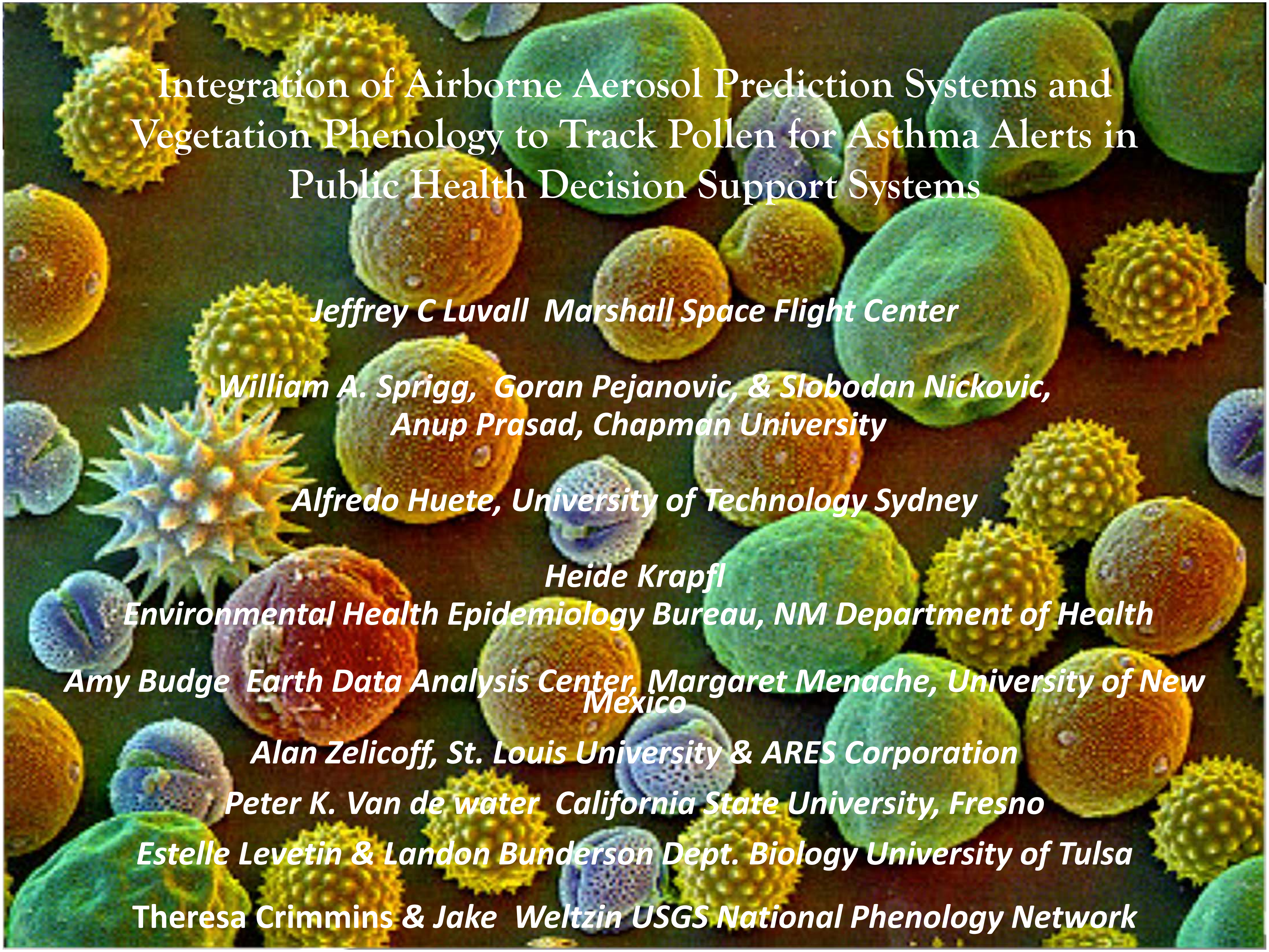


Integration of Airborne Aerosol Prediction Systems and Vegetation Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems

Jeffrey C Luvall Marshall Space Flight Center

William A. Sprigg, Goran Pejanovic, & Slobodan Nickovic,
Anup Prasad, Chapman University

Alfredo Huete, University of Technology Sydney

Heide Krapfl
Environmental Health Epidemiology Bureau, NM Department of Health

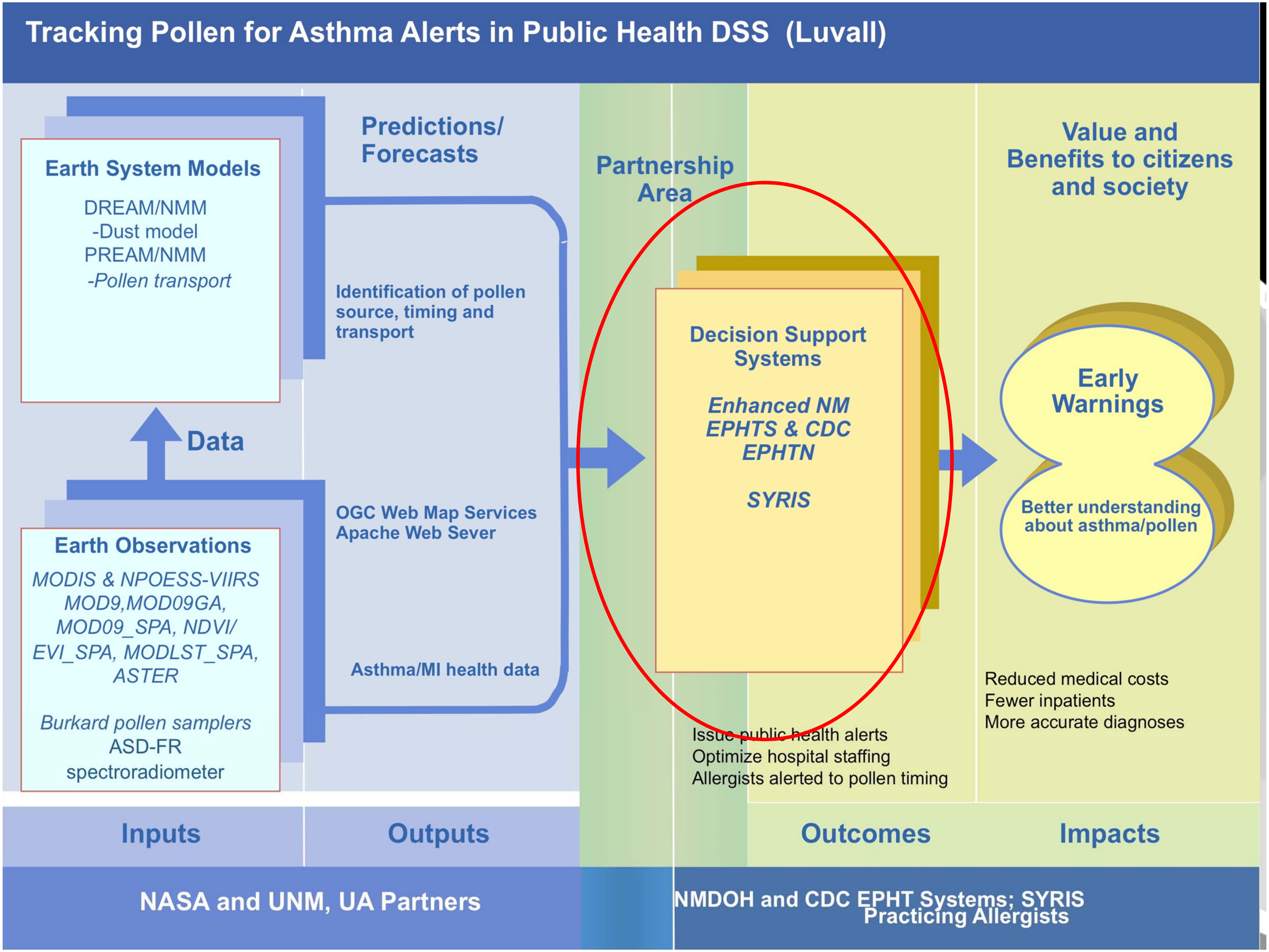
Amy Budge Earth Data Analysis Center, Margaret Menache, University of New Mexico

Alan Zelicoff, St. Louis University & ARES Corporation

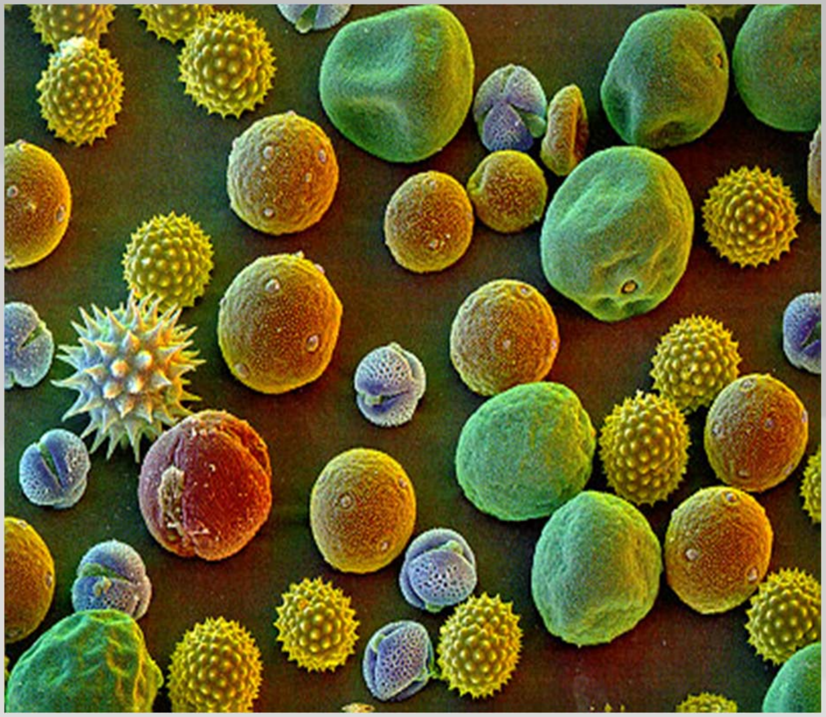
Peter K. Van de water California State University, Fresno

Estelle Levetin & Landon Bunderson Dept. Biology University of Tulsa

Theresa Crimmins & *Jake Weltzin USGS National Phenology Network*


Tracking Pollen for Asthma Alerts in Public Health DSS (Luvall)
Earth System Models
DREAM/NMM
-Dust model
PREAM/NMM
-Pollen transport
Predictions/ Forecasts
Identification of pollen source, timing and transport
Data
OGC Web Map Services
Apache Web Sever
Earth Observations
MODIS & NPOESS-VIIRS
MOD9,MOD09GA,
MOD09_SPA, NDVI/
EVI_SPA, MODLST_SPA,
ASTER
Burkard pollen samplers
ASD-FR
spectroradiometer
Asthma/MI health data
Partnership Area
Decision Support Systems
Enhanced NM EPHTS & CDC EPHTN
SYRIS
Value and Benefits to citizens and society
Early Warnings
Better understanding about asthma/pollen
Issue public health alerts
Optimize hospital staffing
Allergists alerted to pollen timing
Reduced medical costs
Fewer inpatients
More accurate diagnoses
Inputs
Outputs
Outcomes
Impacts
NASA and UNM, UA Partners
NMDOH and CDC EPHT Systems; SYRIS
Practicing Allergists

Top pollen-producing species



Los Alamos

juniper
sagebrush
pine
Alternaria*
oak
grass
ragweed
goosefoot
Cladosporium*
Myxomycete*
cottonwood
mulberry
aster
elm

Albuquerque

mulberry
juniper
ash
goosefoot
cottonwood
grass
sagebrush
pine
elm
aster
ragweed
sycamore
oak
willow

*fungal / slime mold spores

Pollen and Respiratory Disease: What little is known[2]

Increase in mortality of these disorders:

	Poaceae pollen concentrations (grains per m³ air)			
	<22	22–77	78–135	>135
	Relative risk	Relative risk (95% CI)	Relative risk (95% CI)	Relative risk (95% CI)
Cardiovascular disease	1·000	1·015 (1·002–1·029)	1·012 (0·994–1·029)	1·061 (1·038–1·084)
Chronic obstructive pulmonary disease	1·000	1·095 (1·053–1·139)	1·124 (1·069–1·181)	1·150 (1·079–1·225)
Pneumonia	1·000	1·104 (1·049–1·163)	1·093 (1·023–1·168)	1·168 (1·077–1·266)
Total	1·000	1·019 (1·010–1·028)	1·019 (1·008–1·031)	1·043 (1·028–1·058)

- High concentrations of pollen allergens have also been shown to occur in thoracic particles (<10 microns in diameter) and respirable particles (<2·5 microns and these correlated well in time with airborne pollen concentrations. … airborne pollen results in exposure of the lower airways and lung to pollen allergens.

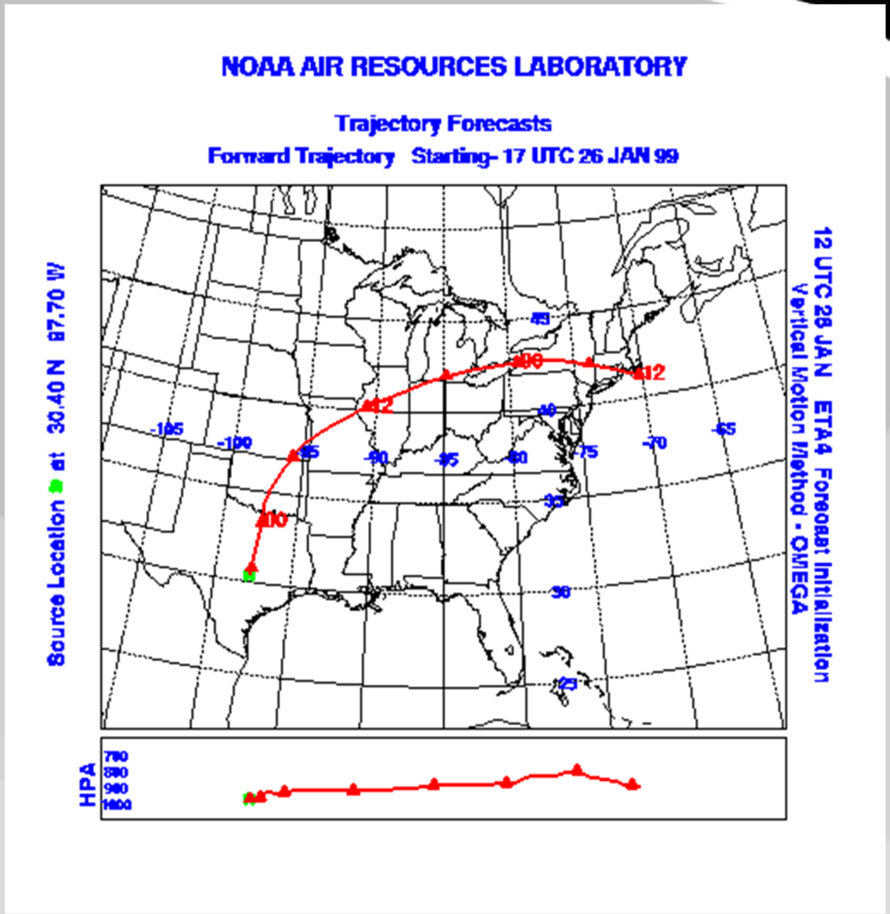
- The association between air pollution and the number of daily deaths may be related to the inflammatory potential of very small particles

- …suggests that high airborne pollen concentrations, which nowadays are mainly seen as triggers of allergic symptoms, may have far more serious effects than previously thought."

[2] Bert Brunekreef, Gerard Hoek, Paul Fischer, Frits Th M Spieksma. Relation between airborne pollen concentrations and daily cardiovascular and respiratory-disease mortality. Lancet Vol 355 (2000): 1517-8.

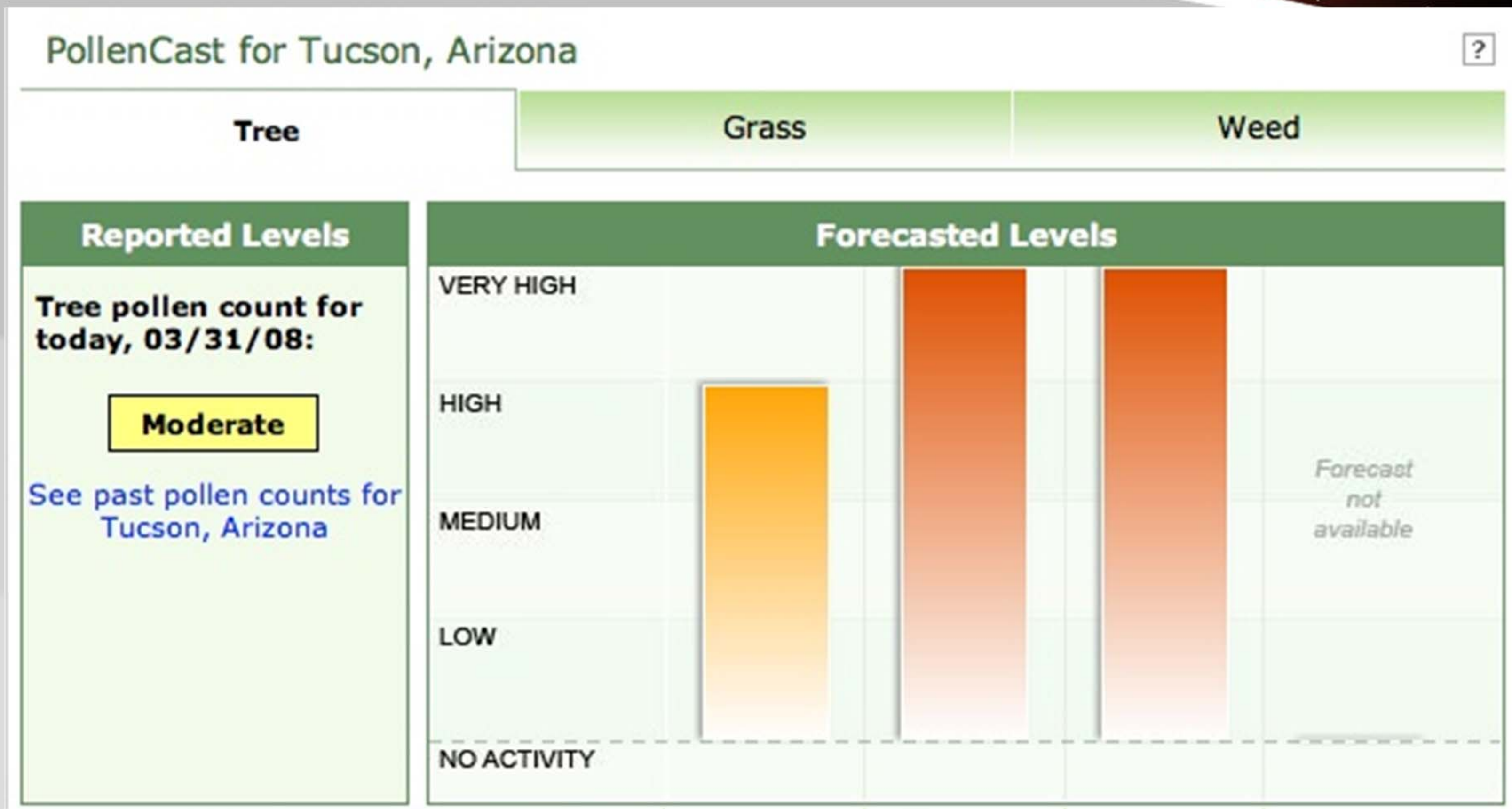
Continental transport

- 27 Jan 99, Jim Anderson in London, Ontario reported atmospheric *Juniperus* pollen - 58 pollen grains/m^3
- Trajectories show that the source of this pollen was Texas population of *Juniperus ashei*
- Our Jan 26 forecast indicated that the "pollen has the potential to travel very long distances."



Van de Water et. al 2003

Burkard Spore Trap


PollenCast for Tucson, Arizona
?
Tree
Grass
Weed
Reported Levels
Tree pollen count for today, 03/31/08:
Moderate
See past pollen counts for Tucson, Arizona
Forecasted Levels
VERY HIGH
HIGH
MEDIUM
LOW
NO ACTIVITY
Forecast not available

Limitations of Pollen Sampling

- Lack of stations
- Count frequency & reporting lag time
- Different sampling instruments Rotorod Sampler/Burkard Spore Trap
- Only indentifiable pollen “grains”
- Expertise in counting/indentification
- Refusal to release sampling information-”*We do not reveal the sources for our data for privacy and proprietary, competitive reasons. Some pollen counts are conducted privately, and are not meant to be broadcast to the public*”

Pollen Timing

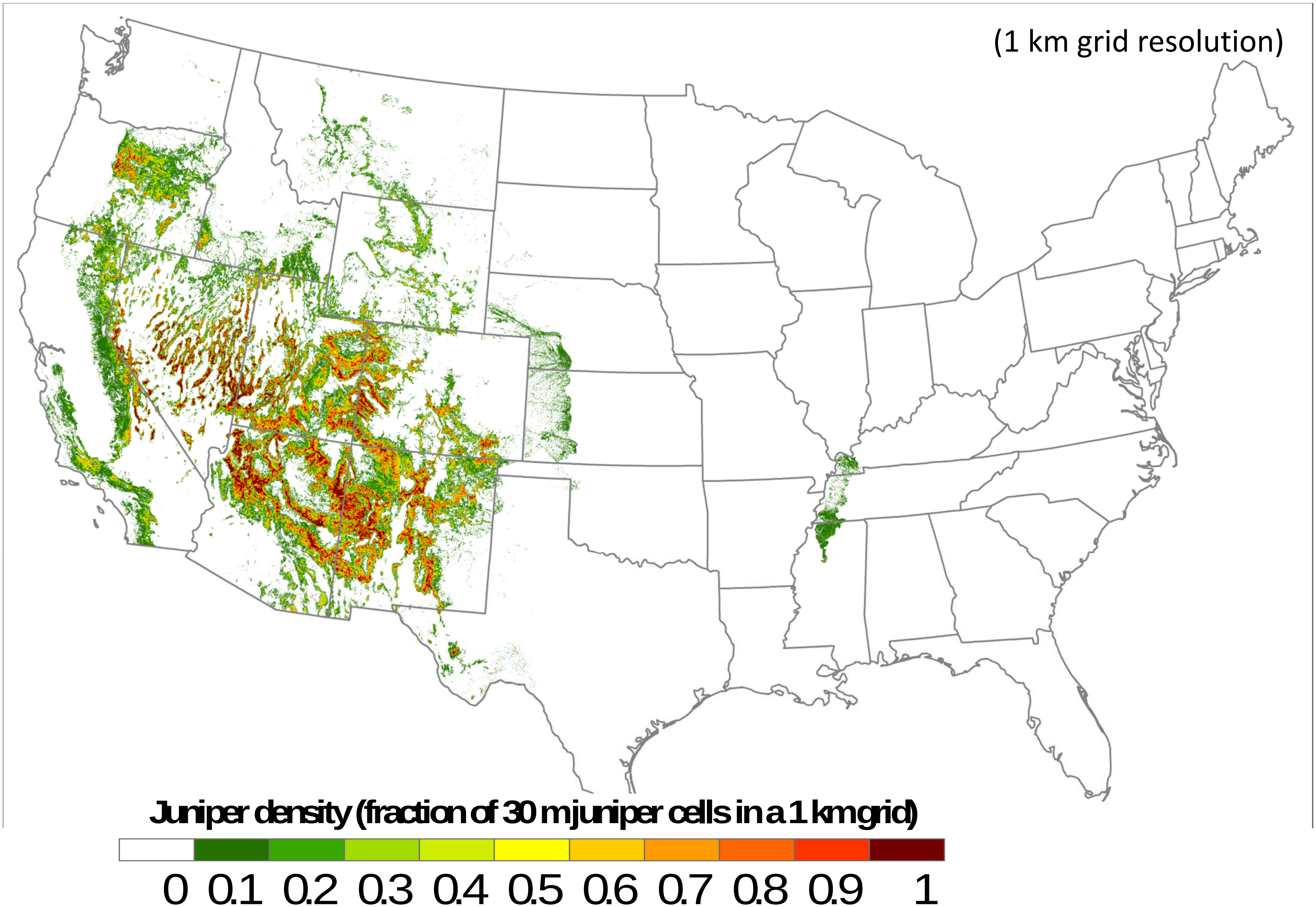
- *Growing Degree Days* - the average of the daily maximum and minimum temperatures compared to a base temperature, T_{base}, (usually 10 °C)
- Response to length of day
- Species differences
- Climate – Variability in Precipatation
- Weather

Juniper species

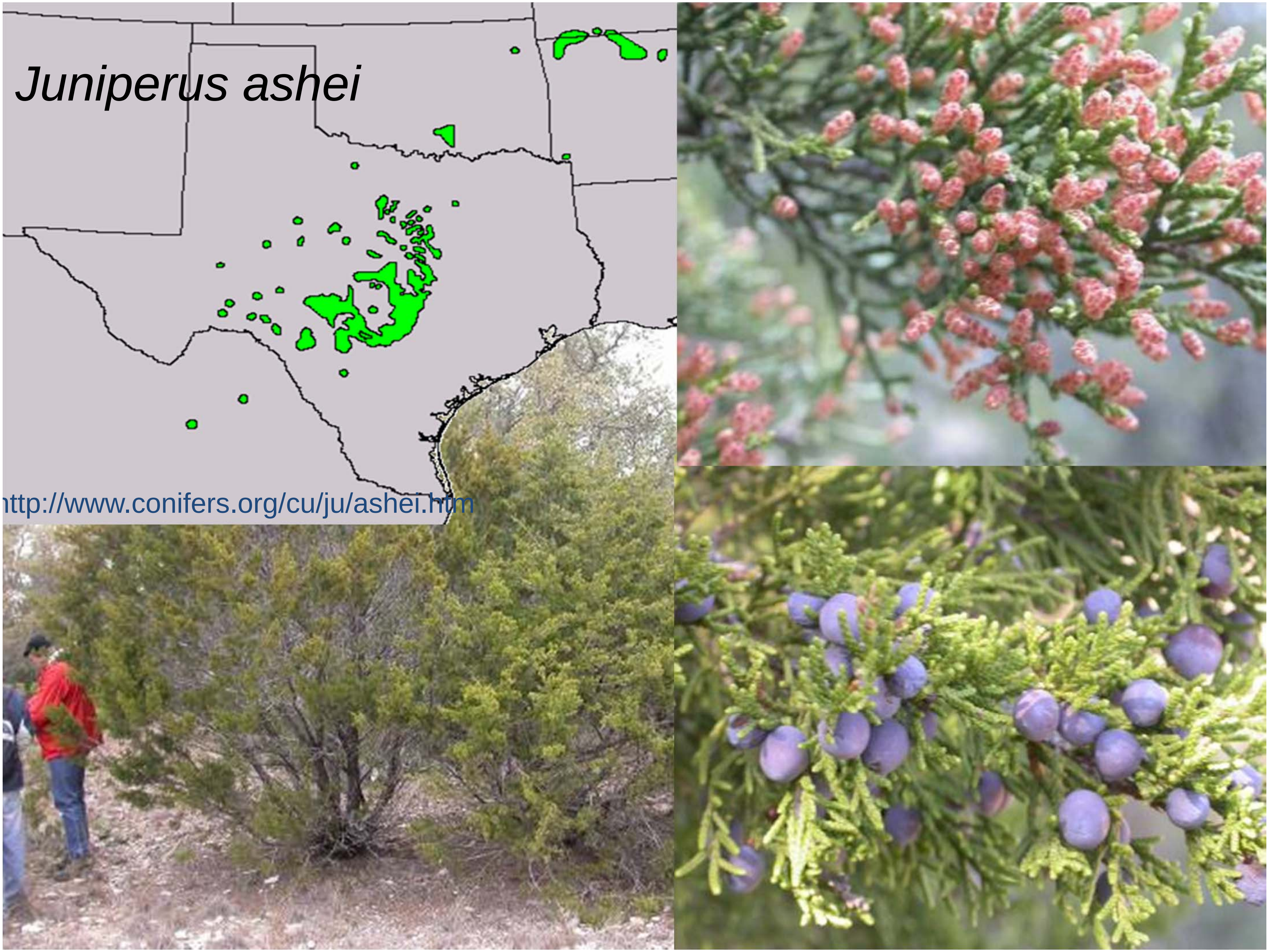
Juniperus ashei (TX, OK)
Juniperus monosperma (NM)
Juniperus scopulorum (NM)
Juniperus pinchotii (TX, OK)



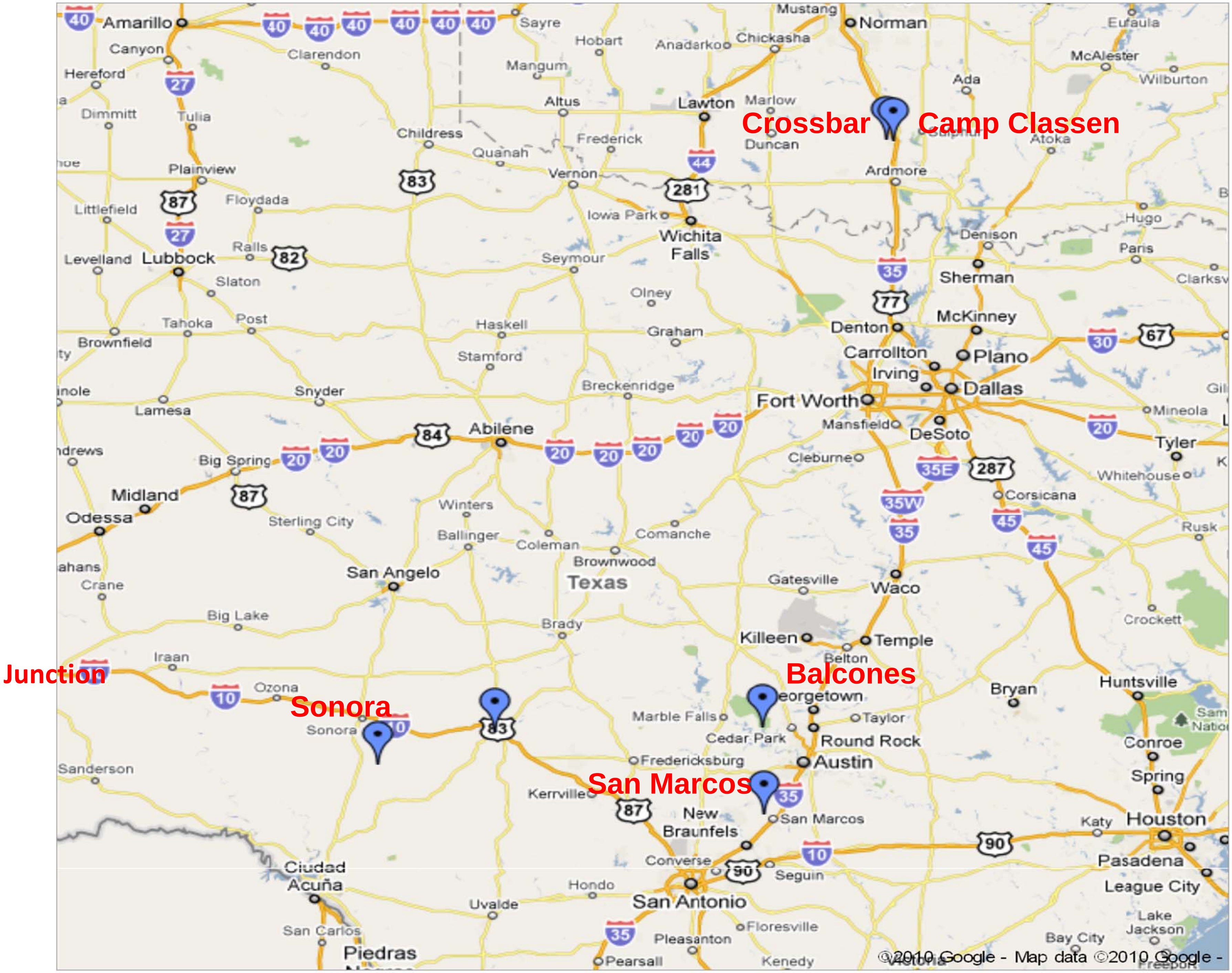
Juniper density* distribution over USA



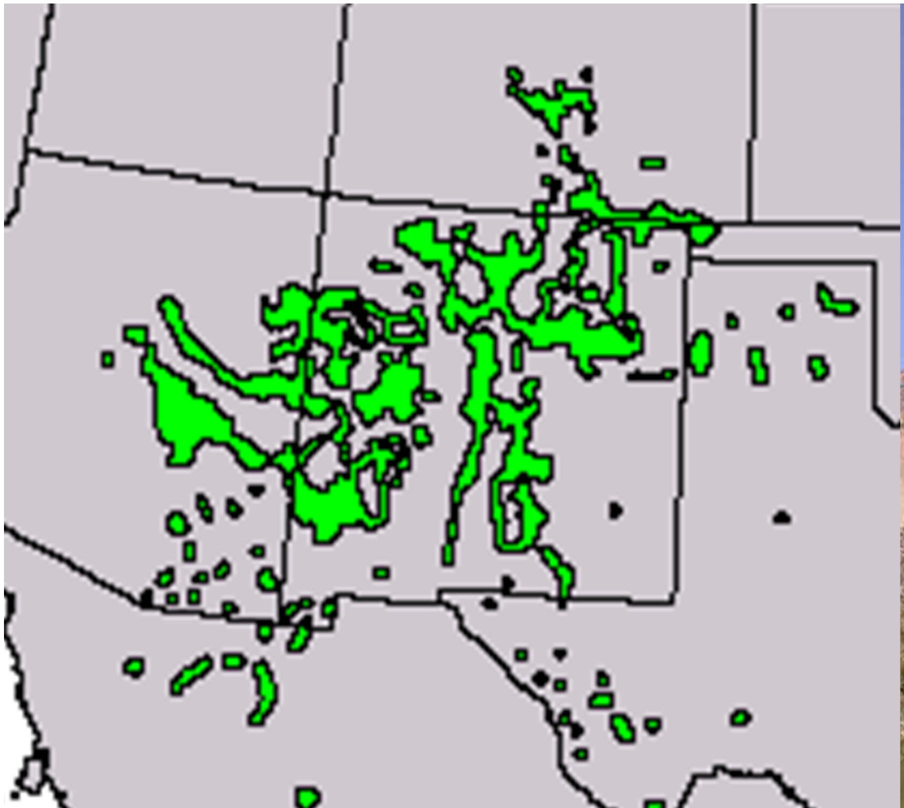
Juniperus ashei



http://www.conifers.org/cu/ju/ashei.htm

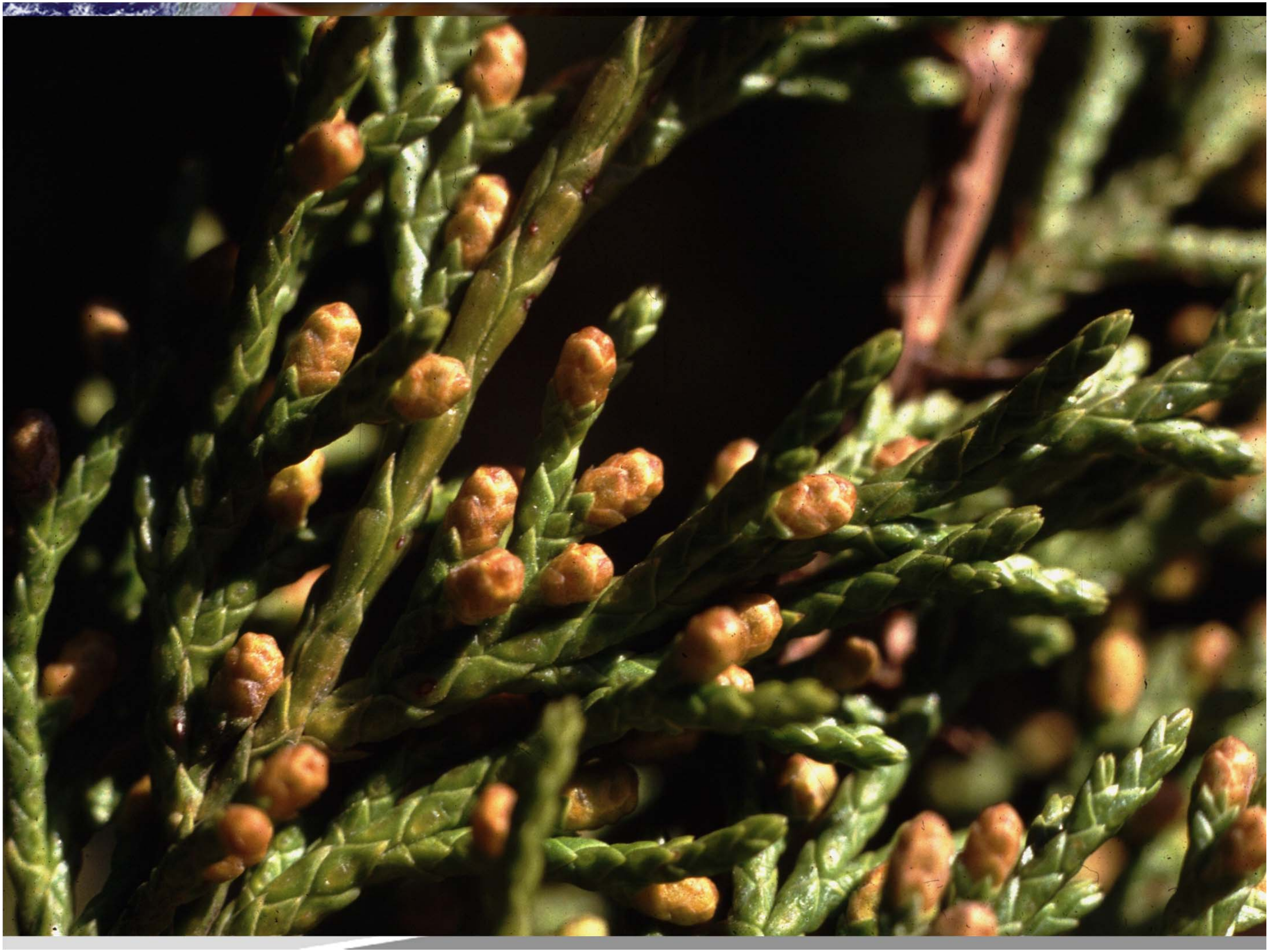

Crossbar
Camp Classen
Junction
Sonora
Balcones
San Marcos
Amarillo
Canyon
Hereford
Dimmitt
Tulia
Plainview
Littlefield
Floydada
Levelland
Lubbock
Ralls
Slaton
Tahoka
Post
Brownfield
Lamesa
Snyder
Big Spring
Midland
Odessa
Crane
Big Lake
Iraan
Ozona
Sanderson
Clarendon
Childress
Quanah
Vernon
Sayre
Hobart
Mangum
Altus
Frederick
Lawton
Anadarko
Chickasha
Mustang
Norman
Marlow
Duncan
Ardmore
Ada
McAlester
Eufaula
Wilburton
Atoka
Hugo
Paris
Denison
Sherman
McKinney
Denton
Carrollton
Plano
Irving
Dallas
Fort Worth
Mansfield
DeSoto
Cleburne
Corsicana
Waco
Temple
Killeen
Belton
Gatesville
Georgetown
Taylor
Round Rock
Cedar Park
Austin
Marble Falls
Fredericksburg
Kerrville
New Braunfels
San Marcos
Seguin
Converse
San Antonio
Hondo
Uvalde
Pleasanton
Floresville
Pearsall
Kenedy
Ciudad Acuña
San Carlos
Piedras
Iowa Park
Wichita Falls
Seymour
Olney
Graham
Haskell
Stamford
Breckenridge
Abilene
Winters
Ballinger
Coleman
Brownwood
Comanche
Sterling City
San Angelo
Texas
Brady
Bryan
Huntsville
Conroe
Spring
Katy
Houston
Pasadena
League City
Bay City
Lake Jackson
Crockett
Rusk
Tyler
Whitehouse
Mineola
©2010 Google - Map data ©2010 Google -

Juniperus monosperma



http://www.conifers.org/cu/Juniperus_monosperma.php

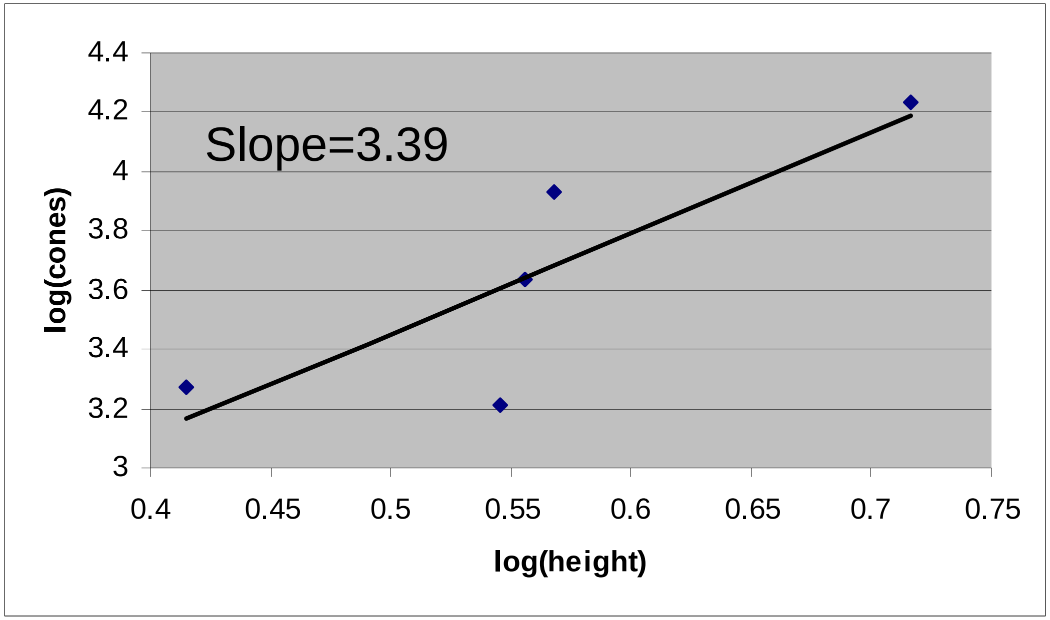

Los Alamos
Jemez Springs
Santa Fe
Tijeras
Santa Fe National Forest
Albuquerque
Rio Rancho
Bernalillo
Corrales
South Valley
Edgewood
Meadow Lake
Estancia
El Cerro-Monterey Park
Belen
Rio Communities
Mountainair
Vaughn
Las Vegas
Pecos
Española
Chimayo
La Puebla
Pojoaque
White Rock
Ohkay Owingeh
Jemez Pueblo
Santo Domingo Pueblo
Cuba
La Jara
Pueblo Pintado
De Taos
Cibola National Forest
Corona
550
285
85
84
25
40
60



Pollen production

- Size of tree, cones per unit area, %veg.
- Cones per tree
- Pollen per cone
  - Preliminary pollen count for *J. ashei* = 381,000 pollen grains/cone

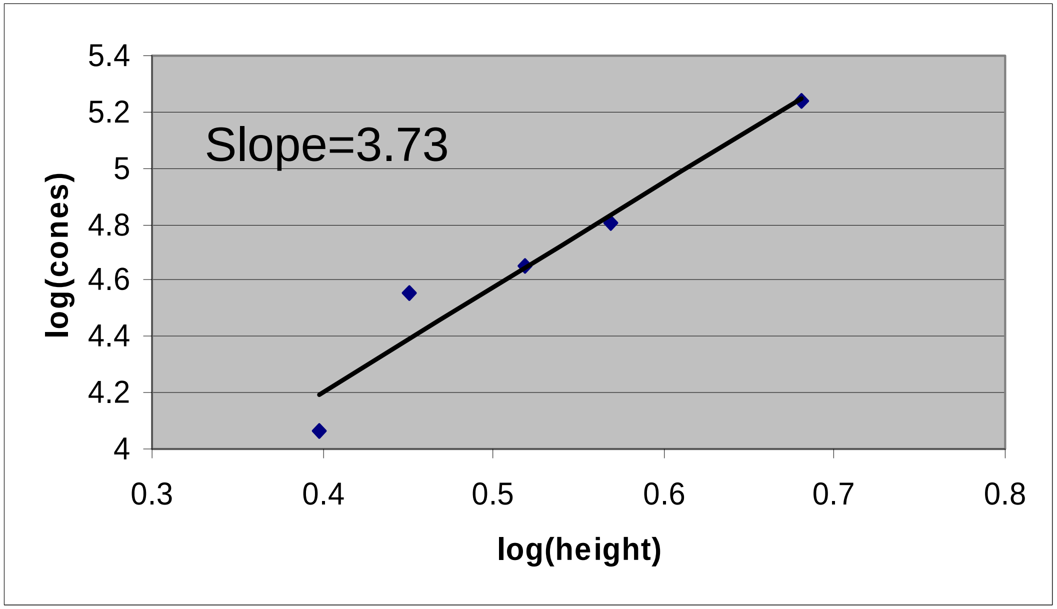
LCP Representative Trees



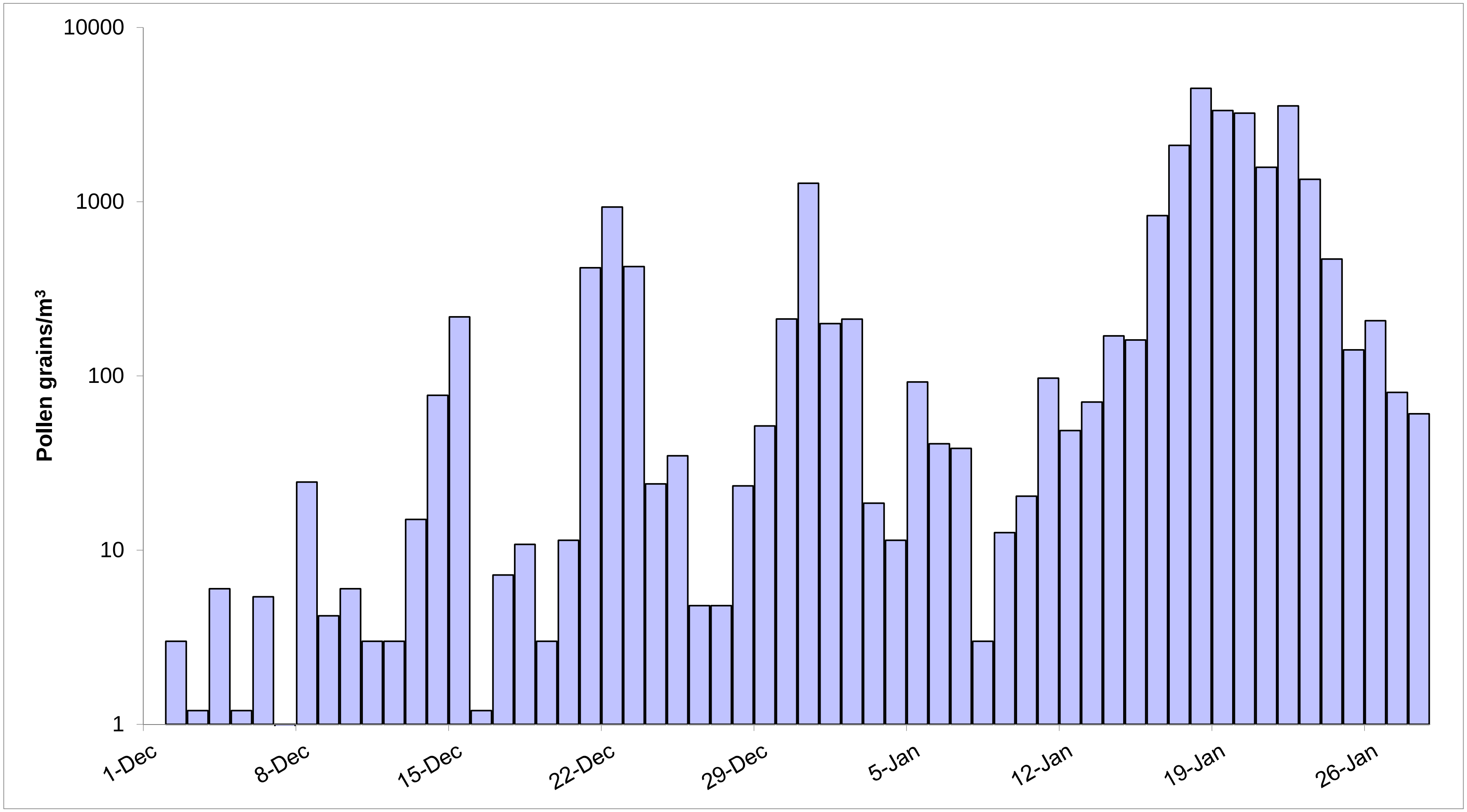
Y intercept = 1.76
10^b = 57.5 = k
n=kh^b
n = 57.5(3^3.39)
n*8 = **19,060 cones**
n = 57.5(4^3.39)
n*8 = **50,550 cones**

HCP Representative Trees

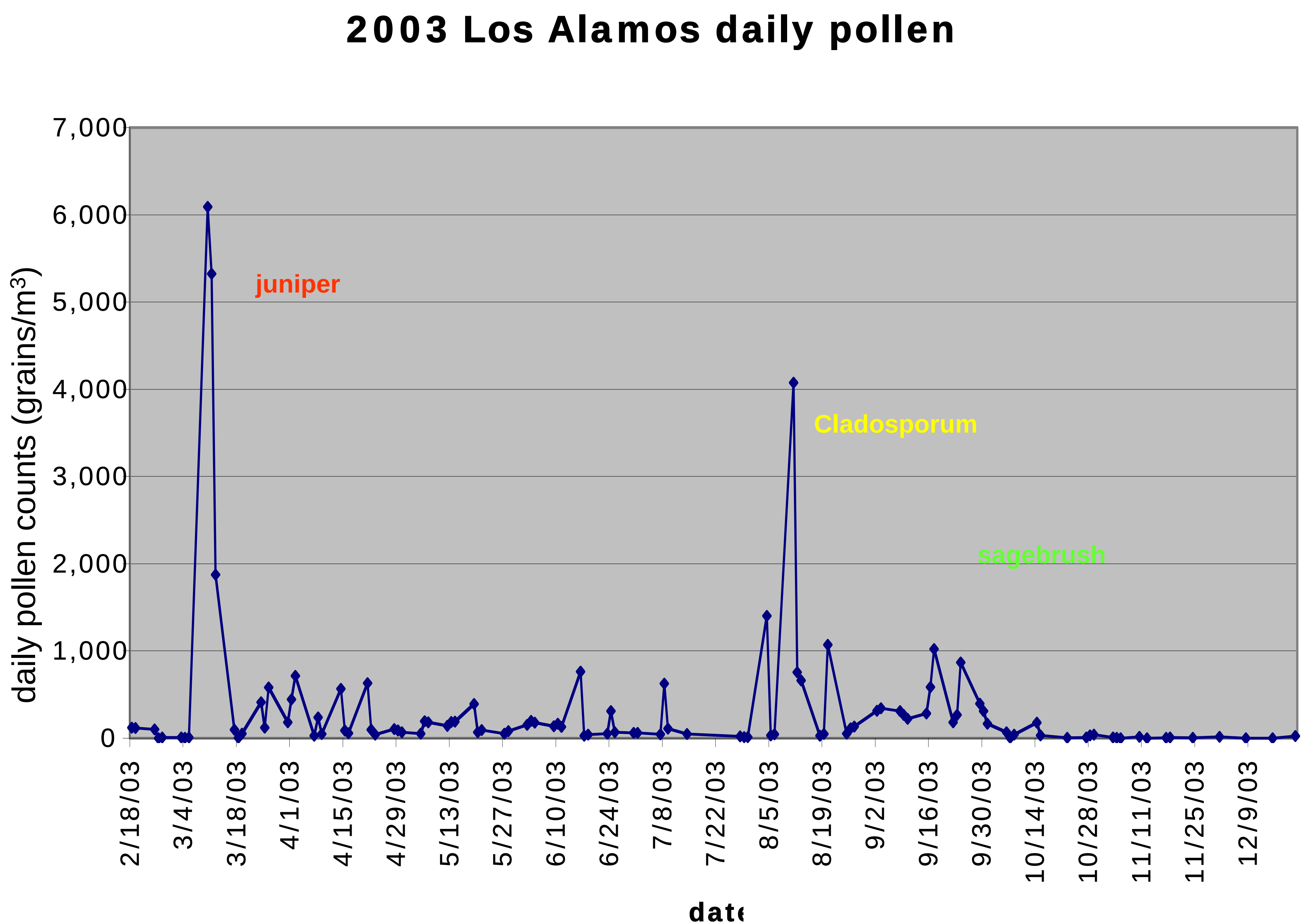
Y intercept=2.71
10^b = 513.2 = k
n=kh^b
n = 513.2(3^3.73)
n*8 = **247,200 cones**
n = 513.2(4^3.73)
n*8 = **722,870 cones**



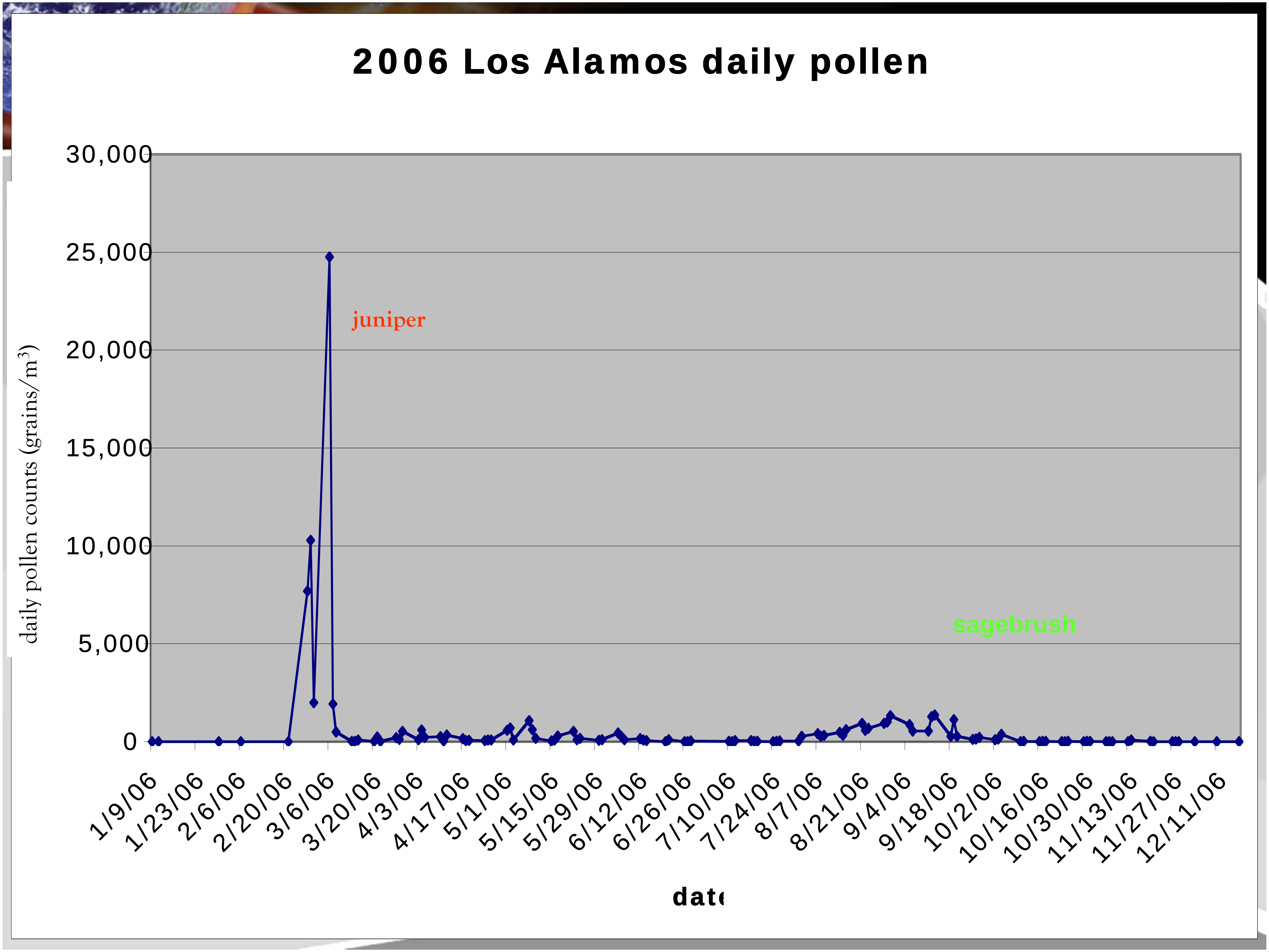
Mean Daily Concentration* of Airborne *Juniperus ashei* Pollen at Sonora, TX



*Concentration for each day is the mean of 12 bihourly concentrations



2003 Los Alamos daily pollen
daily pollen counts (grains/m3)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
juniper
Cladosporum
sagebrush
2/18/03
3/4/03
3/18/03
4/1/03
4/15/03
4/29/03
5/13/03
5/27/03
6/10/03
6/24/03
7/8/03
7/22/03
8/5/03
8/19/03
9/2/03
9/16/03
9/30/03
10/14/03
10/28/03
11/11/03
11/25/03
12/9/03
date


2006 Los Alamos daily pollen
daily pollen counts (grains/m3)
30,000
25,000
20,000
15,000
10,000
5,000
0
juniper
sagebrush
1/9/06
1/23/06
2/6/06
2/20/06
3/6/06
3/20/06
4/3/06
4/17/06
5/1/06
5/15/06
5/29/06
6/12/06
6/26/06
7/10/06
7/24/06
8/7/06
8/21/06
9/4/06
9/18/06
10/2/06
10/16/06
10/30/06
11/13/06
11/27/06
12/11/06
date

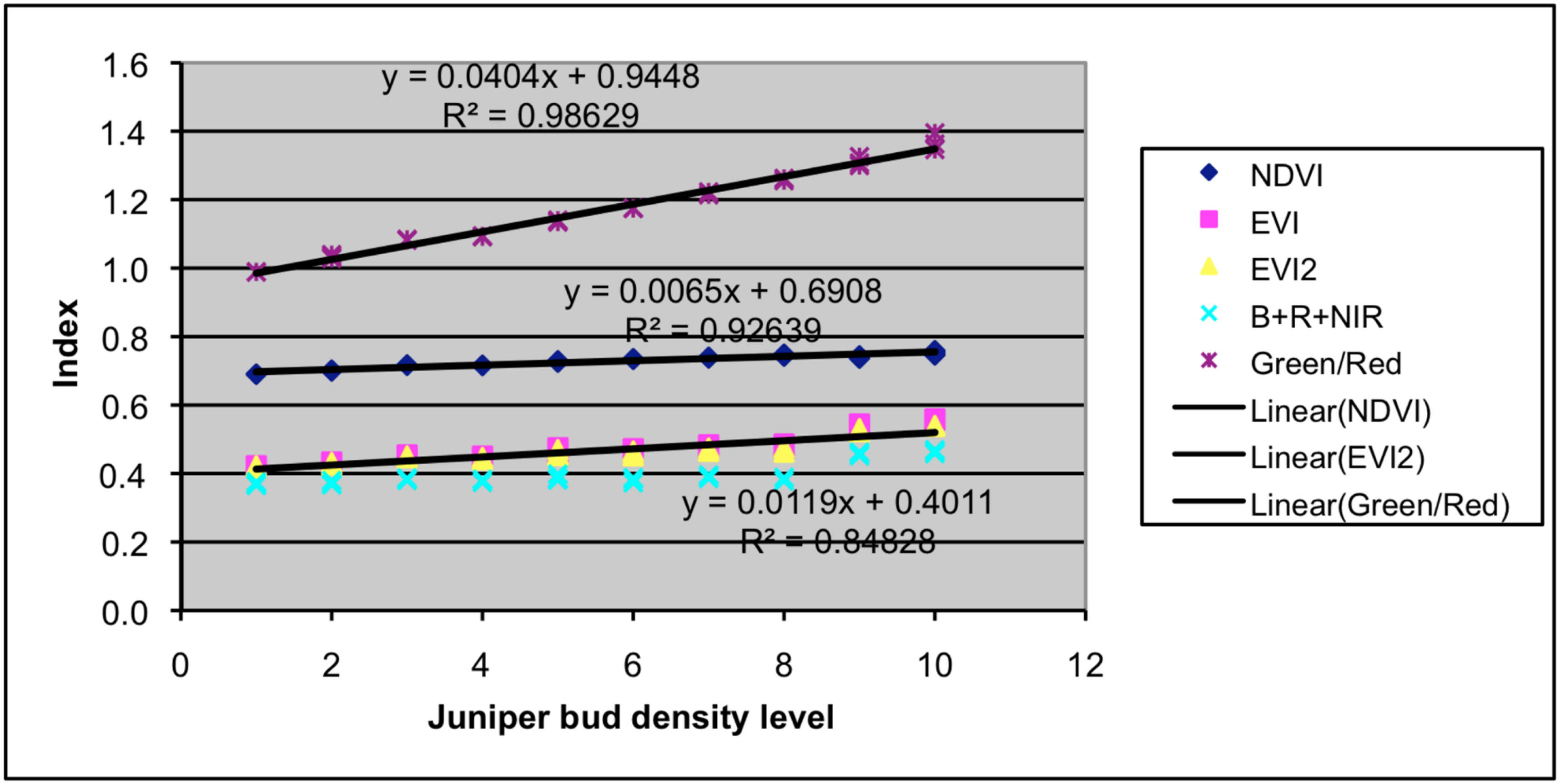

04/13/2009 14:11


04/13/2009 15:05

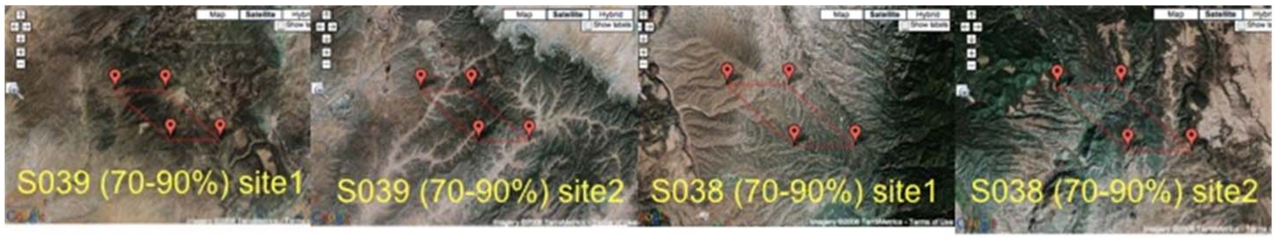
Spectral characteristics of male juniper canopies at different bud density levels

Density level	Bud density (g/m^2)
1	204.2
2	190.0
3	176.9
4	164.9
5	151.1
6	136.2
7	115.8
8	92.9
9	45.9
10	0.0

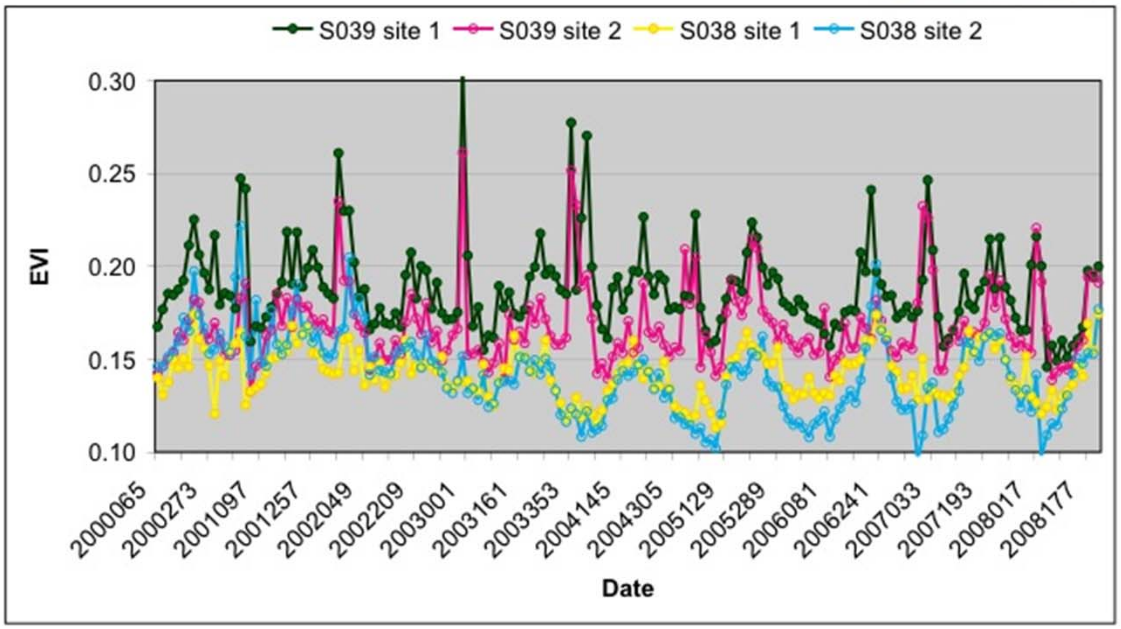
Relationships between spectral indices and juniper bud density levels



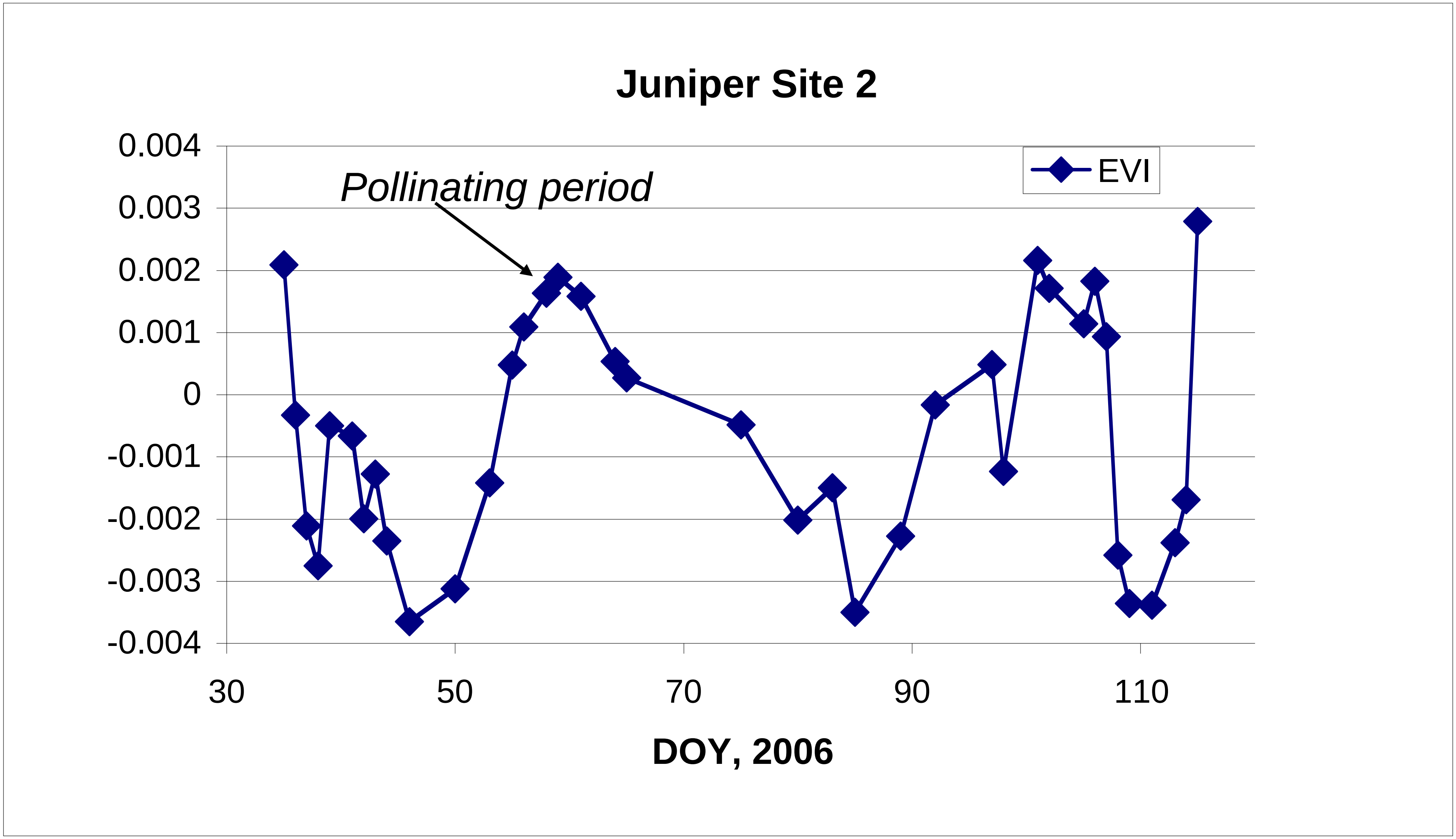
MODIS Juniper Time Series



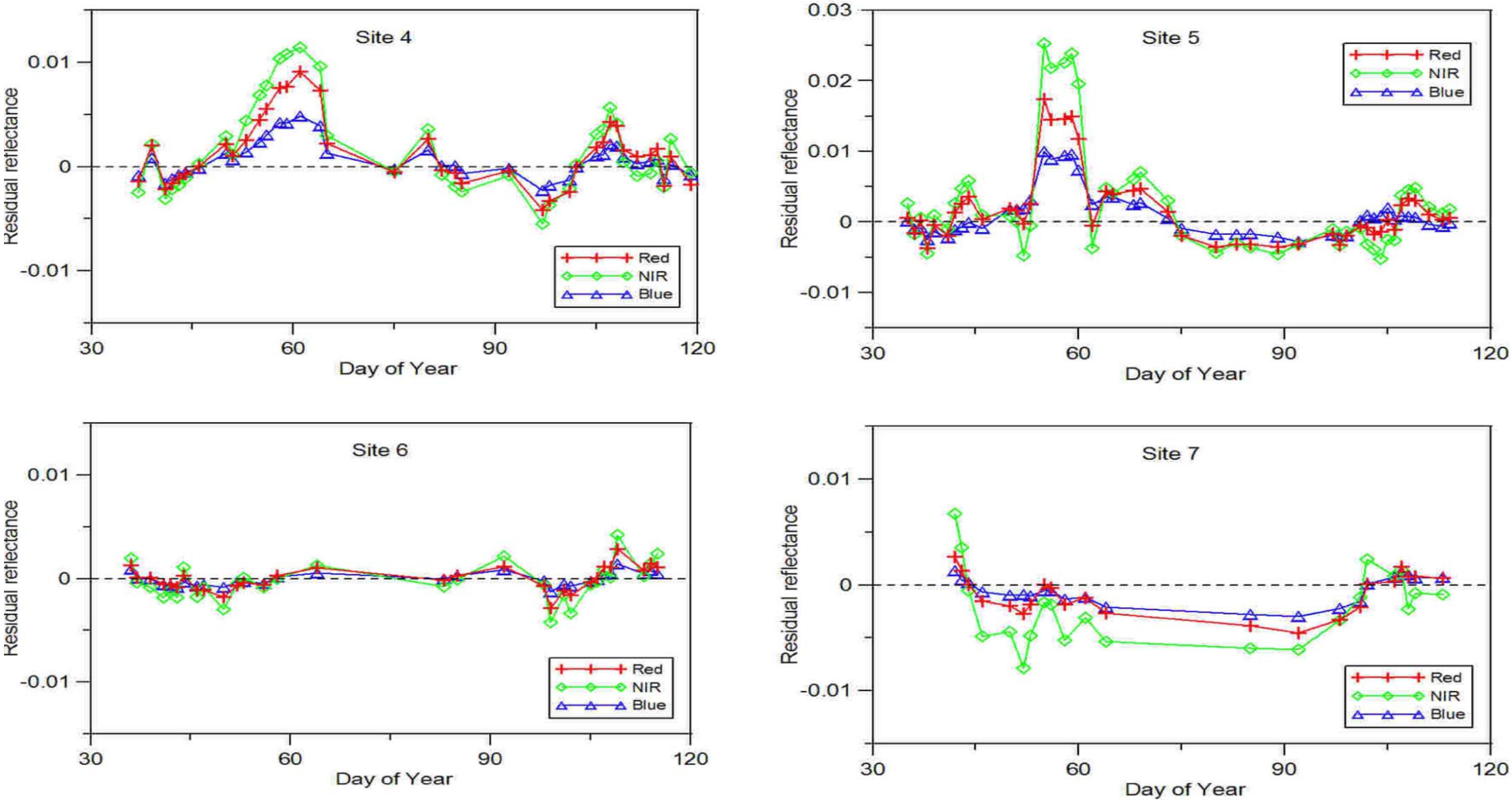
Enhanced Vegetation Index



70-90% density

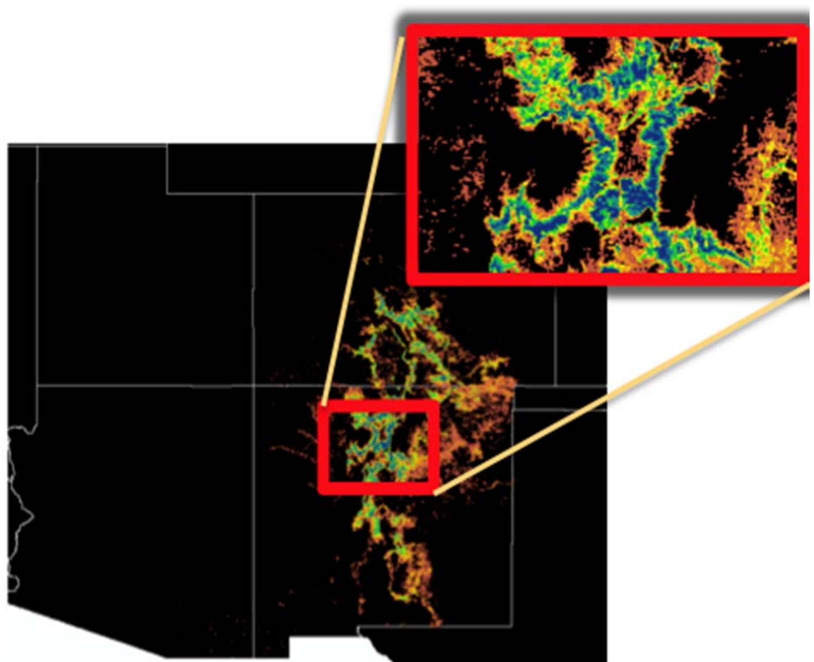


Juniper Site 2
0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
Pollinating period
EVI
30
50
70
90
110
DOY, 2006



Temporal profiles of residual MODIS reflectances at the four study sites.

S038-SOUTHERN ROCKY MOUNTAIN PINYON-JUNIPER
During pollen eruption (Top) and seen from space (Bottom)



Many challenges

- Residual signals and reference baselines
- Landscape vs species level phenology & signals (disaggregate woody from herbaceous)
- Surface heterogeneity and spatial characterization of landscape
- Future sensors & fusion (Lidar, VIIRS, HyspIRI)
- BRDF & surface aerodynamics
- Modeling (vegetation dynamics, phenology)

Airborne Dust Simulations and Forecasts

University of Arizona

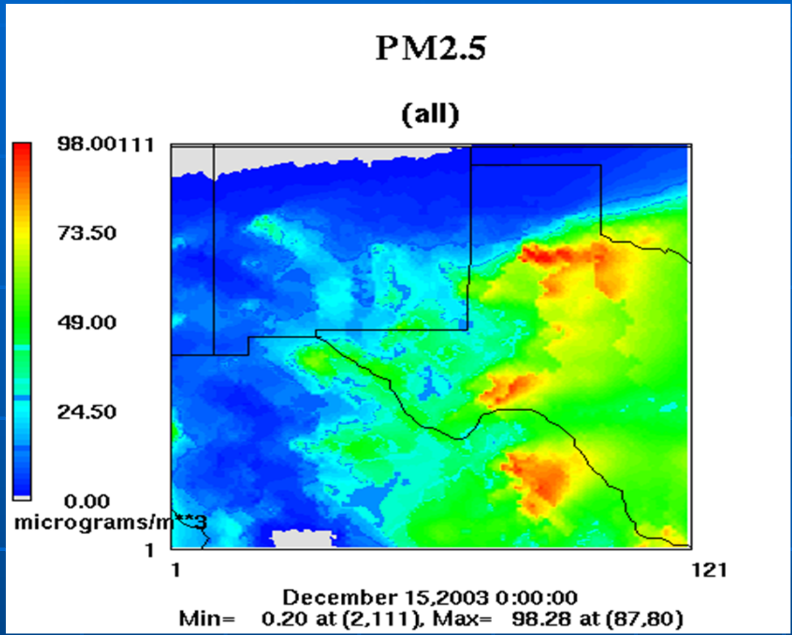
With NASA Earth System Science & University of New Mexico

Department of Atmospheric Sciences

Phoenix dust storm – 7 June 2006
Photo by Robb Schumacher Arizona Republic

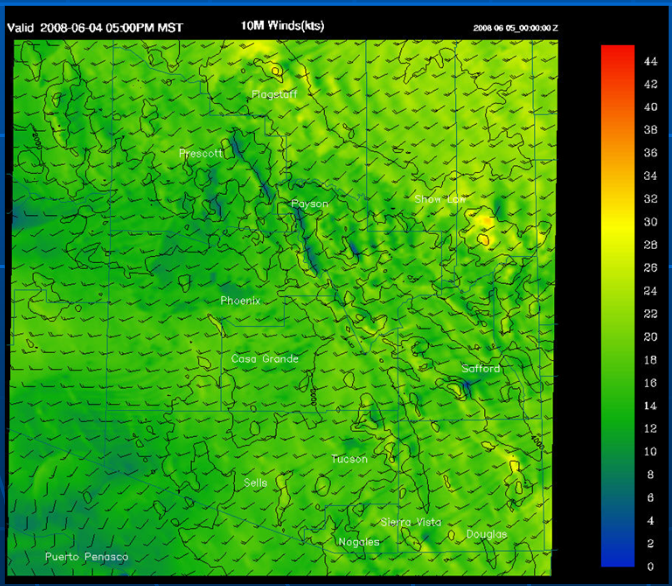
http://www.atmo.arizona.edu/faculty/research/dust/dust.html

Weather - DREAM



Dust REgional Atmospheric Modeling (DREAM) system

- MM5
- WRF



UA WRF 10-m wind forecast

S. Nickovic et al., A model for prediction of desert dust cycle in the atmosphere, *JGR* **106**, 18113–18129 (2001) .

Yin et al., Modeling wind-blown desert dust in the southwestern United States for public health warning: A case study, *Atmos. Environ*. **39**, 6243-6254 (2005).

Yin et al.,The impact of using different land cover data on wind-blown desert dust modeling results in the southwestern United States *Atmos. Environ*., **41**, 2214-2224 (2007).

Adapted from Betterton ppt

VERSATILE DREAM

Applications Have Included:

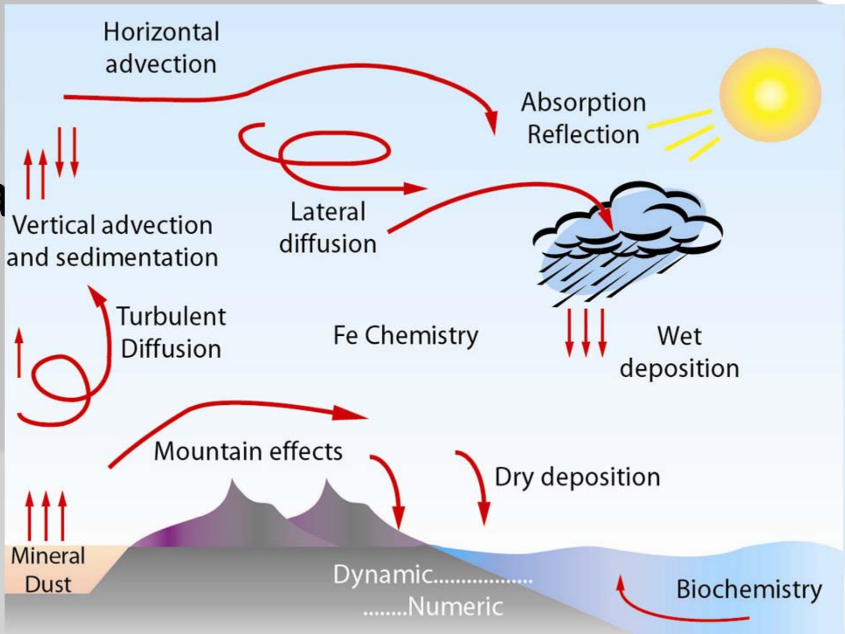
- Dust Storms & Airborne Mineral Dust Concentrations in the Middle East, Africa and the Southwest US
- Pollen in Colorado, New Mexico & Texas
- Volcanic Ash in the Mediterranean
- Soybean Rust in South America

A new test: Forest fire ash and smoke plumes

A proposed test: mold spores

DREAM 4-8 particle bins

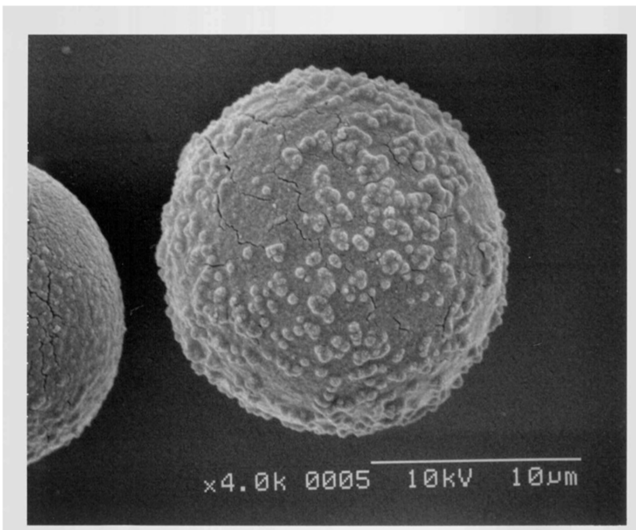
- **Model predictions (72-h):**
- Horizontal distribution
  - Surface concentration
  - Total column mass (dust loa
  - Wet, dry, total deposition
  - Meteorological variables
- Vertical distribution
  - Concentration
  - Cross sections
  - Fixed point/time profiles
- Fixed point (selected sites/cities)



Pollen Strategy

- Select Pollen of Interest
- Map Pollen Source
- Estimate Emission on Test Date
- Prepare Model
  - Insert Terrain & Pollen Aerodynamic Characteristics
  - Insert Source Emission
  - Insert Meteorology
- Simulate Downwind Pollen Dispersal
- Evaluate

Juniper Pollen



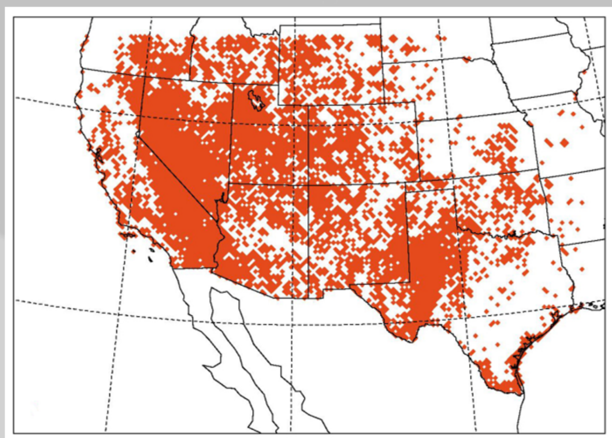
Juniperus virginiana

<u>Good News for Modeling</u>

- Pollination Dec-March, little confusion with other pollinating plants
- *Juniperus* pollens are (mostly) spherical, 18-30 υm size

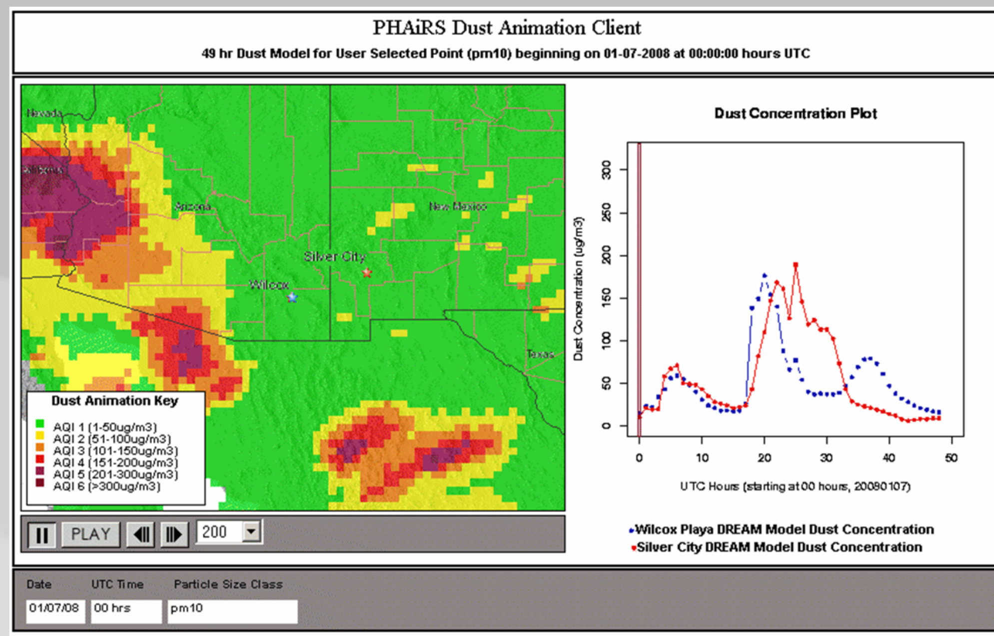
Phenology and Pollen Transport

NASA MODIS data



Pollen sources derived from **phenological** maps

DREAM – UofA numerical meteorological particulate transport model



Final Product – predicted concentrations of pollen in time and space

http://www.atmo.arizona.edu/research/dust/dust.html

Pre-PREAM Test

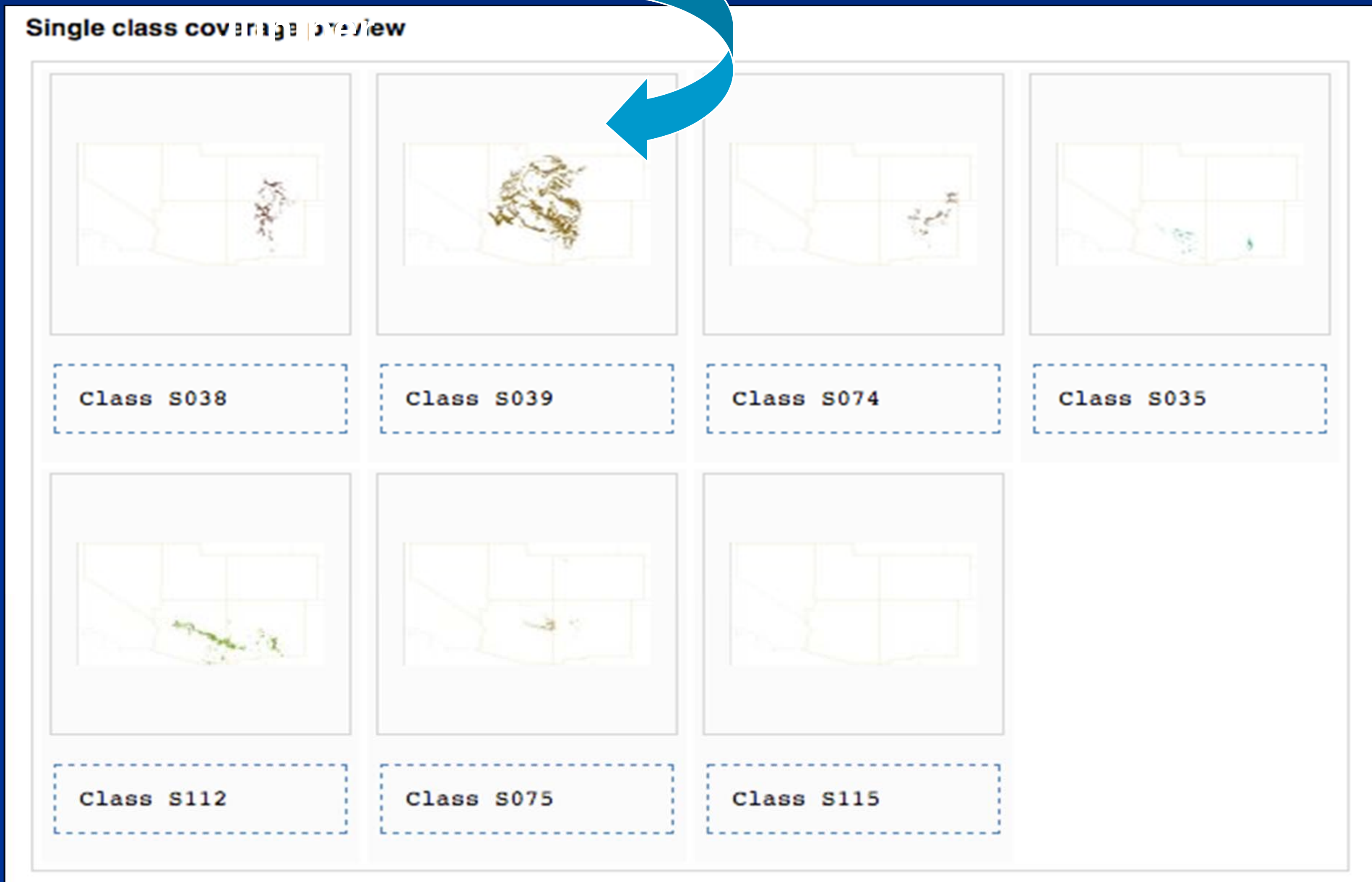
- Single-particle (size) Pre-PREAM
- Simultaneous transport from 4 sources
- Result: sum of transported particles coming from the 4 sources

Preparing Source for Model

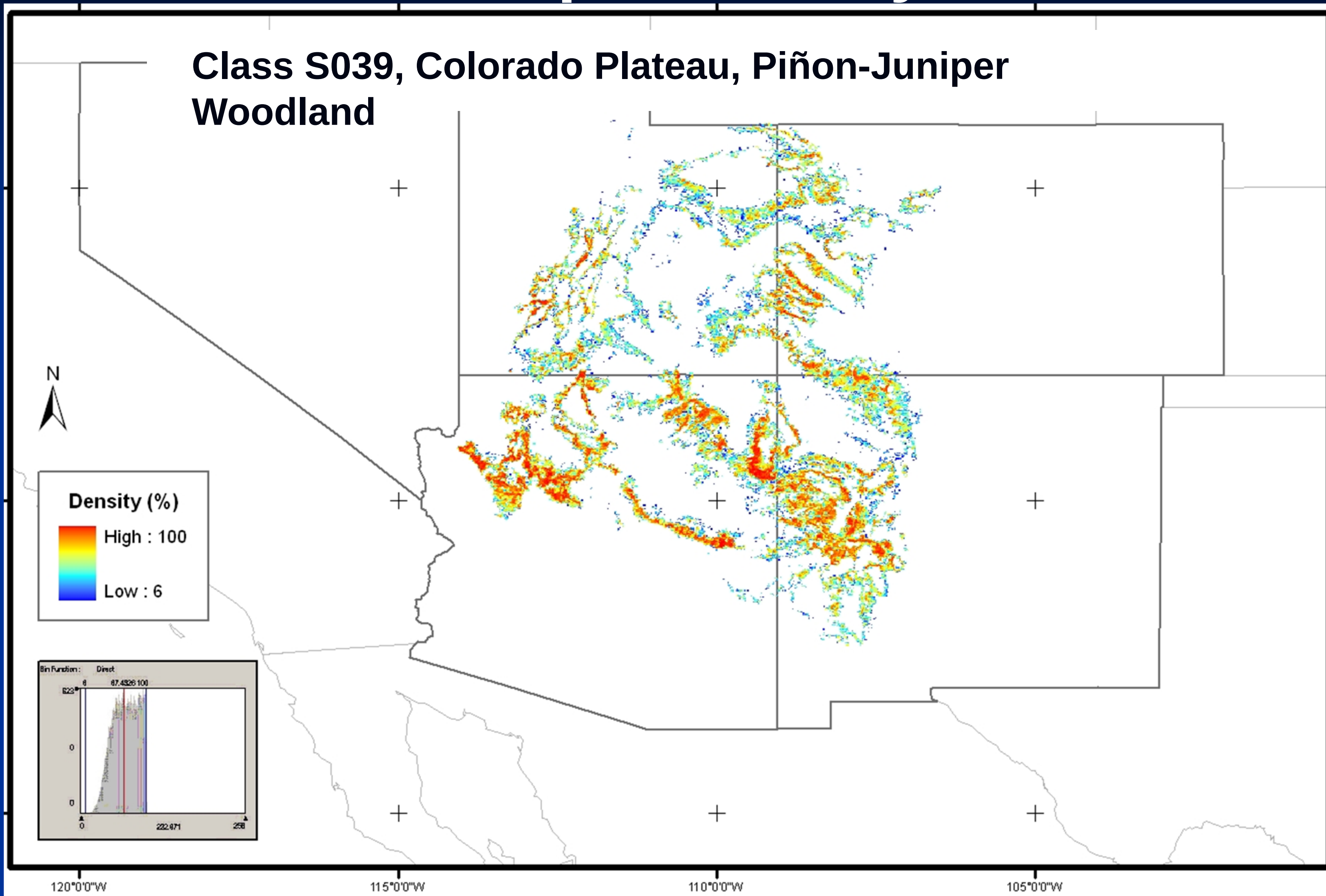
- Model requires juniper density (pixel fraction): percent juniper pixels (30m resolution) present in 2-km cell
  - Each 2km cell has 66 x 66 (4,356) pixels
  - Count juniper pixels
  - (#Juniper Pixels)/4,356 = juniper pixel fraction = juniper density

Juniper Type Filter

CO Piñon-



Juniper Density



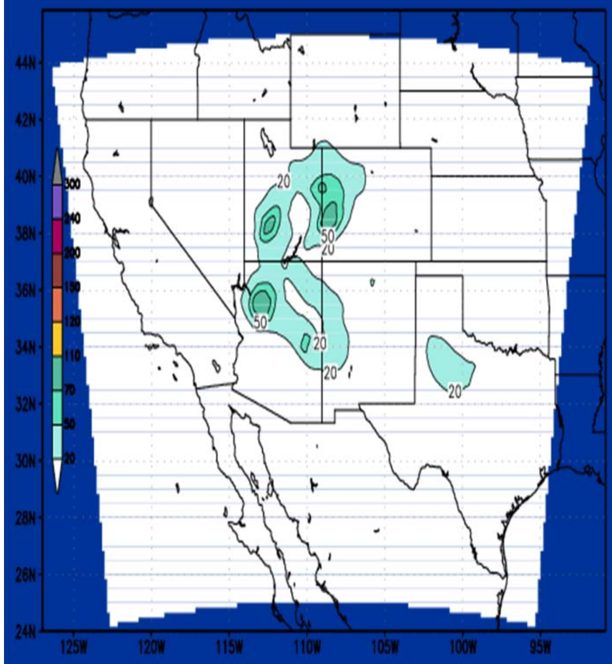
Juniper Density value was estimated from the aggregation of 30-m pixels into 2-km pixels. This value indicates what percentage of the original 30-m pixels corresponds to the new 2-km pixel labeling class.

0 125 250 375 500
Kilometers

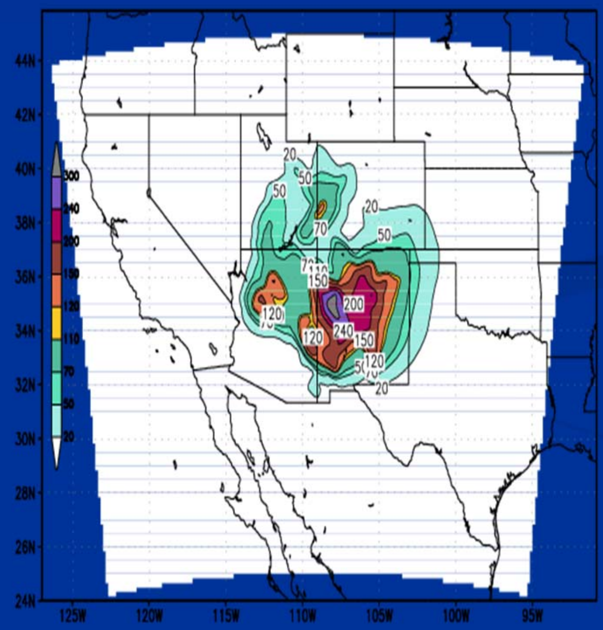
TBRS Lab
The University of Arizona

Juniper Pollen
Near-surface concentration (Nm3)

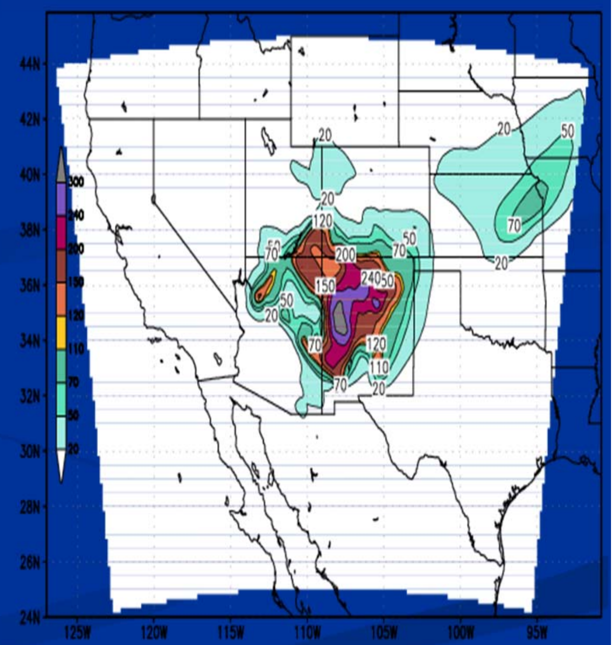
PREAM



6 March 2006

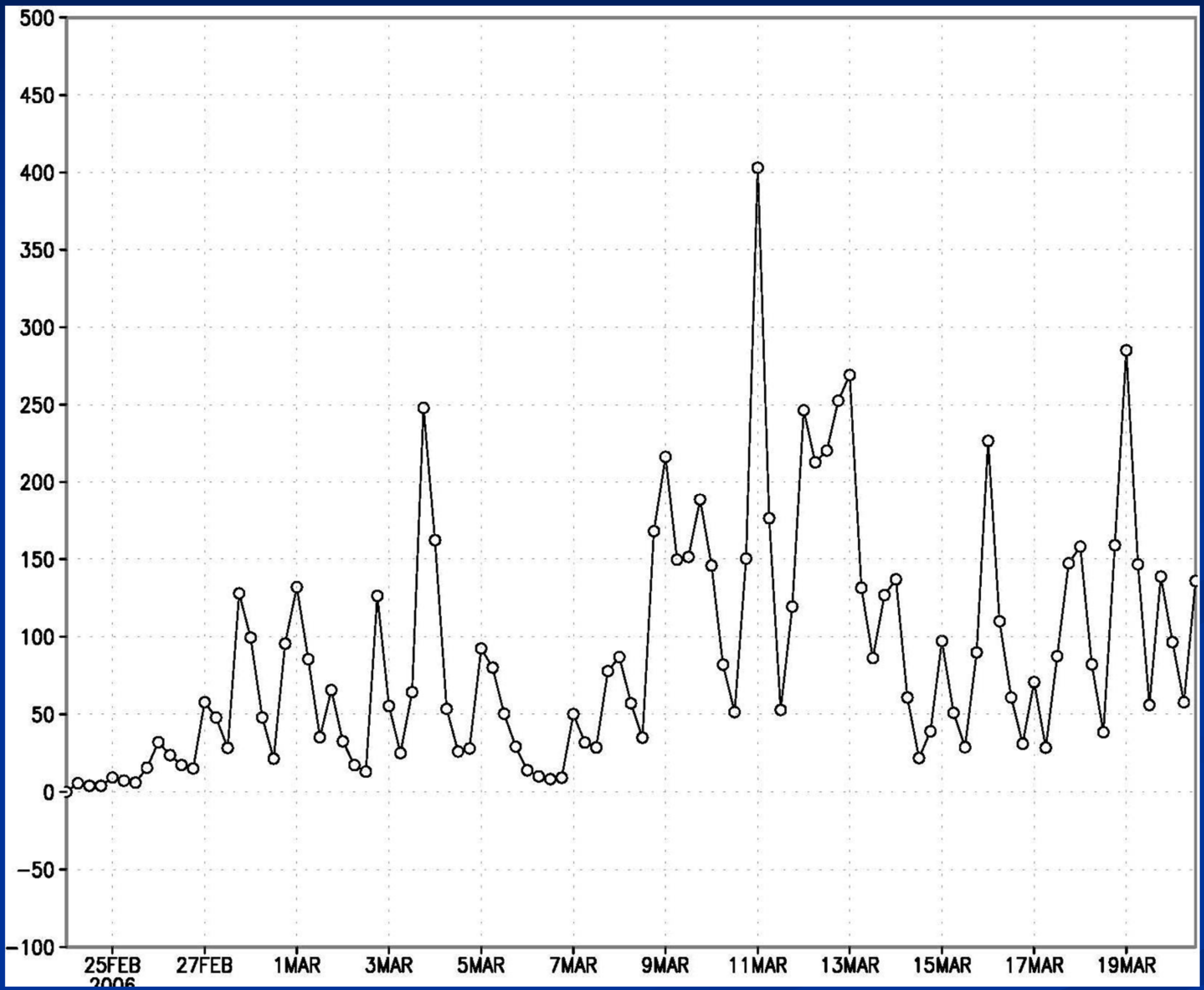


9 March 2006



11 March 2006

Los Alamos:
Pollen concentration: 24 Feb – 19 March 2006

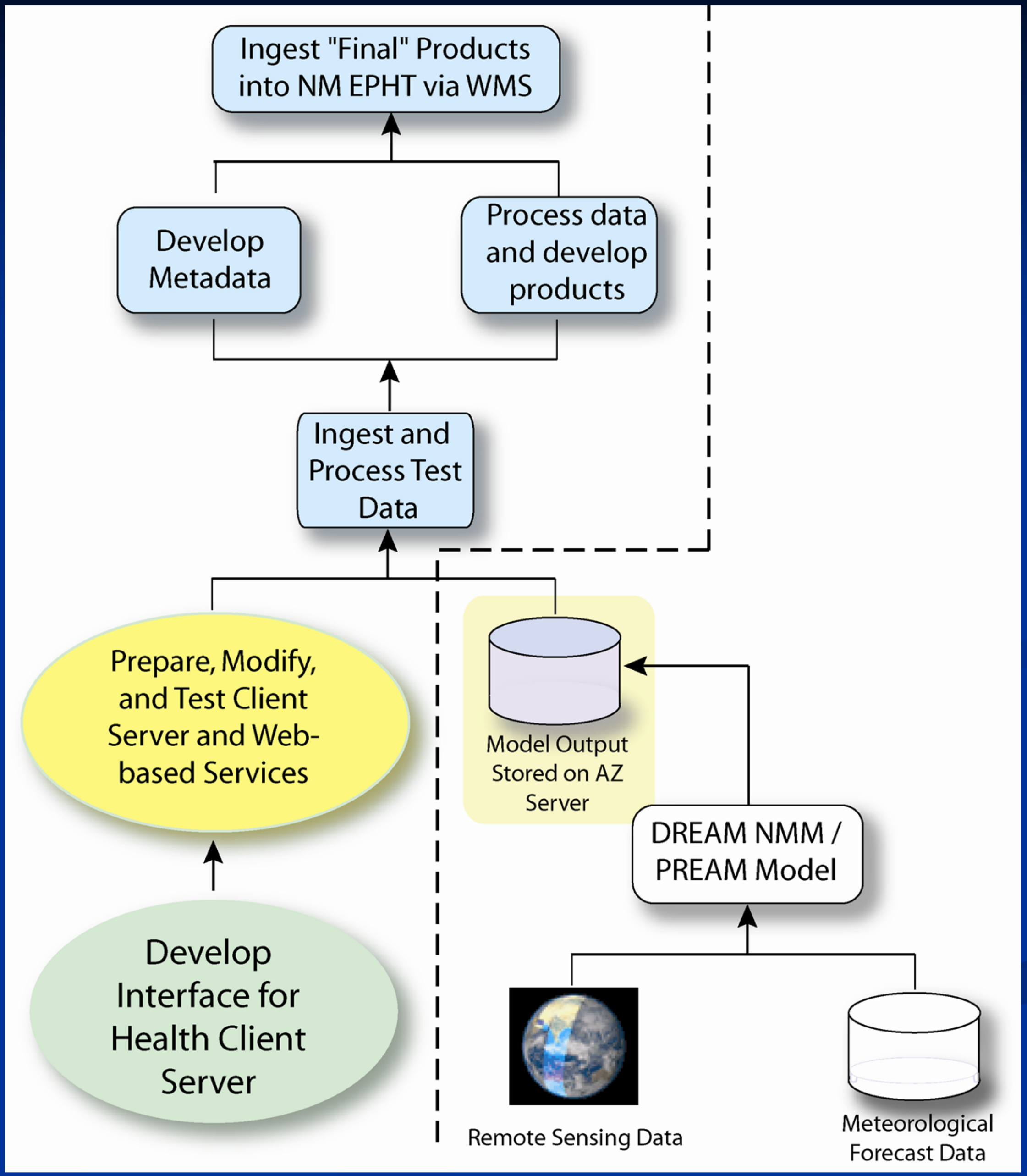


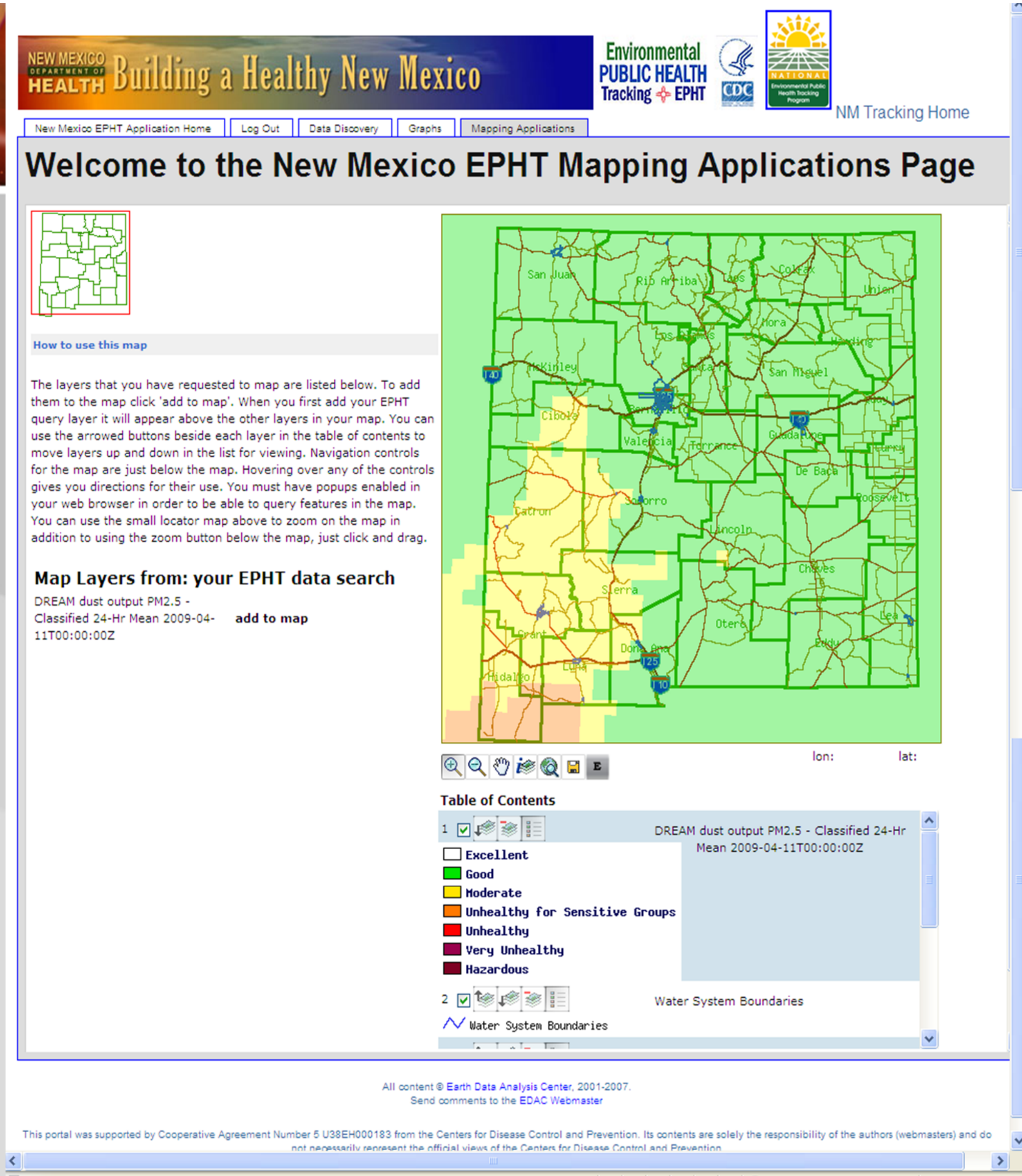
 # grains/m^3

Model integration time

Status of Transitioning Pollen Data Into NM EPHT

- Progress in year 1 (green oval):
  - Prepare interface for health client server
  - Prepare server for pollen data output
- Test server functions: (yellow oval):
  - Dependent upon receiving sample data from modeling team
- Activities for out years: (blue boxes)





NEW MEXICO DEPARTMENT OF HEALTH Building a Healthy New Mexico

Environmental PUBLIC HEALTH Tracking EPHT

NM Tracking Home

New Mexico EPHT Application Home | Log Out | Data Discovery | Graphs | Mapping Applications

Welcome to the New Mexico EPHT Mapping Applications Page

How to use this map

The layers that you have requested to map are listed below. To add them to the map click 'add to map'. When you first add your EPHT query layer it will appear above the other layers in your map. You can use the arrowed buttons beside each layer in the table of contents to move layers up and down in the list for viewing. Navigation controls for the map are just below the map. Hovering over any of the controls gives you directions for their use. You must have popups enabled in your web browser in order to be able to query features in the map. You can use the small locator map above to zoom on the map in addition to using the zoom button below the map, just click and drag.

Map Layers from: your EPHT data search

DREAM dust output PM2.5 - Classified 24-Hr Mean 2009-04-11T00:00:00Z **add to map**

lon: lat:

Table of Contents

1 DREAM dust output PM2.5 - Classified 24-Hr Mean 2009-04-11T00:00:00Z

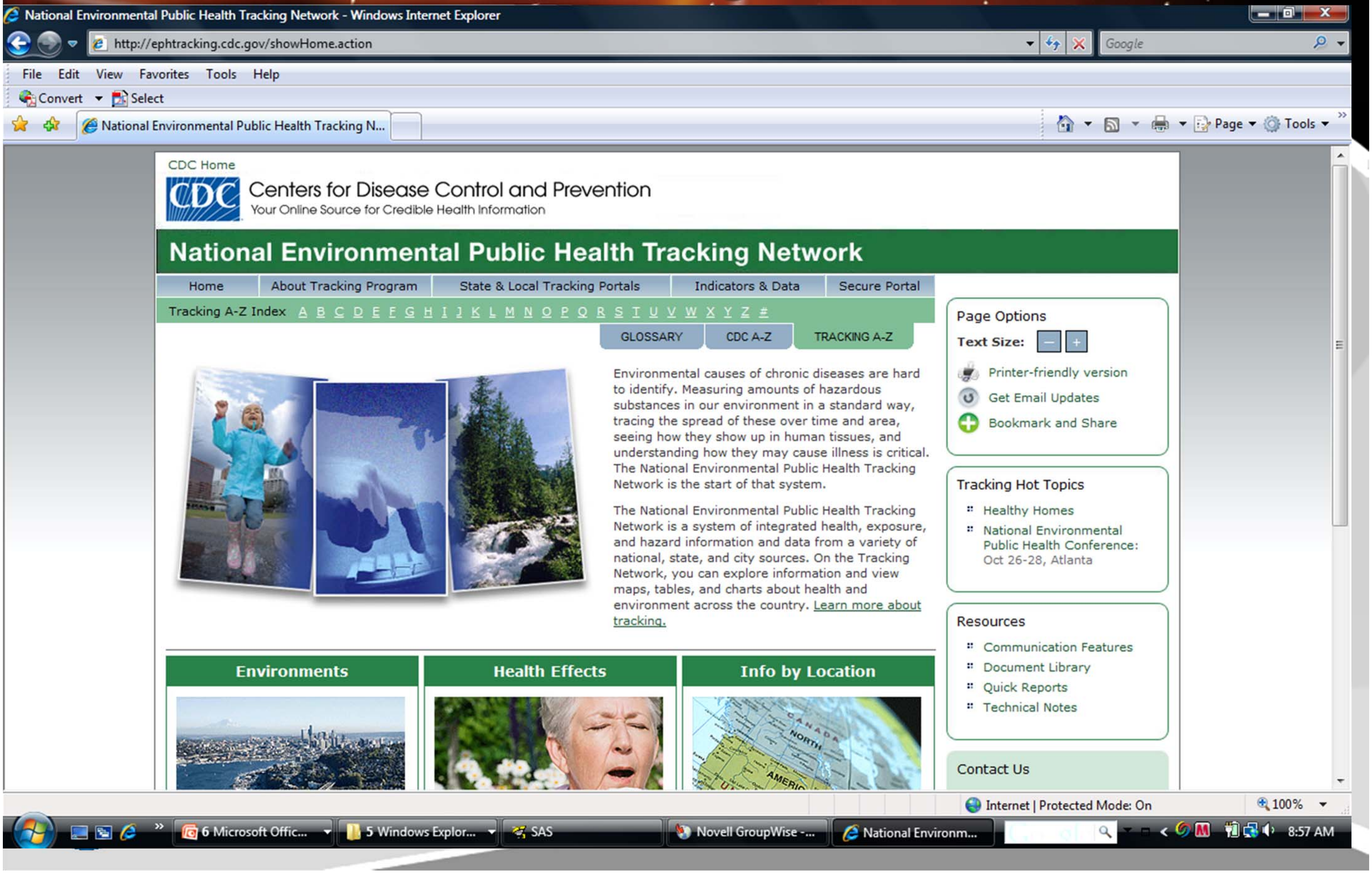
- Excellent
- Good
- Moderate
- Unhealthy for Sensitive Groups
- Unhealthy
- Very Unhealthy
- Hazardous

2 Water System Boundaries

Water System Boundaries

This portal was supported by Cooperative Agreement Number 5 U38EH000183 from the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors (webmasters) and do not necessarily represent the official views of the Centers for Disease Control and Prevention.

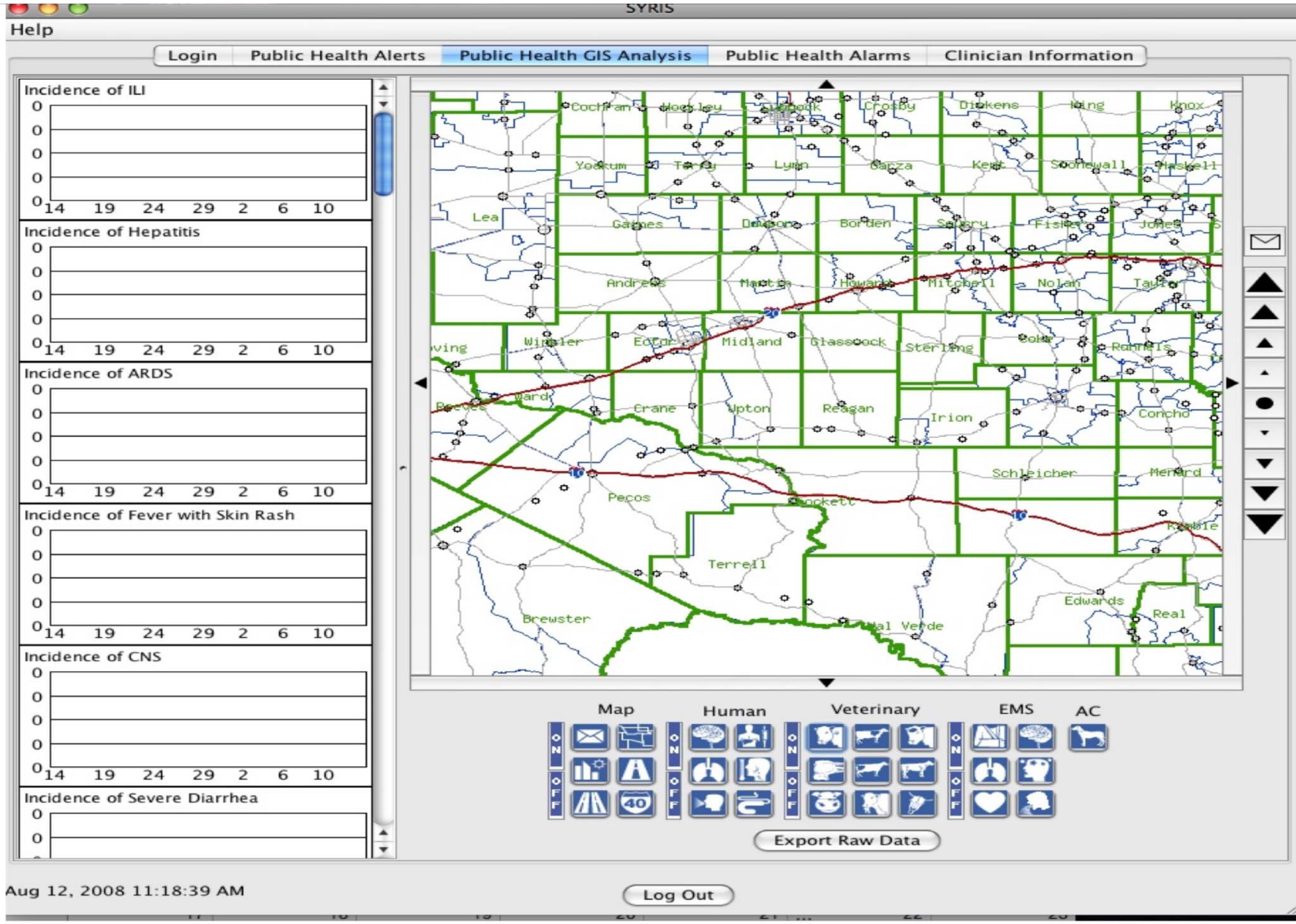
ephtracking.cdc.gov



Syndrome Reporting Information System™

The SYRIS system provides:

- Real-time, Syndrome-Based Reporting Tool
- 2-Way Real-time Communication System - 24/7
- Automated, Immediate 'Alerts' to Public Health Officials (PHO's)
- Health 'Alerts' to Vets, Doctors, Hospitals, & Schools
- Web-Based Tool for Easy Syndrome Entry and Communication
- Geographic Mapping of Disease Outbreaks
- Connects All Health Care Providers to a Common Database
- Instantaneous Geographic Mapping of Disease Outbreaks
- Full compliance with the requirements of Public Law 109-417 (the Pandemic and All-Hazards Preparedness Act)



'RIS will be used by Public Health Officials for interactive display of PREAM pollen maps, syndrome porting and alerts

Conclusions

✓The residual signal indicates that the pollen event may influence the seasonal signal to an extent that would allow detection, given accurate QA filtering and BRDF corrections. MODIS daily reflectances increased during the pollen season.

✓ The DREAM model (PREAM) was sucessfully modified for use with pollen and may provide 24-36 hour running pollen forcasts.

✓Publicly available pollen forecasts are linked to general weather patterns and roughly-known species' phenologies. These are too coarse for timely health interventions. PREAM addresses this key data gap so that targeting intervention measures can be determined temporally and geospatially.

✓The New Mexico Department of Health (NMDOH) as part of its Environmental Public Health Tracking Network (EPHTN) would use PREAM a tool for alerting the public in advance of pollen bursts to intervene and reduce the health impact on asthma populations at risk.

✓SYRIS provides direct feedback *from* and *to* the health community.