandyloam
LOAM	loam
LOAMYCOARSESAND	loamysand
LOAMYFINESAND	loamysand
LOAMYSAND	loamysand
SAND	sand
SANDYCLAYLOAM	sandyclayloam
SANDYLOAM	sandyloam
SILTLOAM	siltloam
SILTYCLAY	siltyclay
SILTYCLAYLOAM	siltyclayloam
UNKNOWN	unknown
VERYFINESANDYLOAM	sandyloam

simplify, these 18 groups were aggregated into 12 soil types, plus unknown (Table 1). These 12 soil types are those listed in the USDA/SCS soil triangle.

Results

The distribution of the five fumigants over the NAAs was highly uneven (Table 2). The SJV

Table 2. Pounds of A.I. applied in NAAs from May through October 2006.

	Sacvalley	SE_desert	SJV	SoCoast	Ventura	Total
Methyl Bromide	300	671	399,589	57,258	310,895	768,713
Chloropicrin	2,401	6,213	100,397	74,444	383,645	567,098
Metam Sodium	38,051	163,340	2,805,682	5,379	137,415	3,149,867
1,3-d	40,042	7,825	1,361,078	25,860	287,043	1,721,848
Metam Potassium	7,742	0	772,645	0	0	780,387
Total	88,535	178,049	5,439,391	162,941	1,118,998	6,987,914

NAA received the largest total pounds of applied fumigants, consisting of 5,439,391 pounds. The next largest was Ventura with about one-fifth of SJV at 1,118,998 pounds. The other three NAAs had totals which were smaller than SJV by more than an order of magnitude. Pounds applied in SJV and Ventura comprised 94% of the total pounds applied. The largest two fumigants were metam sodium and 1,3-d at 3,149,867 and 1,721,848 pounds A.I., respectively. These two fumigants accounted for 70% of the pounds of fumigants applied in these five NAAs in the 2006 VOC season (May to October).

The fraction of use in each soil type by NAA and fumigant is depicted in Table 3. The first and second highest fractions within each NAA are highlighted by orange and light blue, respectively. Sandy loam dominates the soil types in the SJV over all five fumigants. Similarly, in Ventura sandy loam is the highest fraction, except for metam sodium, where loamy sand is the highest and sandy loam is the second highest. Outside of the Sacvalley, four soil classes appear to dominate the areas where fumigants are used: loam, loamy sand, sand, and sandy loam. In the Sacvalley clay loam, silty clay loam, and silt loam were amongst the top two soil types present in sections with fumigant applications. As discussed previously, the spatial resolution of the fumigant PUR data is only to the section level. Consequently, Table 3 does not describe the extent to which fumigants are actually applied to specific soil types, but rather the use-weighted fraction of soil types in sections were fumigants were applied for each NAA.

Table 3. Fumigant use (pounds of active ingredient applied) expressed as normalized weights within each NAA as distributed over basic soil types based on 2006 PUR restricted to five NAAs and for applications from May through October. The shaded cells represent the highest and second highest soil use weights within each NAA. For example, sandyloam was highest at 0.81 for SJV and loam was second at 0.08.

Methyl Bromide

Soil Class	Sacvalley	SE_desert	SJV	SoCoast	Ventura
clay	0.00	0.00	0.01	0.01	0.00
clayloam	0.30	0.00	0.02	0.04	0.01
loam	0.08	0.00	0.08	0.87	0.09
loamysand	0.21	0.00	0.05	0.00	0.02
sand	0.00	1.00	0.02	0.00	0.02
sandyclayloam	0.00	0.00	0.00	0.00	0.00
sandyloam	0.39	0.00	0.81	0.06	0.58
siltloam	0.02	0.00	0.00	0.00	0.00
siltyclay	0.00	0.00	0.00	0.00	0.00
siltyclayloam	0.00	0.00	0.01	0.00	0.28
unknown	0.00	0.00	0.02	0.03	0.00

Chloropicrin

Soil Class	Sacvalley	SE_desert	SJV	SoCoast	Ventura
clay	0.00	0.00	0.00	0.00	0.03
clayloam	0.20	0.00	0.02	0.03	0.02
loam	0.14	0.00	0.09	0.65	0.26
loamysand	0.00	0.00	0.06	0.10	0.05
sand	0.00	0.46	0.08	0.00	0.02
sandyclayloam	0.00	0.00	0.00	0.00	0.00
sandyloam	0.11	0.47	0.65	0.06	0.52
siltloam	0.20	0.00	0.00	0.04	0.00
siltyclay	0.12	0.00	0.00	0.00	0.00
siltyclayloam	0.23	0.07	0.01	0.07	0.10
unknown	0.00	0.00	0.09	0.04	0.00

Metam Sodium

Soil Class	Sacvalley	SE_desert	SJV	SoCoast	Ventura
clay	0.02	0.06	0.00	0.00	0.01
clayloam	0.05	0.08	0.00	0.00	0.01
loam	0.33	0.01	0.01	0.02	0.03
loamysand	0.00	0.01	0.17	0.04	0.55
sand	0.00	0.00	0.31	0.02	0.05
sandyclayloam	0.00	0.01	0.00	0.00	0.00
sandyloam	0.09	0.42	0.47	0.69	0.21
siltloam	0.24	0.01	0.03	0.00	0.14
siltyclay	0.00	0.00	0.00	0.00	0.00
siltyclayloam	0.27	0.00	0.01	0.23	0.00
unknown	0.00	0.41	0.00	0.00	0.00

1,3-dichloropropene

Soil Class	Sacvalley	SE_desert	SJV	SoCoast	Ventura
clay	0.06	0.00	0.04	0.02	0.00
clayloam	0.00	0.00	0.06	0.01	0.02
loam	0.01	0.00	0.07	0.28	0.08
loamysand	0.00	0.00	0.09	0.01	0.02
sand	0.00	0.82	0.04	0.00	0.02
sandyclayloam	0.00	0.00	0.00	0.00	0.00
sandyloam	0.69	0.15	0.51	0.37	0.61
siltloam	0.15	0.03	0.00	0.00	0.00
siltyclay	0.00	0.00	0.00	0.00	0.00
siltyclayloam	0.09	0.00	0.01	0.14	0.24
unknown	0.00	0.00	0.17	0.16	0.01

Metam Potassium

Soil Class	Sacvalley	SJV
clay	0.21	0.02
clayloam	0.00	0.32
loam	0.01	0.02
loamysand	0.00	0.04
sand	0.00	0.04
sandyloam	0.06	0.40
siltloam	0.33	0.00
siltyclay	0.19	0.01
siltyclayloam	0.20	0.00
unknown	0.00	0.15

The representation of four classes: loam, loamy sand, sandy loam, and sand is explicitly presented in Table 4. Generally, fractions exceeded 0.5. It was not possible to classify soils in some sections and these application pounds were assigned to the unknown soil class. Soil type unknown was prominent in SE_desert for metam sodium, SJV and SoCoast for 1,3-d and SJV for metam potassium (Table 3).

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Table 4. Summary of fraction of soils in the groups: loam, sandy loam, loamy sand and loam.

	Sacvalley	SE_desert	SJV	SoCoast	Ventura
Methyl Bromide	0.69	1.00	0.95	0.92	0.72
Chloropicrin	0.25	0.93	0.88	0.81	0.84
Metam Sodium	0.42	0.44	0.96	0.77	0.85
1,3-dichloropropene	0.70	0.97	0.71	0.66	0.72
Metam Potassium	0.07		0.49		

Conclusion

The PUR for 2006 was queried for fumigant use within the five NAAs for 2006. The resulting section by section use information was merged with soils information and the dominant soil types within sections associated with fumigant use was quantified. Excluding the Sacvalley, four dominant soil types occurred in sections with fumigant use: loam, loamy sand, sandy loam, and sand.

References

Soil Conservation Service. 1983. National soils handbook. Soil Conservation Service, U.S. Department of Agriculture, U.S. Govt. Print. Off., Washington D.C.

Soil Survey Staff. 1997. Title 430 National Soil Survey Handbook, Revision Issued December, 1997. National Resources Conservation Service, Washington D.C., U.S. Government Printing Office, December 1997.

APPENDIX

PROCEDURE FOR ESTIMATING FRACTIONS OF FUMIGANT APPLICATIONS
APPLIED TO DIFFERENT SOIL TEXTURES IN NAAs

1. create 2006 ozone season fumigant use data (*lbs applied, acres_treated*) listed by comtrs,
fumigant, and NAA.
    a. source is PUR (see example SQL query)and then imported into SAS. *Unit_treated*='A'
       only; chemicals = chloropicrin, methyl bromide, 1,3-d, metam sodium and metam
       potassium.
    b. screen *comtrs* to include only sections in each NAA using VOC NAA comtrs lookup
       table, file=new_statewide_AB_NAA.dat
    c. create *sum_lbs_applied* and *sum_acre_treated* for each *comtrs*
    d. dataset created=WORK.FUMI

2. run "import_all_soildata.sas"
    a concatenate 92 excel files to create data set WORK.SOIL containing:
       ssaid (soil survey number)
       musym (soil type)
       county_cd
       ddlat (centroid coord, used in diagnostics, discarded in ouput file)
       ddlong (centroid coord, used in diagnostics, discarded in ouput file)
       mtrs
       co_mtrs (a variable that contains errors, it is discarded and recreated as *comtrs* in
       subsequent processing)
       Total_acres_section (total acres in section)
       Soil_musym_acres (total acres soil type in section)

3. Create SAS data set called WORK.TEXTURE from ASCII data file MUSYM_texture.lst.
    a. This data file is an SQL download from the ORACLE table Troiano.layer99 (located in
       ORACLE EMON partition). The ASCII file contains variables *ssaid,musym, layernum,*
       texture and was downloaded taking ONLY *layernum*=1 (i.e. surface soil).
    b. The variable *texture* is a code describing main textural class (e.g. sand), textural subclass
       (e.g. coarse sand) and modifier (e.g. gravelly, cobbely etc).
    c. create *muid* from concatenation of *ssaid* and *musym*

4. Run program "get_textureNO_OTHER.sas"
   a. generates corrected *comtrs* and *muid* (concatenation of *ssaid* and *musym* – the *muid* is the actual soil type code used from here on out).
   b. merge with WORK.FUMI by *comtrs* iff *comtrs* is in WORK.FUMI, creating WORK.JOIN. This merge is used only to eliminate *comtrs* where fumigants are not used in step d below. Actual fumigant PUR data is merged in the last step of this section as described below.
   c. assign main textural class from *texture* in WORK.TEXTURE. This step removes textural class modifiers, creating a variable called *class* that describes main textural class plus sub_class each *muid* (e.g. VeryFineSandyLoam, LoamyCoarseSand etc.). Note: all records missing texture are assigned *class*='OTHER' (this include sections that are missing soil survey data.) Also, nonstandard texture designations such as "variable" or "fragments" are assigned *class*='OTHER.'
   d. merge WORK.JOIN with WORK.TEXTURE by *muid*; this retains only soil data from sections where fumigants are actually used and EXCLUDING *class* =OTHER. Dataset created = WORK.JOIN2.
   e. calculate *classfrac* (=class fraction) for each *class* in each *comtrs*: *classfrac* = $\sum$ (acres each class in section)/ $\sum$ (total acres all classes in section). NOTE: as program is currently written, the denominator is summed excluding *class*=other). Dataset created = WORK.CLASSFRAC
   f. Merge WORK.CLASSFRAC with WORK.FUMI by *comtrs* (a one to many merge – multiple *comtrs* listed for each *comtrs* in WORK.CLASSFRAC). Also note this file contains fumigant use data for *comtrs* that have no *class* designation because soil survey data are not available for every *comtrs*. These *comtrs* are assigned *classfrac*=1 and *class* = '.' (i.e. missing data). EXPORT to EXCEL: file=get_textureNO_OTHER.xls. In EXCEL, assign *class* = '.' to *class* =UNKNOWN.