Development of an Air Emission Inventory for the Western Arizona Sonora Border Air Quality Study (WASBAQS)
Part 1 – U.S. Emission Inventory

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Presentation Outline

- Introduction
- Inventory Scope
- Technical Approach
  - Stationary Point
  - Area Sources
  - Mobile Sources
    - On-road, Off-road
  - Fugitive Dust
    - Agricultural Dust
    - Road Dust
    - Windblown Dust
    - Construction
  - Agricultural Burning & Wildfires
- Emissions Modeling

Introduction

- Western Arizona – Sonora Border Air Quality Study
  - Cross-border risk assessment study conducted by ADEQ
- WASBAQS Goals & Objectives
  - Characterize air emissions along Arizona/Mexico border
  - Health risk assessment for Yuma, San Luis Rio Colorado & NE Baja California
  - Evaluate proposed control strategies within the WASBAQS domain
- Phased Approach to Achieve Objectives
  1. Air Quality Monitoring
  2. Emission Inventory Development
  3. Air Quality Modeling & Control Strategy Evaluation
  4. Human Health Risk Assessments

Emission Inventory Objectives & Approach

- Development of complete emission inventory CAPs & HAPs
  - Refinements based on local data sources and information
  - Conduct site visits
  - Focus on major sources (agricultural activities; fugitive dust; mobile sources)
  - Preparation for air quality modeling
    - Temporal, spatial allocation; speciation
- Review & recommend emissions and AQ modeling systems
  - Emissions Processing System, version 3 (EPS3)
  - Comprehensive Airquality Model w/ extensions (CAMx)
- Prepare emission inventory for AQ modeling

Inventory Scope

Geographic Domain

- Southern Yuma County, AZ
- Southeastern Imperial County, CA
- Northwestern Sonora, Mexico
- Northeastern Baja California, Mexico

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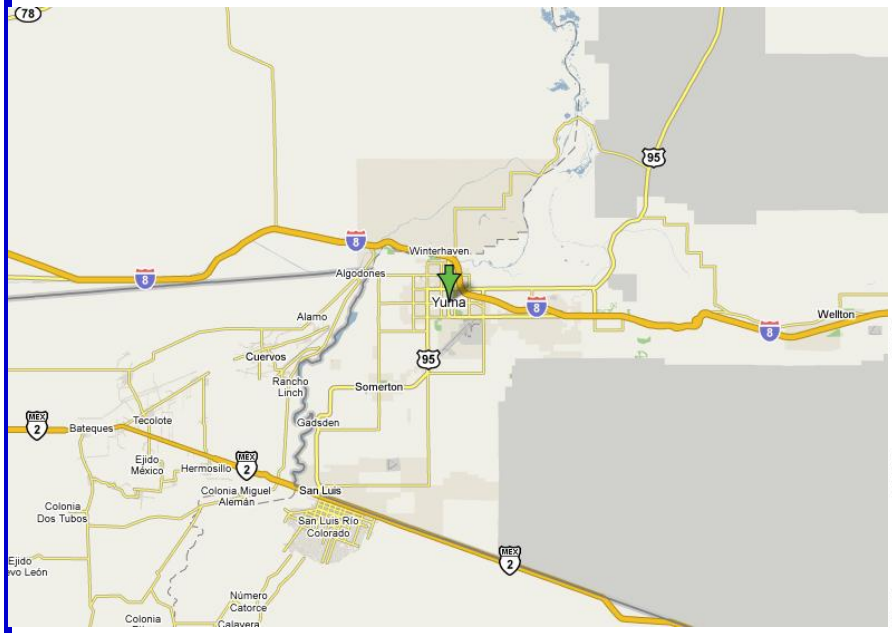
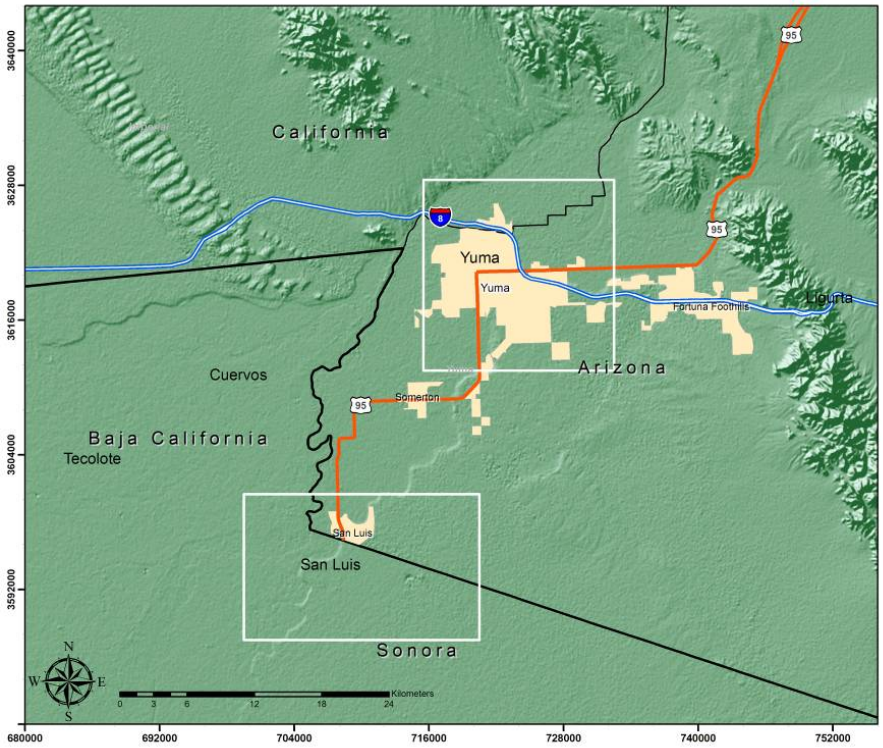
Inventory Scope

Modeling Domains





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Inventory Scope

- Pollutants
  - Criteria pollutants (CAPs)
    - NO_x, SO_x, VOC, CO, PM_{10}, $PM_{2.5}$, NH_3
  - Hazardous pollutants (HAPs)
    - 189 HAPs as listed in 1990 CAAA under Title III
- Source Categories
  - Stationary Point (≥ 10 tpy of relevant pollutant)
  - Stationary Area
  - Mobile (On-Road & Off-Road)
  - Fugitive Dust (agricultural, road, construction, windblown)
  - Fires (agricultural, wildfire & prescribed burning)
- Temporal Resolution
    - Calendar year 2005
    - Hourly for typical weekday & weekend day for each season

Speciation

- Based on EPA's SPECIATE4 database
- VOC and PM-based speciation profiles
- Assumptions for missing profiles
- Estimated all applicable HAPS (189 HAPs defined in 1990 CAAA)
- Inventory summarized for selected HAPS
  - 1,3-Butadiene
  - Acetaldehyde
  - Benzene
  - Carbontetrachloride
  - Chloroform
  - Dichloromethane
  - Ethylbenzene
  - Formaldehyde
  - m,p-Xylene
  - o-Xylene
  - Styrene
  - Toluene
  - Trichloroethene
  - Vinylchloride
  - Arsenic
  - Cadmium
  - Chromium
  - Manganese
  - Nickel
  - Perchloroethylene

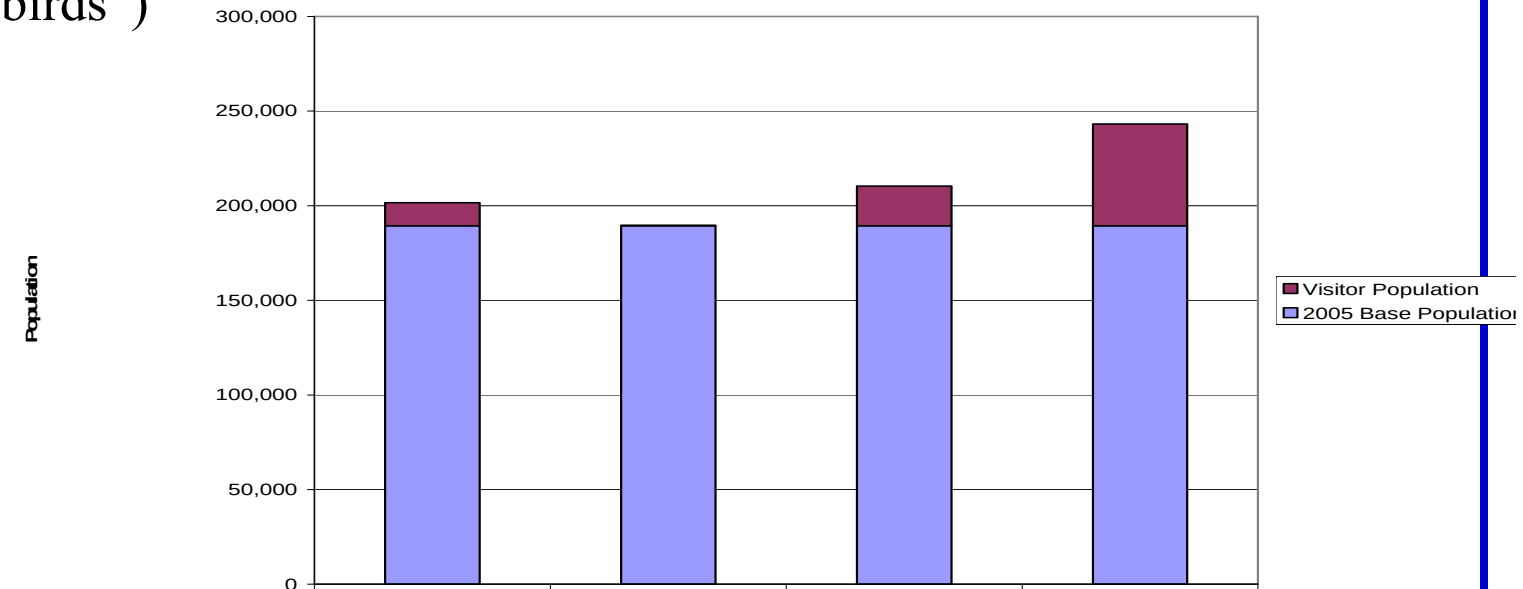
Stationary Point Sources

- 2005 emission estimates of NOx, VOC, CO, SOx, PM & total HAPs from ADEQ
- Major Stationary Points (> 10 tpy)
  - APS Yucca Power Plant – 150 MW natural gas-fueled turbines
  - Yuma Cogeneration Assoc. – 55 MW combine cycle gas turbines
  - Temporal profiles based on RPO "typical" modeling inventories
- Minor Points
  - light industry, MCAS, landfills, WWTP
  - Distributed movable sources – sand & gravel operations, concrete batch plants, etc.

Annual WASBAQS US Stationary Point Emissions (tons/year)					
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10**
APS - Yuma	8.9	61.0	272.0	3.2	18.2
Yuma Cogen Assoc.	3.2	28.9	152.5	3.6	10.0
Minor Points	47.0	82.3	87.7	18.9	90.1
Total	**59.1**	**172.1**	**512.2**	**25.7**	**118.3**

Area Sources

- Solvent utilization, fuel combustion, dry cleaners, RWC, open burning, structure fires, etc.
  - Estimation methodologies from EIIP guidance
  - US Census, Yuma City & County Agencies, ADEQ, ADOT
  - Per-capita emission factors
- Adjustments for seasonal population increases
  - Increased winter population (winter visitors, seasonal residents, i.e., "snowbirds")



	Spring	Summer	Autumn	Winter
Visitor Population	12,095	213	20,869	53,719
2005 Base Population	189,480	189,480	189,480	189,480

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Area Sources

- Gasoline distribution (Stage I & II refueling)
  - ADEQ survey of local gasoline distributors and gas stations
    - Throughput based on surveys (75% response rate)
    - Fuel sampling – RVP, sulfur content, seasonal variation based on sample averages by season & EIA sales data
    - Monthly & weekly sales data used for temporal allocation
    - Gas station locations geo-coded for spatial allocation
  - Emission factors from EIIP & MOBILE6

Area Sources

- Pesticide Application
  - Yuma Co. – 2005 Pesticide Use Reporting (PUR) database
    - Application type & amounts by crop, application methods, dates, locations
    - Locations provided by Township/Range/Section (TRS)
    - Arizona State TRS GIS layers used for spatial allocation
  - Imperial Co. – CA Department of Pesticide Regulation
  - Estimation methodology based on CARB method using VOC 'emissions potential'
  - HAPs estimated from reported active ingredients; assumptions for inert ingredients

- US Army Yuma Proving Grounds
  - Emission estimates provided by US Army
    - Boilers, generators, industrial processes, woodworking, waste disposal, other miscellaneous sources
  - 2005 seasonal estimates of NOx, VOC, CO, SOx and total HAPs by SCC and location

Ammonia Sources

- Estimates based on WRAP RMC GIS NH3 Model
  - Developed as GIS-based modeling system
  - Applied domain-wide (US & Mexico)
  - Incorporates environmental parameters – soil pH, met data (winds, temperatures)
  - Source categories include:
    - Livestock, Fertilizers, Native Soils, Domestic Sources

- Incorporates county-level and local activity data
  - Livestock headcounts adjusted based on University of Arizona Agricultural Extension
  - Fertilizer usage based on county-level data from USDA & NASS
  - Activity data for soil emissions based on LULC; crop locations from pesticide database & TRS data
  - Monthly activity data for fertilizers; annual for livestock, domestic,

- Model estimates hourly emissions based on temporal variations of met data (not used in current application)

Domain-wide Annual Ammonia Emissions

Annual NH3 Emissions -- WASBAQS Domain (tpy)					
Category	**Yuma, AZ**	**Imperial, CA**	**Baja**	**Sonora**	**Total**
Livestock	22	8	95	2	**127**
Fertilizers	1,563	289	5,928	677	**8,458**
Native Soils	550	315	56	202	**1,122**
Domestic	78	10	5	30	**122**
Total	**2,213**	**621**	**6,084**	**911**	**9,830**

Annual WASBAQS US Domain-wide CAP Emissions (tons/year)							
Source Category	**VOC**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**NH3**
Auto Body Refinishing	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	2487.6	248.8	0.0
Degreasing	272.2	0.0	0.0	0.0	0.0	0.0	0.0
Dry Cleaning	43.2	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Combustion	4.0	90.7	181.6	227.6	52.3	34.9	1.7
Gasoline Distribution	587.1	0.0	0.0	0.0	0.0	0.0	0.0
Graphic Arts	131.6	0.0	0.0	0.0	0.0	0.0	0.0
Industrial Surface Coating	290.5	0.0	0.0	0.0	0.0	0.0	0.0
Open Burning	0.2	0.8	0.0	0.0	0.2	0.2	0.0
Residential Wood Combustion	11.3	27.7	0.4	0.1	3.9	3.9	0.0
Traffic Marking	9.7	0.0	0.0	0.0	0.0	0.0	0.0
Architectural Coatings	289.6	0.0	0.0	0.0	0.0	0.0	0.0
Cutback Asphalt	86.1	0.0	0.0	0.0	0.0	0.0	0.0
Vehicle Fires	0.3	1.4	0.0	0.0	1.1	1.1	0.0
Structural Fires	1.6	8.8	0.2	0.0	1.6	1.6	0.0
Consumer Solvent	634.7	0.0	0.0	0.0	0.0	0.0	0.0
Commercial Cooking	6.9	19.6	0.0	0.0	51.5	47.7	0.0
Pesticides	159.6	0.0	0.0	0.0	0.0	0.0	0.0
Yuma Proving Grounds	14.9	18.4	3.3	1.7	1.0	0.2	0.0
Total	**2563.4**	**167.4**	**185.5**	**229.3**	**2599.2**	**338.2**	**1.7**

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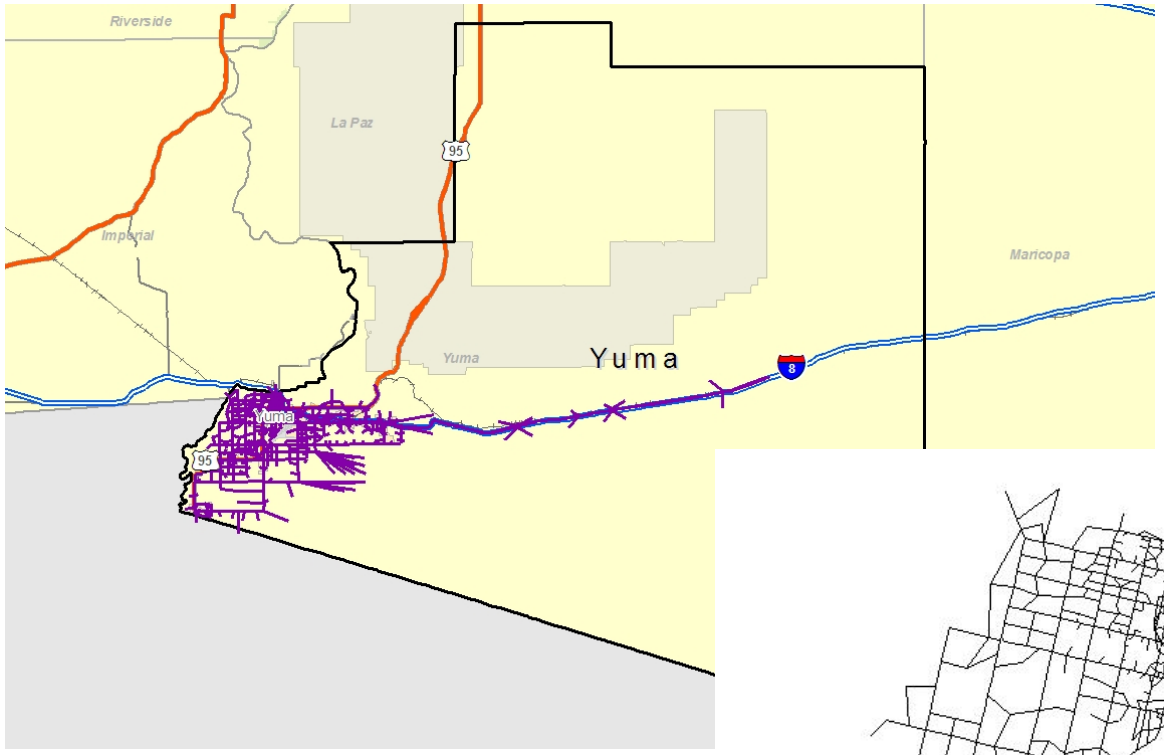
On-Road Mobile Sources

- Link-based estimates in Yuma
  - Travel Demand Modeling by YMPO (TransCAD)
  - Data included VMT, link lengths, roadway classes, free-flow speeds, roadway capacities & total daily volumes
  - Transportation network provide in GIS format
- HPMS estimates outside transportation network region
  - 2005 HPMS VMT data from ADOT
- MOBILE6 applied with:
  - adjustments for specific fuel properties; vehicle registration data

Roadway Type	TransCAD VMT (1000mi/day)	Yuma County-wide HPMS VMT (1000mi/day)	Non-YMPO VMT estimates		
			Functional Code	Functional Class	Donut VMT (1000mi/day)
Interstate	1,203	1,908	1	Rural Interstate	705
Principal Arterial	1,052	1,094	2	Rural Principal Arterial	42
Minor Arterial	816	769	-	-	-
Collector	815	789	-	-	-
Local	430	664	9	Rural Local	234
Totals	**4,316**	**5,223**	**Totals**		**980**

YMPO Transportation Network



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On-Road Mobile Emissions

Source	Exhaust VOC	Evap VOC	CO	NOx	PM10	PM2.5	SO2	NH3	Total HAPS
Wednesday									
Transportation Network	4.301	3.483	101.16	15.060	0.305	0.216	0.222	0.455	1.953
HPMS "donut"	0.972	0.776	21.5	2.908	0.077	0.056	0.063	0.097	0.417
Totals	**5.273**	**4.259**	**122.65**	**17.968**	**0.381**	**0.273**	**0.285**	**0.552**	**2.370**
Saturday									
Transportation Network	3.295	3.124	84.15	10.003	0.204	0.133	0.144	0.413	1.507
HPMS "donut"	0.863	0.709	19.54	2.055	0.049	0.034	0.041	0.087	0.369
Totals	**4.157**	**3.834**	**103.69**	**12.058**	**0.253**	**0.167**	**0.186**	**0.500**	**1.876**

Season	VOC exhaust	VOC evap	CO	NOx	PM10	PM2.5	SO2	NH3	Total HAPS
Wednesday									
Winter	7.130	4.617	172.94	22.539	0.454	0.325	0.322	0.651	3.138
Spring	4.947	4.073	111.99	17.432	0.372	0.267	0.324	0.527	2.244
Summer	4.052	4.297	94.75	14.273	0.321	0.229	0.227	0.470	1.903
Autumn	4.961	4.048	110.90	17.629	0.380	0.270	0.266	0.558	2.196
Saturday									
Winter	5.583	4.139	145.38	15.151	0.300	0.198	0.206	0.590	2.416
Spring	3.883	3.667	93.91	11.700	0.247	0.164	0.224	0.478	1.783
Summer	3.272	3.883	82.20	9.622	0.213	0.140	0.144	0.426	1.573
Autumn	3.891	3.646	93.26	11.760	0.252	0.165	0.169	0.506	1.735

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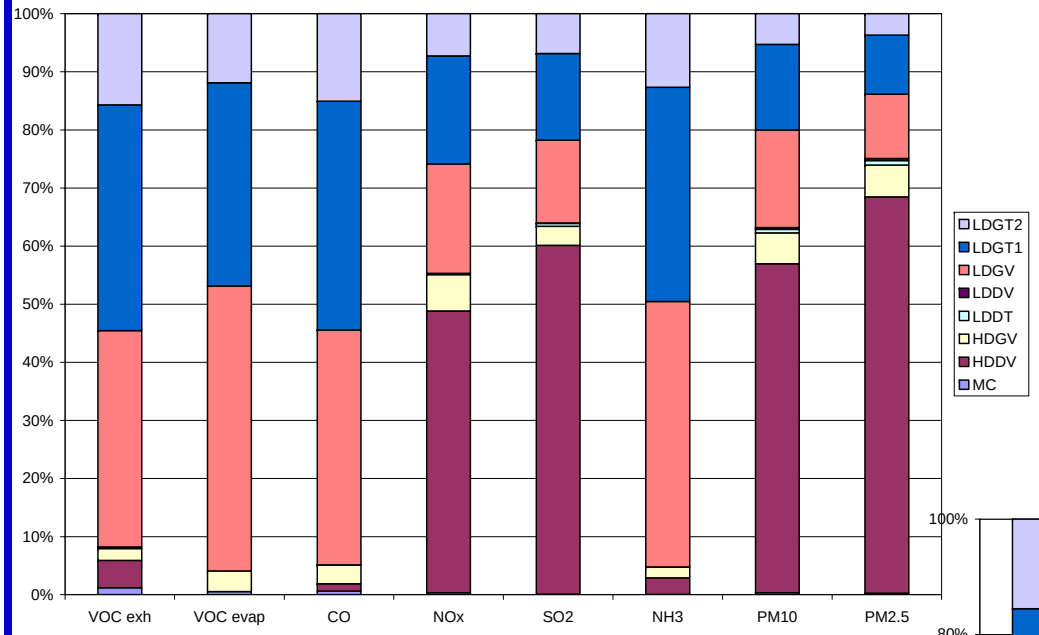
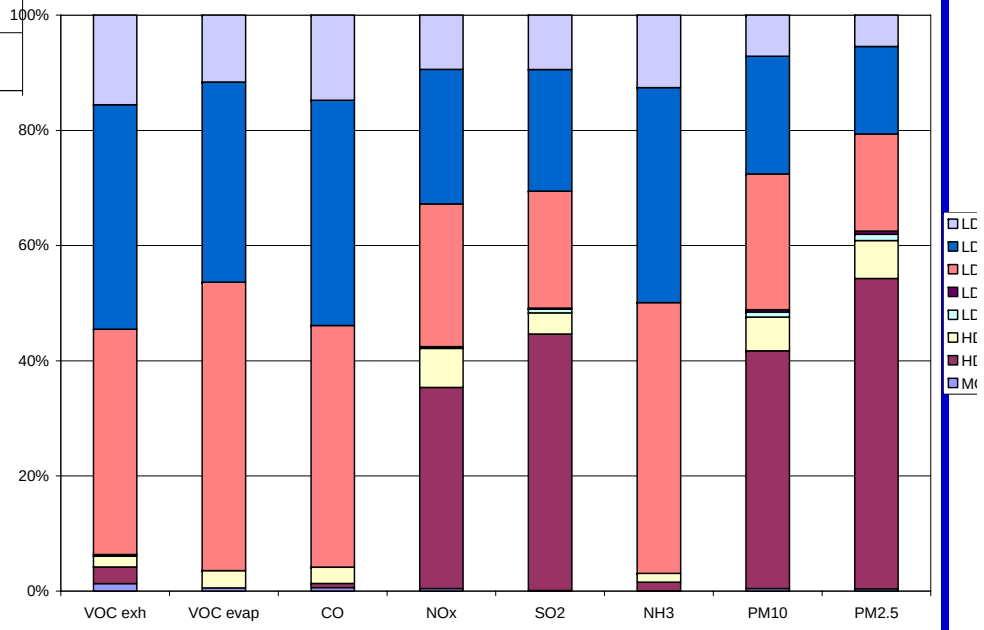
On-road Mobile Emissions by Vehicle Class

Weekday



Weekend



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Off-Road Mobile Sources

- Off-road Mobile Source Categories
  - agricultural equipment
  - airport ground support
  - construction equipment
  - industrial and commercial equipment
  - residential and commercial lawn and garden equipment
  - recreational equipment (OHVs & ATVs)
  - locomotive

- NONROAD for Yuma; OFFROAD for Imperial
  - Fuel properties as from gasoline survey & sampling
  - Adjustments to default agricultural equipment data for Yuma Co. from 2006 NASS

Equipment	NONROAD 2005 default	Revised population
Combines	197	63
Balers	16.3	115
Tractor with < 40hp	204	237
Tractor with hp between 40 -99	332	799
Tractor with > 100hp	447	539

Adjustments for OHVs & ATVs at Imperial Sand Dunes

- Imperial Sand Dunes Sheriff's office provided activity statistics for ATVs & OHVs
- 90% of Imperial activity occurs at Imperial Sand Dunes; 25% of activity from Arizona

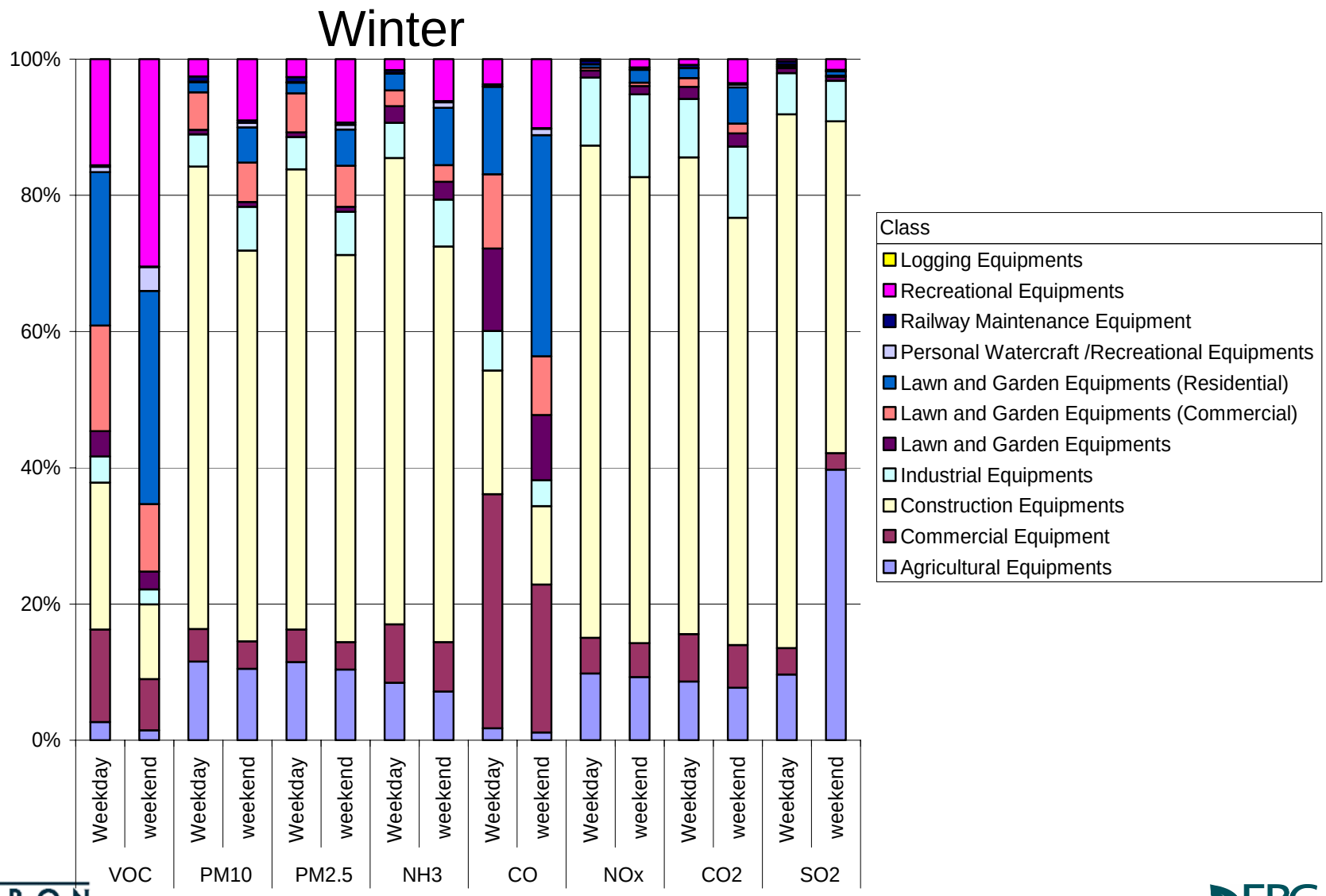
$$AZ\text{-}ISD = 0.90\% \text{ of } IC_{catotal} * 0.25$$
$$IC_{total} = AZ\text{-}ISD + IC_{catotal}$$
$$Yuma = Yuma_{nonroadtotal} - AZ\text{-}ISD$$

AZ-ISD = Arizona registered OHVs & ATVs operated only in Imperial Sand Dunes
$IC_{catotal}$ = California registered OHVs & ATVs total in Imperial County from OFFROAD
IC_{total} = Total of all OHVs & ATVs operating anywhere in Imperial County
$Yuma_{nonroadtotal}$ = Total population of OHVs and ATVs operating in Yuma County from NONROAD
Yuma = Estimated population of Arizona registered OHVs &ATVs operating only in Yuma Co.

Off-Road Mobile Emissions

Seasonal WASBAQS US Domain-wide Off-Road Mobile Emissions (tons/day)							
Season	**VOC**	**CO**	**NOx**	**PM10**	**PM2.5**	**SO2**	**NH3**
Fall							
Weekday	2.025	26.053	2.684	0.264	0.244	0.046	0.002
Weekend	2.367	26.179	1.457	0.165	0.153	0.026	0.002
Spring							
Weekday	1.969	25.234	2.66	0.258	0.24	0.047	0.002
Weekend	2.315	25.435	1.46	0.163	0.153	0.027	0.002
Summer							
Weekday	2.05	27.557	2.893	0.273	0.253	0.049	0.002
Weekend	2.248	27.653	1.588	0.16	0.149	0.028	0.002
Winter							
Weekday	1.026	10.382	1.766	0.158	0.146	0.03	0.001
Weekend	1.06	8.342	0.944	0.095	0.089	0.025	0.001

Off-Road Mobile Emissions



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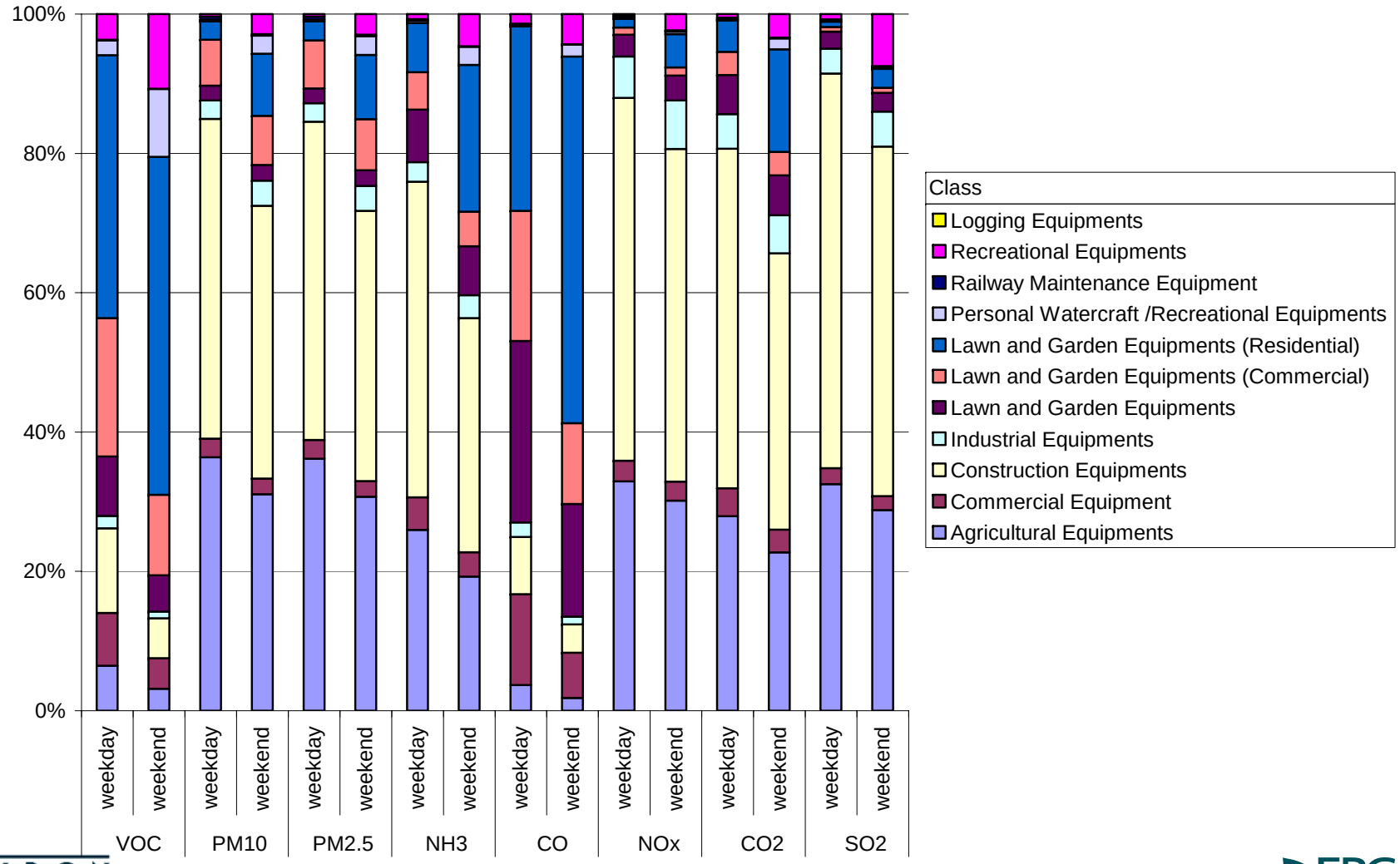
Off-Road Mobile Emissions

Summer



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Fugitive Dust Sources

- Agricultural Dust (harvesting & tilling)
  - Activity data based on harvested acres by crop type from Ag Extension staff
  - Spatial allocation based on Yuma Pesticide database, CA Dept. Water Resources, TRS shapefiles
- Agricultural Tilling

$$E_{crop} = (EF_{till\ method} * P_{till\ method\text{-}crop}) * A_{crop}$$

Parameter	Description	Approach
E_{crop}	PM10 emissions per crop	
$EF_{till\ method}$	lbs/acre-pass for different till methods	Based on factors for 5 different till methods – data collected by UC Davis researchers in San Joaquin Valley. Mapping of the 5 basic till methods to multiple other till methods are found in CARB 2003a.
A_{crop}	Acres (harvested)	Crop acreage obtained from references: The University of Arizona 2006, Imperial County 2006.
$p_{till\ method\text{-}crop}$	Number of passes or tillings per year by till method and crop	Default values from ARB inventory methods (CARB 2003a) were used for this analysis.

Fugitive Dust Sources

- Agricultural Haresting

$$E_{crop} = EF_{crop} * Acres_{crop}$$

Parameter	Description	Approach
E_{crop}	PM_{10} fugitive dust emissions	
EF_{crop}	Variable factor by crop type (mass/area)	Factors for total fugitive dust emissions for total harvesting process measured by UC Davis for cotton, almonds, and wheat. A mapping of these 3 factors to over 200 different crop types, adjusting the numbers for different crops, is included in CARB 2003b.
$acres_{crop}$	Acres harvested for each crop.	Crop acreage obtained from references: The University of Arizona 2006, Imperial County 2006.

Road Dust Sources

- Methodology based on recently revised AP-42 (EPA, 2006)
- Paved Road Dust

$$E = (k * (s/2)0.65 * (W/3)1.5 – C) * (1 – P/(4*N))$$

E = particulate emission factor (g/VMT)
k = particle size multiplier (g/VMT)
s = road surface silt loading (g/m2); W = mean vehicle weight (tons)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.
P = number of days with at least 0.01 inch of precip.;N = number of days in the avg. period

- Unpaved Road Dust

$$E = [(k * (s/12)a * (S/30)d) / (M/0.5)c] - C * (N – P/N)$$

E = particulate emission factor (g/VMT)
k, a, b, c = empirical constants; **s = road surface silt content (%); M = road surface moisture content (%)**
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.
P = number of days with at least 0.01 inch of precip.; N = number of days in the avg. period

- Silt loading & soil moisture from road dust sampling conducted by ERG
  - Paved – silt (5.5-28.9%); silt loading (0.13-22.5 g/m^2)
  - Unpaved – silt (4.3-10.8%); soil moisture (0.2-0.8%)
- Paved VMT – as for on-road mobile
- Unpaved VMT – based on % of paved roads in Yuma PM Maintenance Plan (~2.67%)

Windblown Dust

- PM emissions estimates based on WRAP RMC WB Dust Model
  - Developed for regional applications, based on recent literature reviews, results of fields studies, erosion models
  - Estimates WB fugitive dust emissions from Barren, Shrub, Grass, and Ag lands (No forest or Urban lands)
  - Applied Domain-wide (US & Mexico)
  - Highly dependent on accurate, detailed LULC, soil characteristics & wind fields
  - Agricultural adjustments incorporated for Yuma & Imperial Counties
- Agricultural information from University of Arizona Ag Extension Office
  - Crop types, crop calendars
  - Spatially allocated using TRS and pesticide database
- LULC – from Shupe Geomapping & 2001 NALC
- Soil characteristics from SSURGO & STATSGO
- Meteorological data – surface wind fields interpolated from observed data, no precipitation
- Preliminary emission estimates

Fugitive Dust Sources

- Construction Dust
  - Residential activity from construction permits
  - Non-residential activity available for City of Somerton; Yuma activity based on interpolated data from Yuma Co. PM Maintenance Plan (ADEQ)
  - Road construction activity from ADOT, City of Yuma, City of Somerton, San Luis and Yuma Co.

Annual WASBAQS US Domain-wide Fugitive Dust Emissions (tons/year)		
Category	**PM10**	**PM2.5**
Agricultural Tilling	945	142
Agricultural Harvesting	195	29
Paved Road Dust	5,657	697
Unpaved Road Dust	11,863	1,183
Construction Dust	3,420	342
Total	**22,081**	**2,393**

Annual WB Dust Emissions -- WASBAQS Domain (tpy)		
Region	**PM10**	**PM2.5**
Yuma, AZ	3,749	375
Imperial, CA	2,456	246
Sonora	643	64
Baja	793	79
Domain Total	**7,640**	**764**

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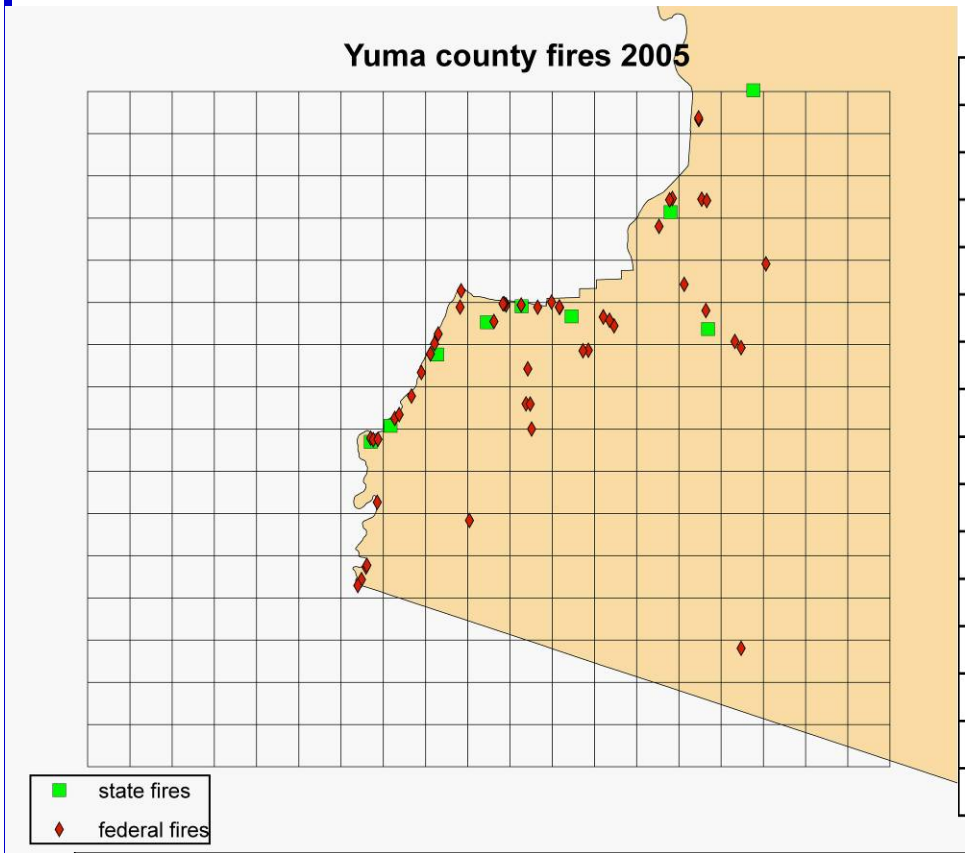
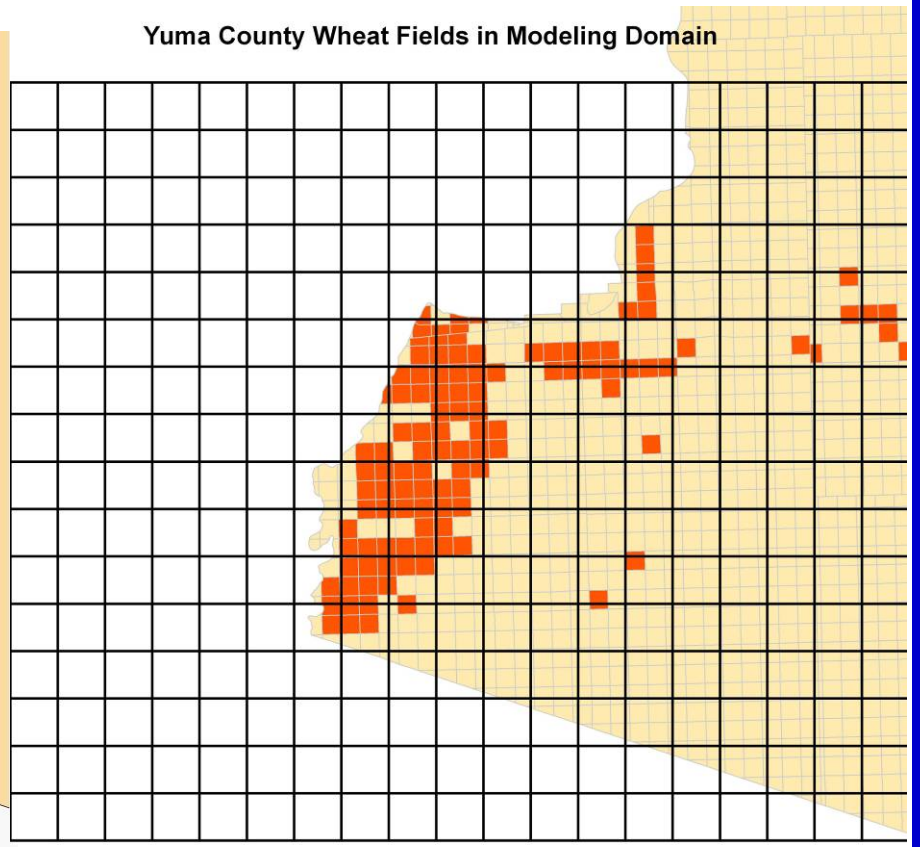
Fire Sources

- Activity data for Yuma from:
  - personal communications w/ Forestry Division, Arizona State Land Department, Ag Extension staff;
  - Geo Spatial Multi Agency Coordination website
  - No prescribe fires within domain
- Wildland fire incidents by date, location and acres burned
- Agricultural burning in Yuma limited to wheat stubble (~40% total wheat acreage burned in June & July)
- Spatial allocation for agricultural burning based on TRS pesticide database and TRS shapefiles
- Imperial Co activity data from the Air Pollution District of Imperial County
- Emission estimation methodology based on WRAP Phase III/IV Fire Inventory

Fire Sources





Annual WASBAQS US Domain-wide Burning Emissions (tons/year)							
Category	**VOC**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**NH3**
Agricultural Burning	80.8	985.6	34.4	6.4	86.7	82.3	19.3
Wildland Fires	11.8	10.1	5.4	1.5	24.4	20.9	1.1
Total	**92.6**	**995.7**	**39.8**	**7.9**	**111.1**	**103.2**	**20.4**

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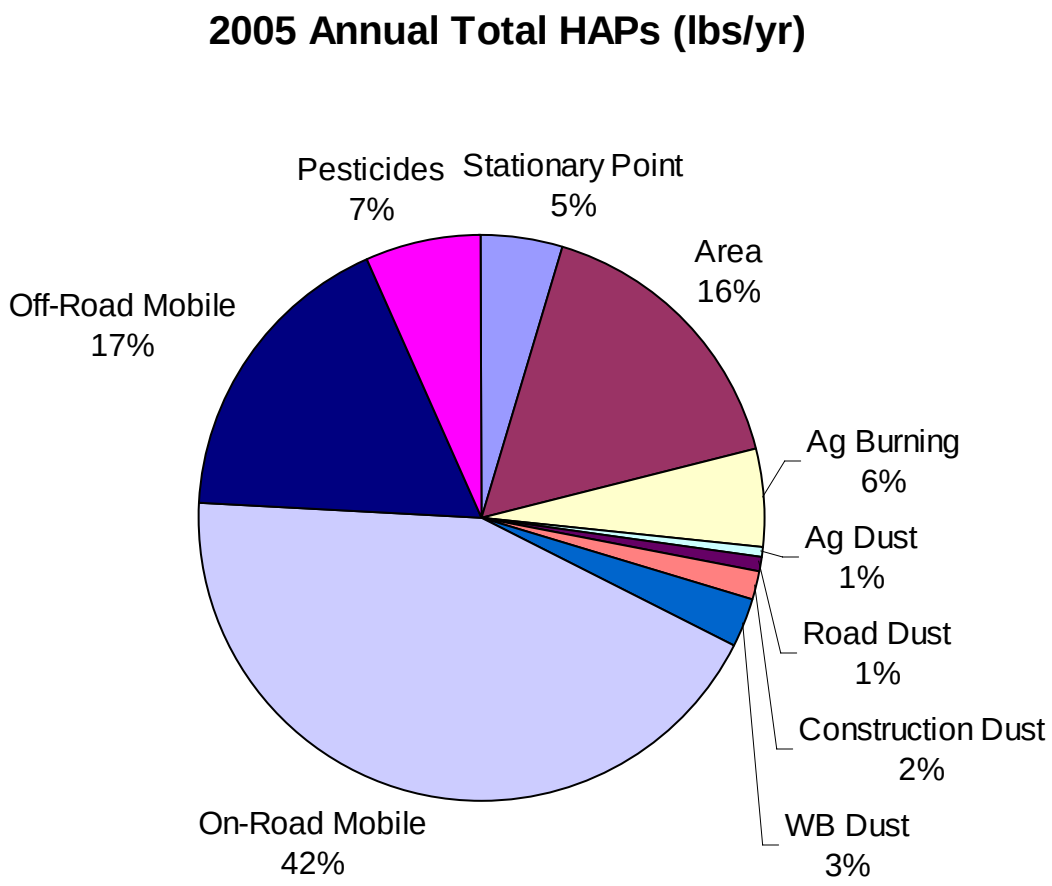
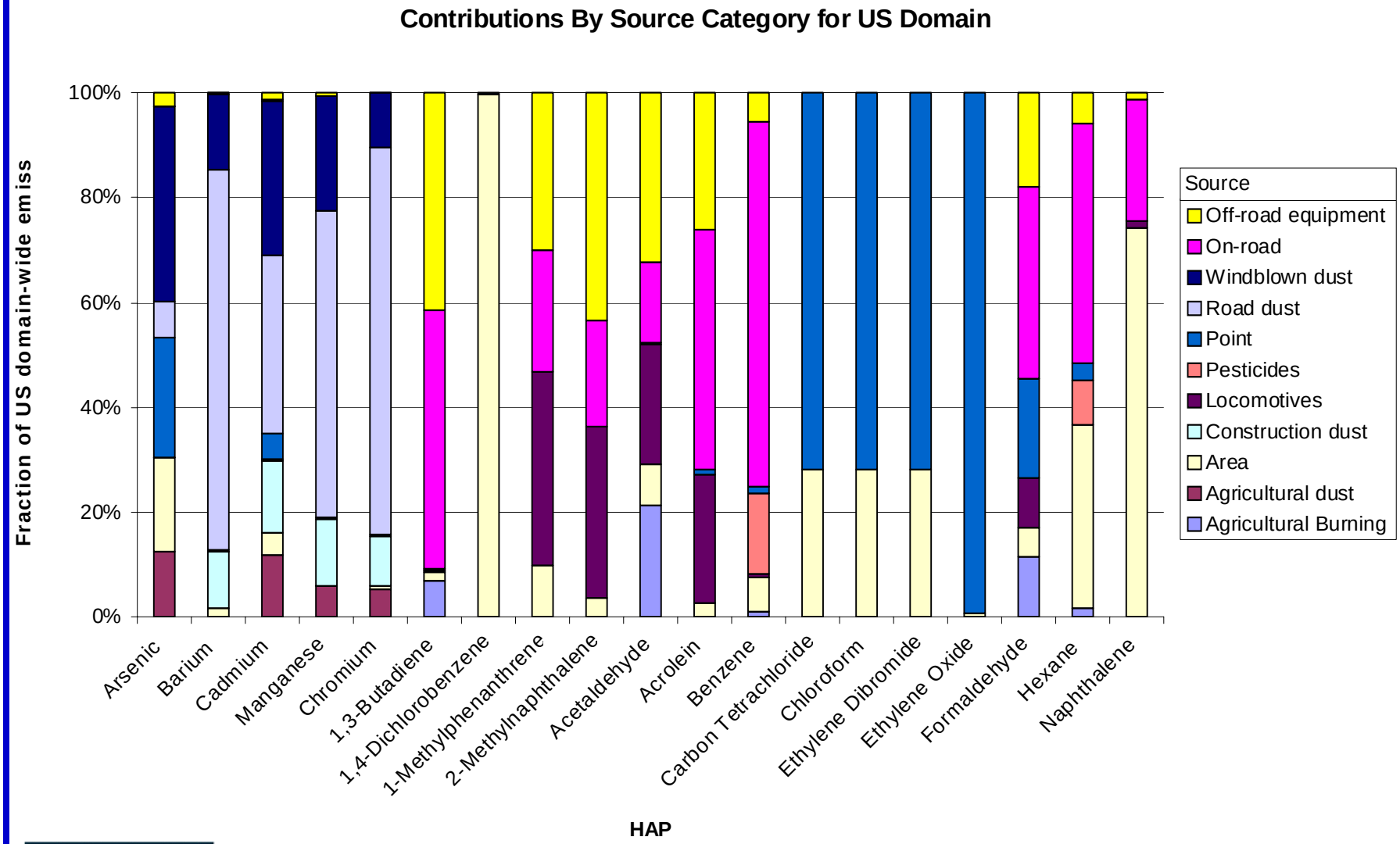
HAP Emissions Summary



HAP Emissions Summary

2005 Annual Estimates



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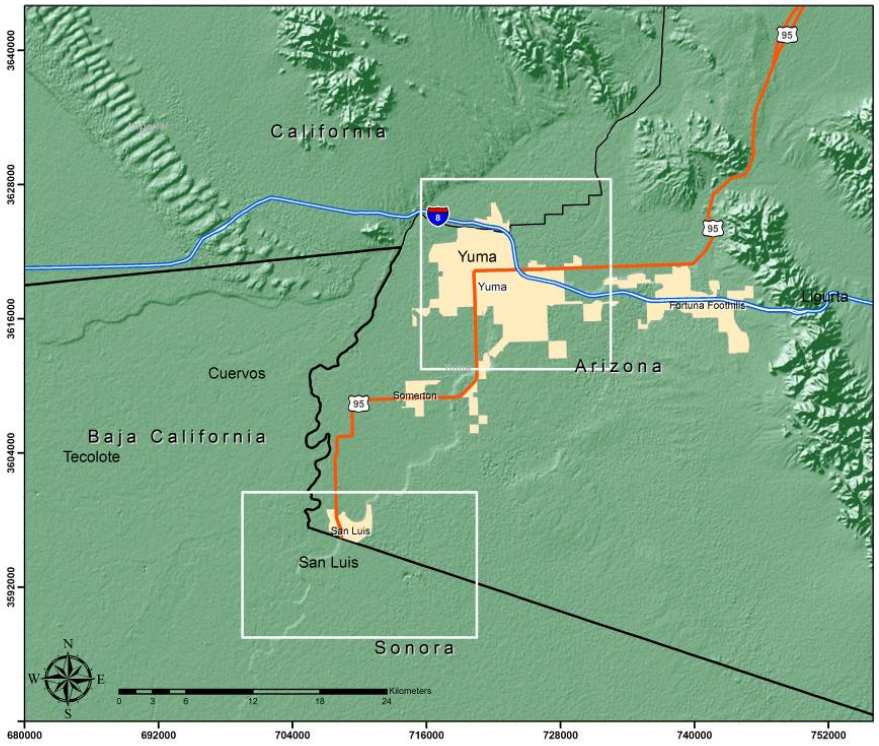
Emissions Modeling

- Emission Processing System, Version 3 (EPS3)
- EPS3 application
  - Chemical speciation: Emission estimates of criteria pollutants (VOC) speciated for the CB05 chemical mechanism; HAPs based on SPECIATE4.
  - Temporal allocation: Annual, or seasonal, emission estimates are resolved hourly for air quality modeling. Based on locally obtained data and information; EPA default temporal profiles by pollutant & SCC.
  - Spatial allocation: Regional or county level emission estimates spatially resolved to the modeling grid cells for air quality modeling. Spatial allocation based on locally obtained data and information, US Census, transportation networks, LULC.

Emissions Modeling

- Nested grid modeling domains
  - 4.0 km coarse grid domain
  - 0.5 km nested grid domains



- LULC data
  - ETM (4-km domain)
  - IKONOS aerial photos (urban domains)
  - Developed by Shupe Geomapping under contact to ADEQ

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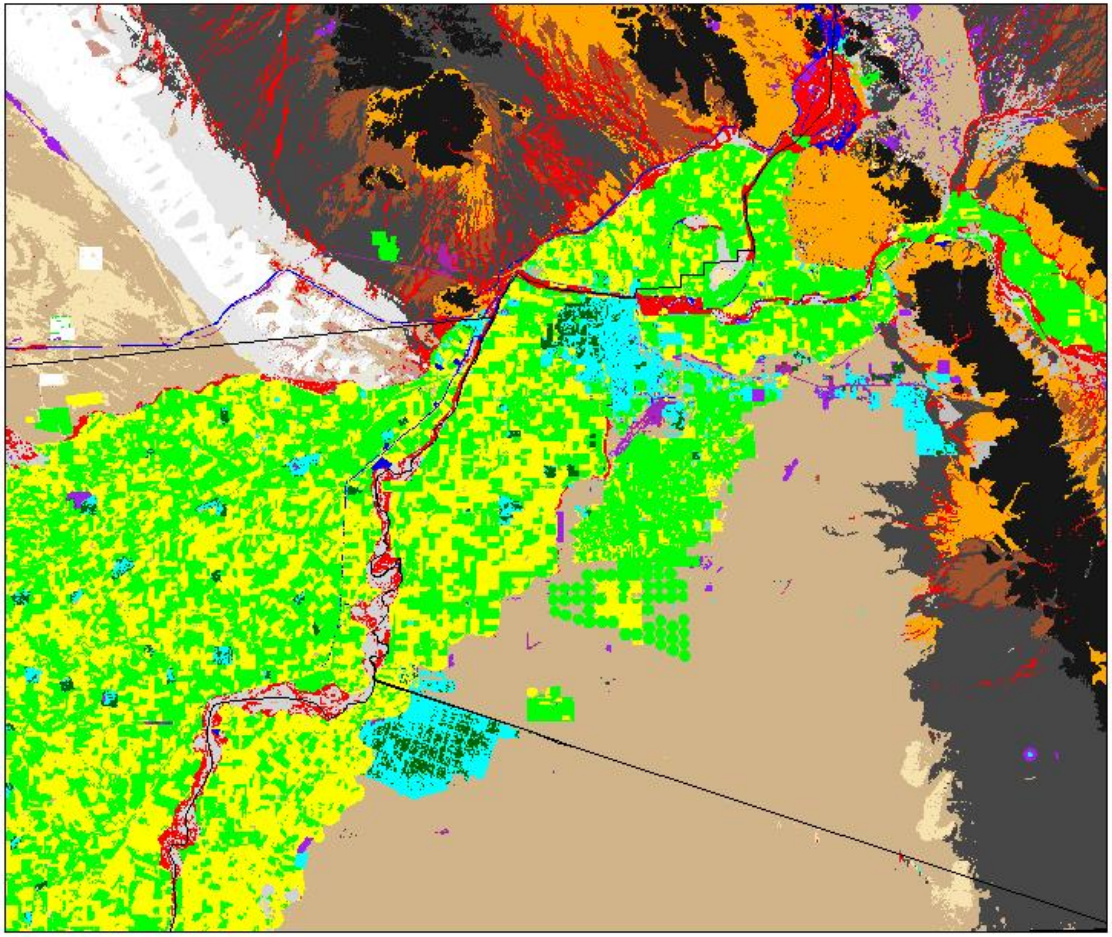
Landuse/Landcover Data
4-km WASBAQS Modeling Domain



LULC Description

- Unassigned
- Water
- Mountain
- Desert Pavement/Plains
- Eroded Alluvial Hills
- Desert Plains
- Alluvial Plains/Washes
- Riparian (dense shrub and/or trees)
- Agriculture
- Dissected Pavement
- Wash Terraces/Plains
- Sandy, Shrubby Desert
- Bare/Cleared/Disturbed
- Roads
- Urban Vegetation
- Mixed Urban Features
- Mixed Desert
- Fallow Agriculture
- Dunes (unvegetated)
- Vegetated Dunes
- Quarry
- Interdune Basin/Plains
- Sandy,Shrubby Desert w/ off-road disturbance
- Orchards
- Abandoned Agriculture

ENVIRON

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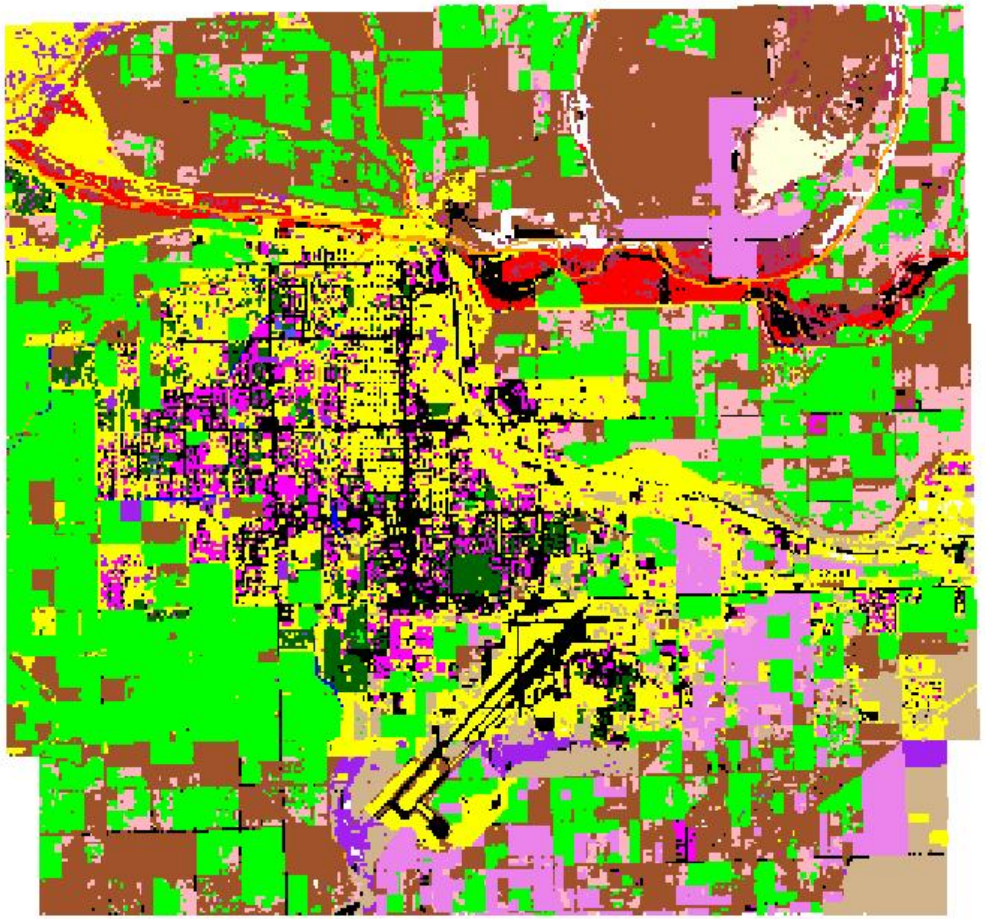
Landuse/Landcover Data

0.5-km Yuma Modeling Domain



LULC Description

- Unclassified
- Urban Tree
- Urban Turf
- Urban Marginal Green
- Agriculture
- Orchards
- Marginal Agriculture (new growth, etc)
- Fallow Ag
- Riparian Veg
- Riparian Veg, Burned
- Riparian Area, Bare
- Desert (undisturbed)
- Desert, Sandy
- Not Used
- Residential/Urban Bare
- Disturbed Ground
- Paved Roads and Parking Lots
- Paved/Non-Paved, Confused
- Canal Banks
- Buildings
- Water
- Shadows
- Dirt Sport/Ball Fields

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