“A GIS Based Emissions Estimation System for Wild and Prescribed Fire”

Research in progress by the University of California Center for the Assessment and Monitoring of Forest and Environmental Resources (CAMFER)

Presented by Nicholas Clinton

EPA 12th Annual Emission Inventory Conference

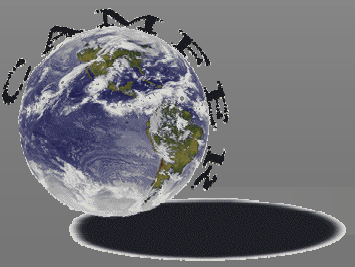
California Air Resources Board

Berkeley
University of California

Fire Emissions in Action

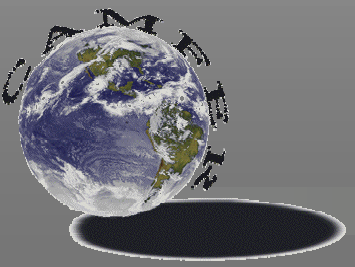
Purpose

"…to develop a method for producing coherent, consistent, spatially and temporally resolved GIS based emission estimates for wildfire and prescribed burning."

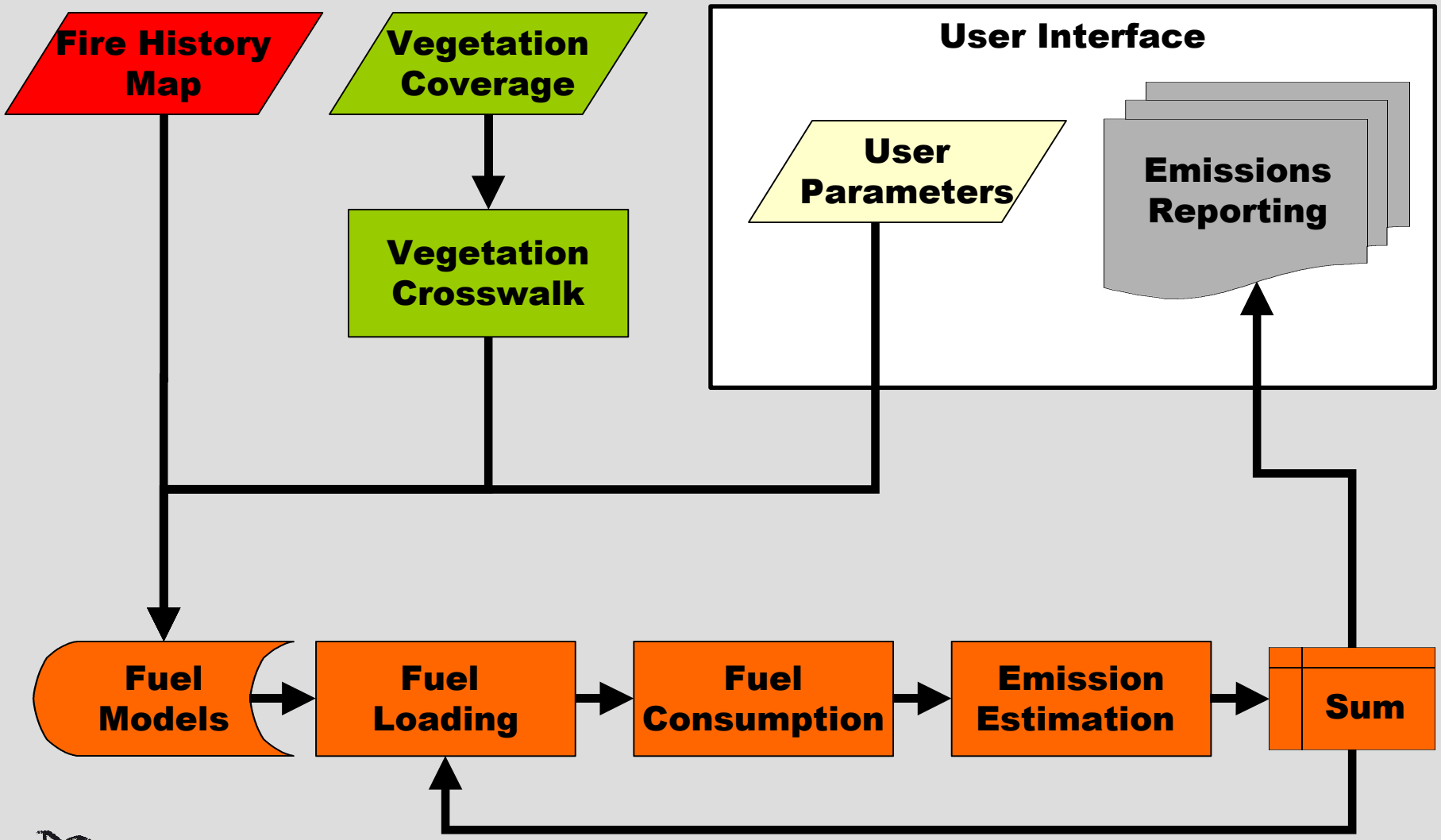


Modular approach

- A way to build a flexible, dynamic system
- Adaptation to new or updated technology
- Re-use of implemented models
- Examination of individual component models

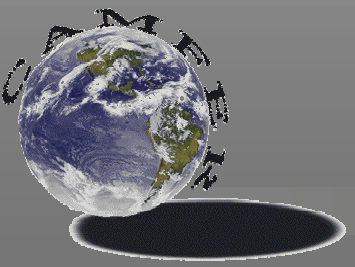


Modular System



Emissions Modeling in GIS

- Input as vegetation class and area
- Output as emissions mass
- Can implement algorithms in Avenue
- FOFEM!



FOFEM in ArcView

FOFEMload

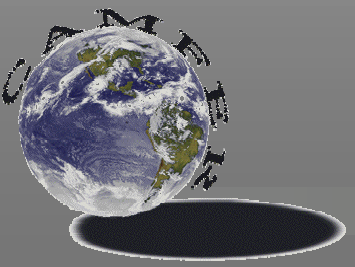
```
end

dw13Load = dw13Mass

dw13Mass = dw13Mass * 0.65  'EQ 25
  dw13MassPct = 0.65 'Needed for dw13 (1 & 10 hour) calcs

'**DW01 (1 & 10 hour fuel) Section: ****************
dw01Mass = covV.returnValueNumber(dw01F, recno)  'EQ 211
' Dead fuel adjustment factor
if (deadfuel = "light") then
  dw01Mass = ( dw01Mass * 0.7 )
elseif (deadfuel = "heavy") then
  dw01Mass = ( dw01Mass * 1.3 )
end

dw01Load = dw01Mass

if (dw13MassPct < 0.9)
  then dw01Mass = dw01Mass * 0.9  'EQ 21
end

'**DW3p (1000 hour fuel) Section: ****************
dw3pMass = covV.returnValueNumber(dw3pF, recno)
' Dead fuel adjustment factor
if (deadfuel = "light") then
  dw3pMass = ( dw3pMass * 0.4 )
elseif (deadfuel = "heavy") then
  dw3pMass = ( dw3pMass * 1.6 )
end

dw3pLoad = dw3pMass

meandia = covV.returnValueNumber(meandiaF, recno)

diared = 7.917 - (0.252 * 1.4 * wmoistpercent) + (0.34 * meandia)  'EQ 33 (32)
   ' wmoistpercent assumed to be NFDTH number

if (diared > meandia)   'Accomodate range annomolies of EQ 33 (32) and UsersMan p53
  then diared = meandia
elseif (diared < 0)
  then diared = 0
end

dw3pMass = dw3pMass * (1 - (((meandia - diared) / meandia) ^ 2))  'UsersMan p53

'**Canopy Section: ****************
if (crown = "yes") then
  ' Canopy Foliage:
```

FOFEM relational tables

FUELCODE	LITTER	DW01	DW13	DW3P	DUFF	HERBS	HERBT
11	1.40	0.7	0.8	5	5.00	0.10	0.20
12	3.90	5.0	8.0	12	5.00	0.10	0.20
21	1.50	1.0	1.0	10	25.00	0.10	0.20
22	4.00	5.0	8.0	12	25.00	0.10	0.20
31	0.60	0.9	0.8	7	10.00	0.10	0.20
32	2.60	7.0	8.0	20	10.00	0.10	0.20
41	0.80	1.0	0.8	40	30.00	0.10	0.15
42	2.80	7.0	8.0	50	30.00	0.10	0.15
51	1.00	0.9	1.3	20	20.00	0.10	0.15
61	0.60	0.9	0.9	20	30.00	0.10	0.15
62	2.60	7.0	8.0	20	30.00	0.10	0.15
71	0.60	0.7	1.5	14	25.00	0.10	0.15
72	2.60	7.0	8.0	20	25.00	0.10	0.15
81	1.50	1.0	1.5	20	40.00	0.10	0.20
82	4.00	5.0	8.0	12	40.00	0.10	0.20
91	0.60	0.9	0.6	15	15.00	0.10	0.20
92	2.10	7.0	12.0	15	15.00	0.10	0.20
101	0.30	0.7	0.5	7	10.00	0.10	0.20
102	1.80	7.0	12.0	15	10.00	0.10	0.20
111	0.90	1.0	1.5	7	5.00	0.20	0.35
121	0.70	1.1	0.0	3	34.00	0.00	0.00
131	1.10	1.6	0.0	3	12.00	0.00	0.00
141	0.70	1.1	0.0	3	11.00	0.00	0.00
151	13.90	0.0	0.0	0	50.00	0.00	0.00
161	11.10	0.0	0.0	0	35.00	0.00	0.00
171	1.00	3.0	2.8	50	35.00	0.10	0.20
172	3.00	7.0	7.0	50	35.00	0.10	0.20

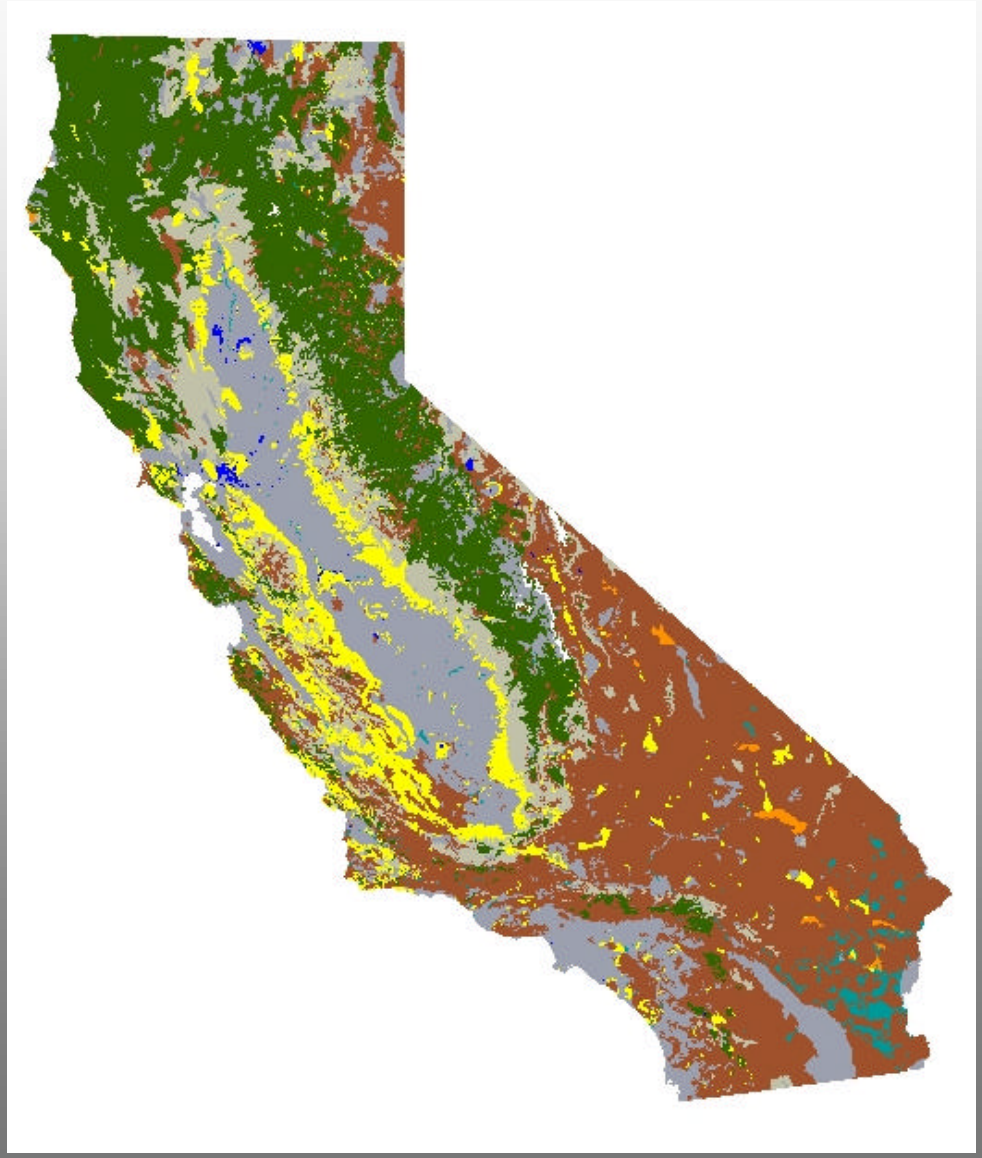
Data Collection and Processing

- Preprocessing and examination of vegetation inputs
- Crosswalking to FOFEM fuel models
- Temporal classification of fire history inputs



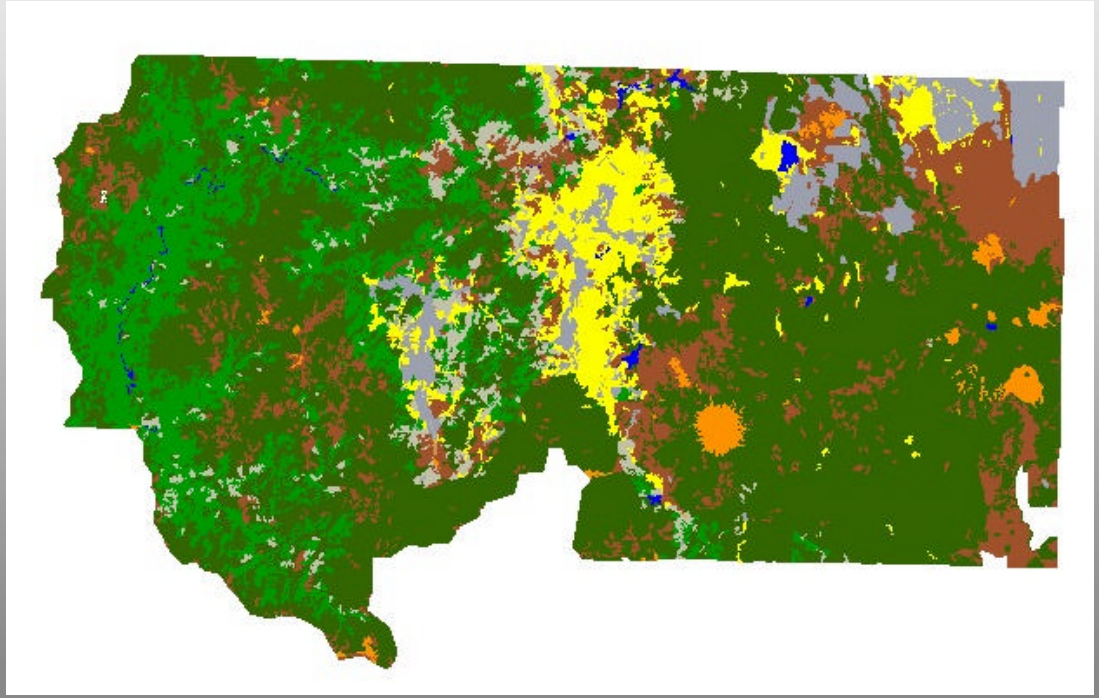
Vegetation Data

- **The GAP vegetation layer**
  - Statewide coverage
  - Less complex than other vegetation layers such as CALVEG
  - 1990 source data



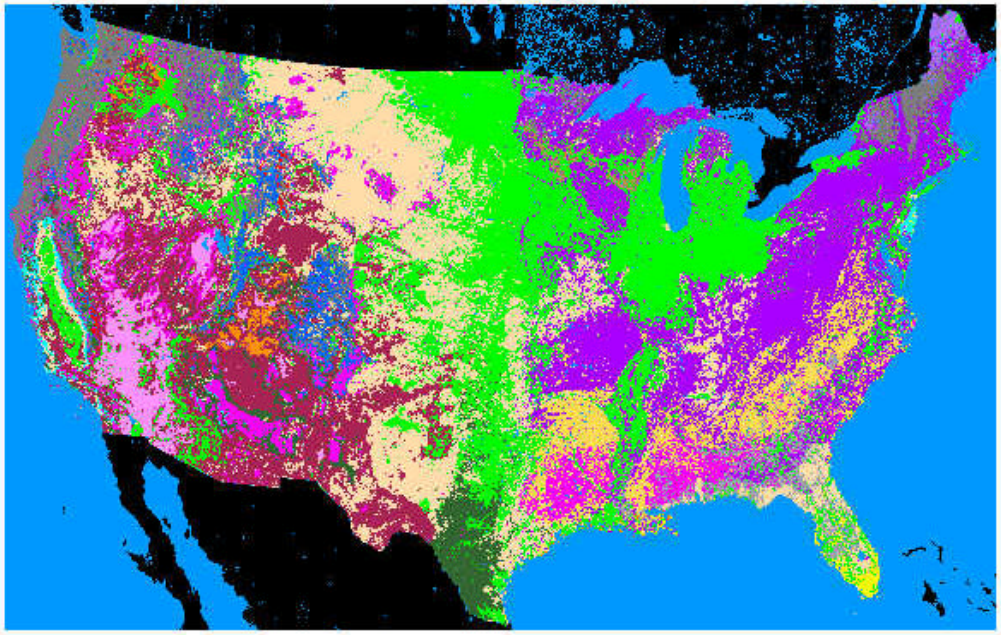
Vegetation Data

- **The CALVEG vegetation layer**
  - Incomplete coverage
  - More complex than other vegetation layers such as GAP
  - 1994 - 1997 source data



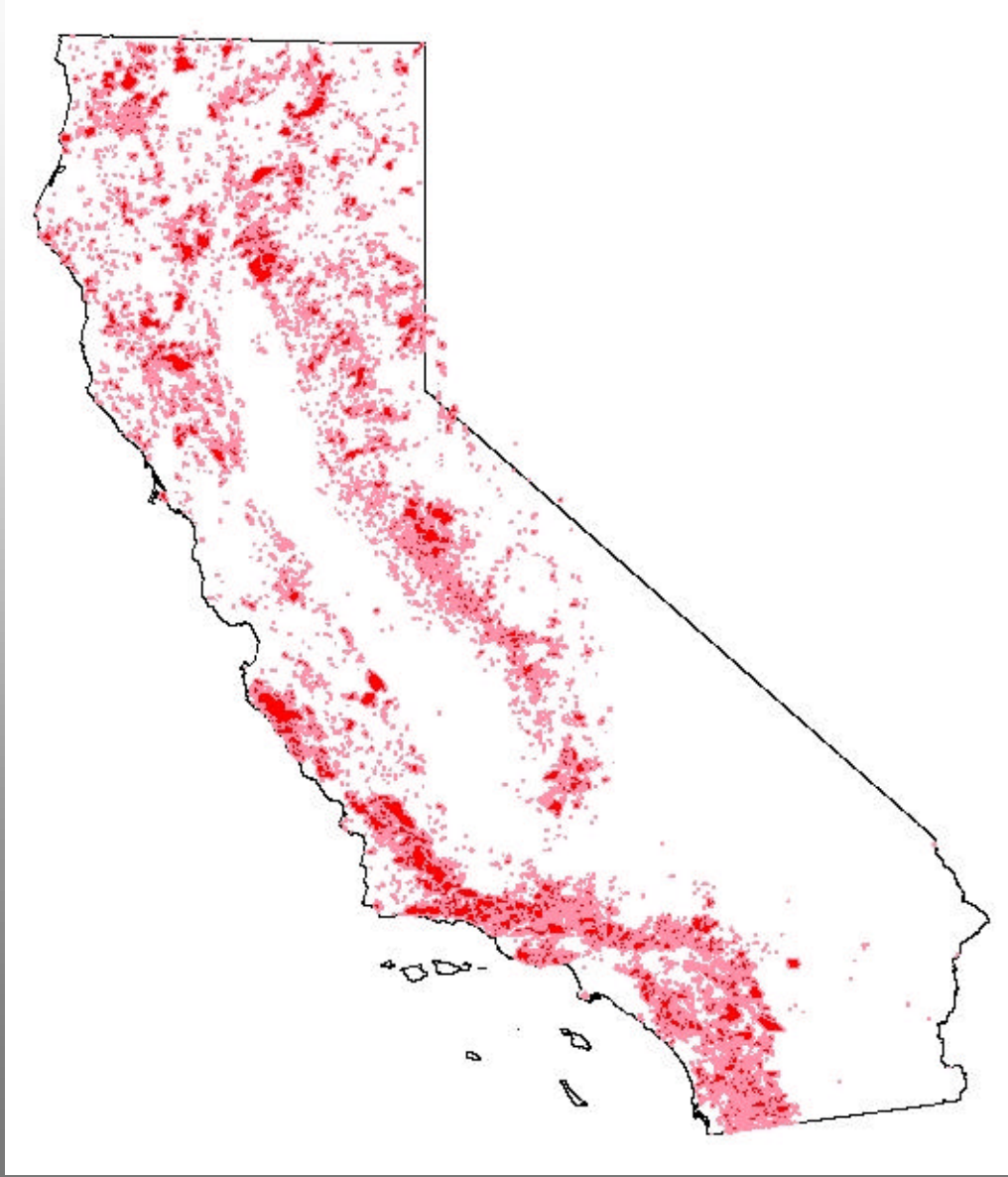
National Inputs

- The spatial inputs are the NFDRS fuel model grid (seen left) and a grid of remotely sensed fire detections (both 1km resolution).
- Utilizes the same emissions equations as with polygon processing.
- Requires crosswalk of FOFEM fuel models to NFDRS fuel models (proof of concept).

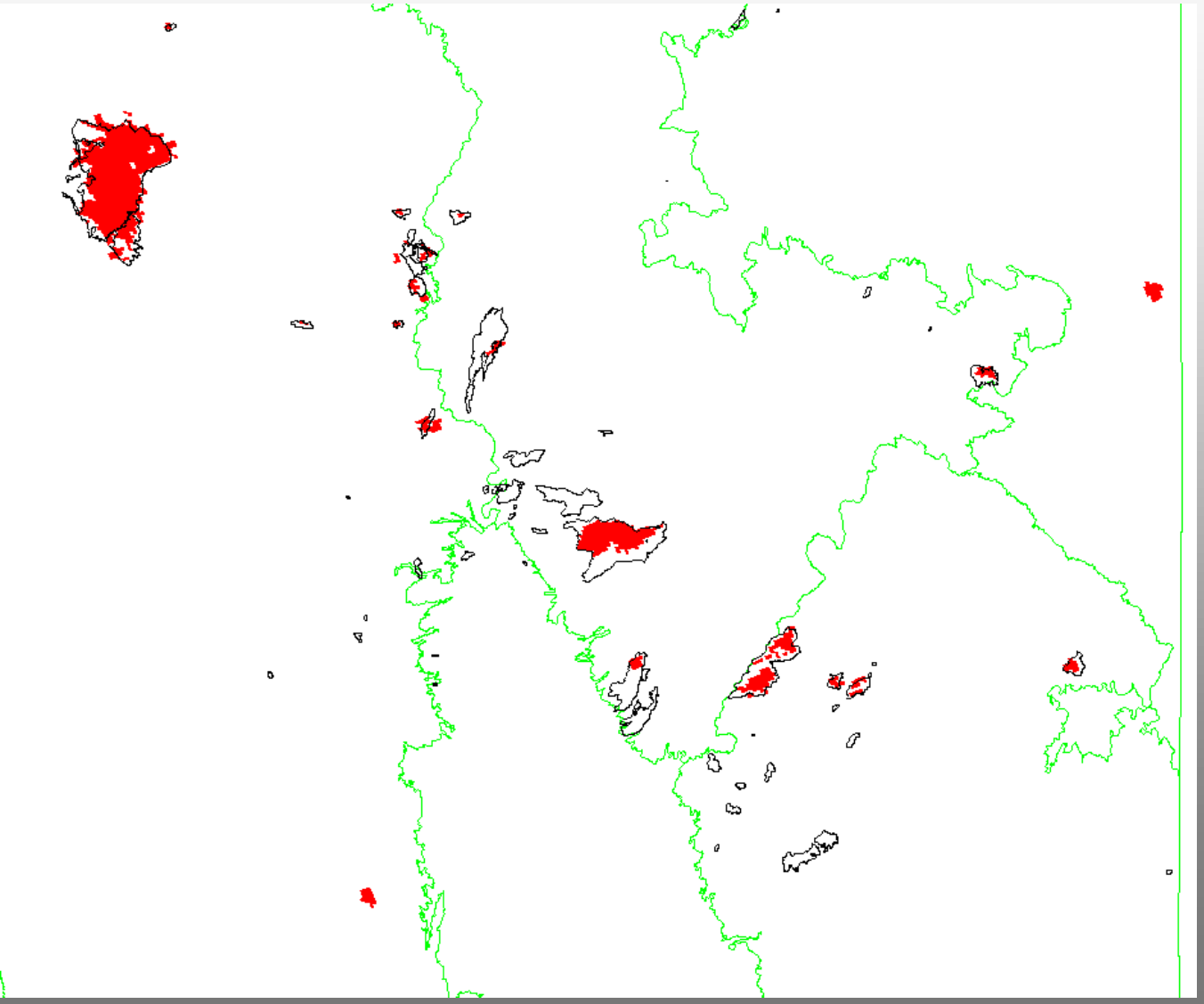


Fire History – Agency Data

- CDF fire polygons
- Historical database
- Completeness??
- Remote sensing based fire map

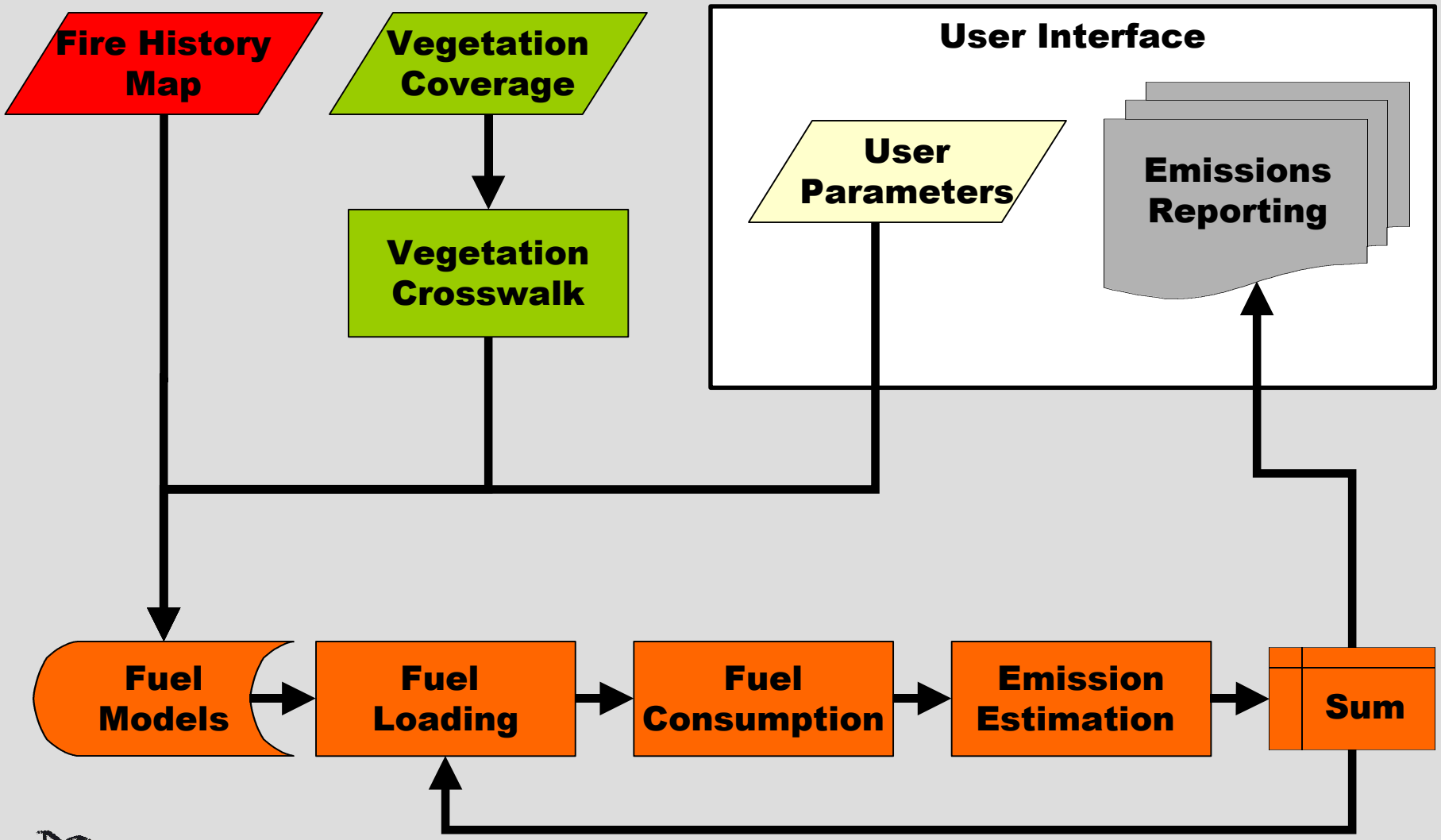


Overlay of CDF and CAMFER



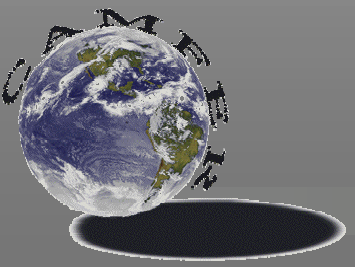
- RED is RS detections. Black is CDF data. Green is Jepson ecoregion.
- Lambert Conformal Conic Projection
- No Post-processing
- Potential for more data refinement by incorporating hotspots…

Modular System

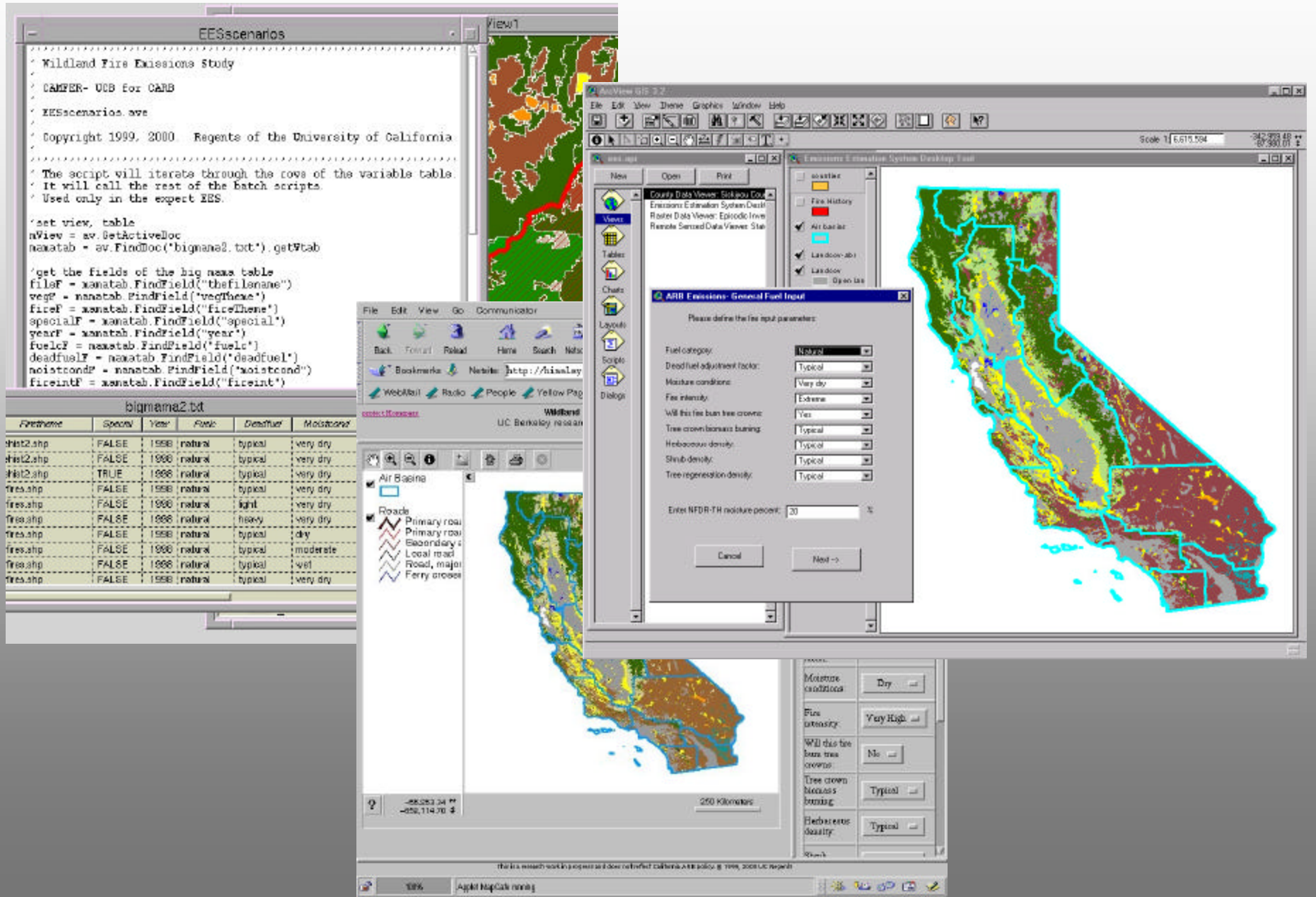


Multiple User Interfaces

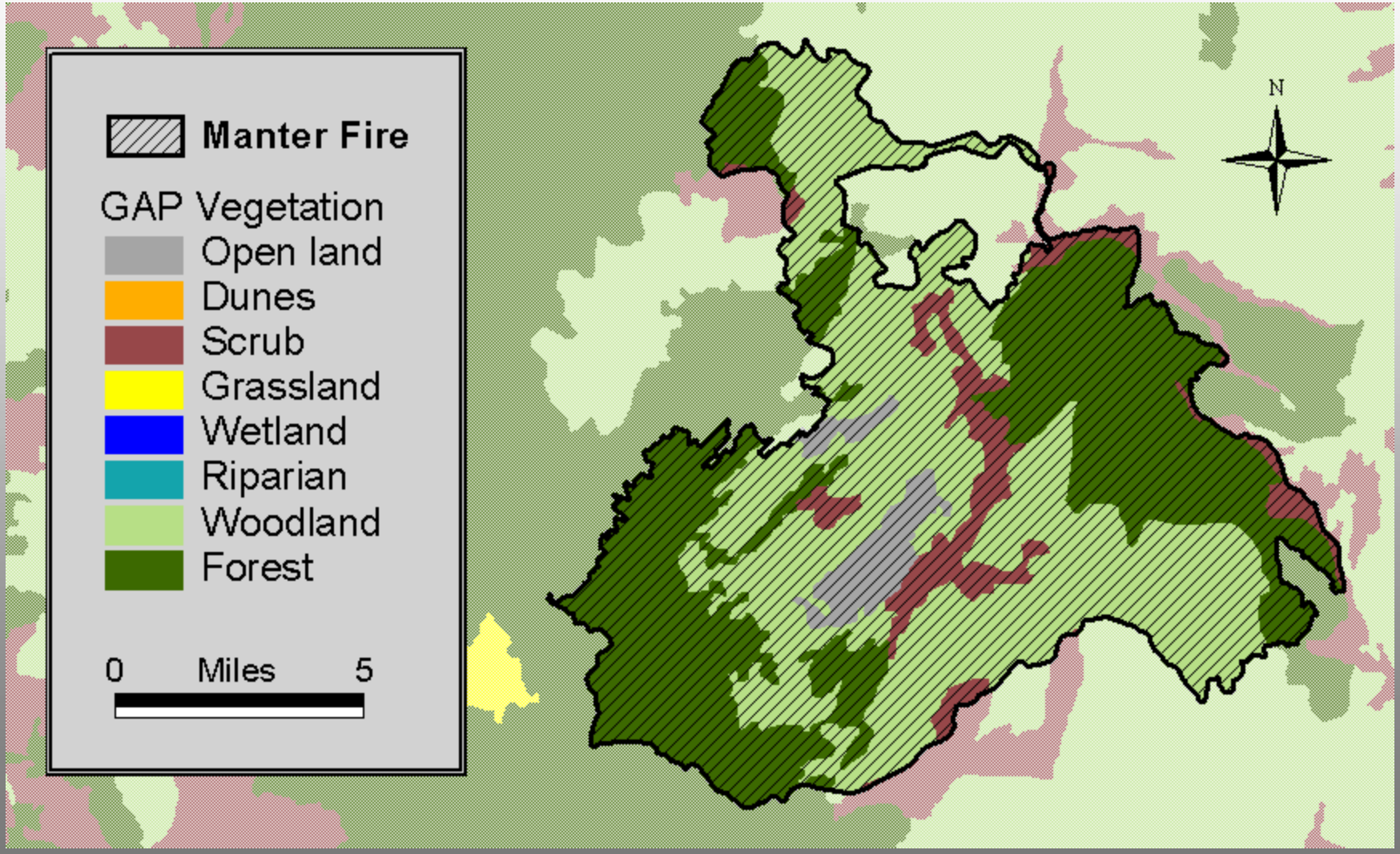
- The Interface module can be customized according to the needs of the user
- UNIX, PC and HTML based interfaces
- Interchangeable, as are the other modules



PC, Web, UNIX

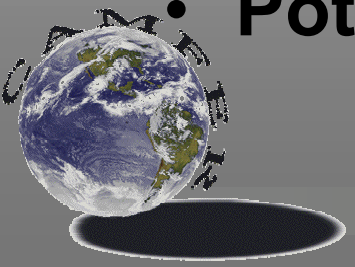

EESscenarios
' Wildland Fire Emissions Study
' CAMFER- UDB for CARB
' EESscenarios.avw
' Copyright 1999, 2000 Regents of the University of California
' The script will iterate through the rows of the variable table.
' It will call the rest of the batch scripts.
' Used only in the expert EES.
'set view, table
nView = av.GetActiveDoc
namatab = av.FindDoc("bigmama2.txt").getVtab
'get the fields of the big nama table
fileF = namatab.FindField("thefilename")
vegF = namatab.FindField("vegTheme")
fireF = namatab.FindField("fireTheme")
specialF = namatab.FindField("special")
yearF = namatab.FindField("year")
fuelcF = namatab.FindField("fuelc")
deadfuelF = namatab.FindField("deadfuel")
moistcondF = namatab.FindField("moistcond")
fireintF = namatab.FindField("fireint")
bigmama2.txt
Firetheme
Special
Year
Fuels
Deadfuel
Moistcond
View1
ARB Emissions- General Fuel Input
Please define the fire input parameters:
Fuel category:
Dead fuel adjustment factor:
Moisture conditions:
Fire intensity:
Will this fire burn tree crowns:
Tree crown biomass burning:
Herbaceous density:
Shrub density:
Tree regeneration density:
Enter NFDR-TH moisture percent:
Cancel
Next ->
Air Basins
Roads
250 Kilometers
Moisture conditions
Dry
Fire intensity
Very High
Will this fire burn tree crowns
No
Tree crown biomass burning
Typical
Herbaceous density
Typical

Vegetation “Clipped” by Fire Input



Output

- Output in the form of relational database tables
- Summarization by individual fire, fuel component, county or airbasin
- Used as information for ARB permitting and projection purposes
- Used in comparative analysis of various model configurations
- Potential for MUCH more…



The BIG Table

COVCODE	COVERDESC	COMPONENT	PRELOAD	FIRES_	PM10	PM25	CO	CH4	TNMHC	NH3	N2O
72100	GREAT BASIN WOODLAND	Litter	2.00	1	18.6	15.8	104.8	4.2	7.3	1.0	1.0
72100	GREAT BASIN WOODLAND	Wood 0-1 inch	0.50	1	4.2	3.6	23.6	0.9	1.7	0.2	0.2
72100	GREAT BASIN WOODLAND	Wood 1-3 inch	0.00	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72100	GREAT BASIN WOODLAND	Wood 3+ inches	0.00	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72100	GREAT BASIN WOODLAND	Herbs	0.05	1	1.3	1.1	12.5	0.5	0.9	0.1	0.0
72100	GREAT BASIN WOODLAND	Shrubs	0.10	1	1.5	1.3	15.0	0.6	1.0	0.1	0.0
72100	GREAT BASIN WOODLAND	Regen	0.05	1	0.8	0.6	7.5	0.3	0.5	0.1	0.0
72100	GREAT BASIN WOODLAND	Duff	4.00	1	98.6	83.7	1025.4	41.0	71.8	10.3	1.4
72100	GREAT BASIN WOODLAND	Canopy foliage	0.00	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72100	GREAT BASIN WOODLAND	Canopy branchwood	0.00	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85100	JEFFREY PINE FOREST	Litter	1.50	1	14.0	11.9	78.6	3.1	5.5	0.8	0.7
85100	JEFFREY PINE FOREST	Wood 0-1 inch	1.00	1	8.4	7.1	47.2	1.9	3.3	0.5	0.4
85100	JEFFREY PINE FOREST	Wood 1-3 inch	1.00	1	9.1	7.7	72.4	2.9	5.1	0.7	0.3
85100	JEFFREY PINE FOREST	Wood 3+ inches	10.00	1	191.0	162.0	1744.0	69.8	122.1	17.4	4.5
85100	JEFFREY PINE FOREST	Herbs	0.20	1	5.0	4.3	49.8	2.0	3.5	0.5	0.1
85100	JEFFREY PINE FOREST	Shrubs	0.25	1	3.8	3.2	37.4	1.5	2.6	0.4	0.1
85100	JEFFREY PINE FOREST	Regen	0.15	1	2.3	1.9	22.4	0.9	1.6	0.2	0.0
85100	JEFFREY PINE FOREST	Duff	25.00	1	616.4	523.1	6408.9	256.4	448.6	64.1	8.5
85100	JEFFREY PINE FOREST	Canopy foliage	6.00	1	150.6	127.8	1495.2	59.8	104.7	15.0	2.6
85100	JEFFREY PINE FOREST	Canopy branchwood	0.70	1	8.8	7.5	87.2	3.5	6.1	0.9	0.2

- **Covertype (code and description)**
- **Fuel Component**
- **Polygon ID (for spatial referencing)**
- **Pre-load (tons per acre)**
- **Emissions**

A Summarized Table

Attributes of Daily.shp

Shape	date	id	Pm10	Pm25	Co	Ch4	Tnmhc	Nh3	N20	Nox	So2
Polygon	20000722	1	666.67	565.70	6637.53	265.49	464.72	66.40	11.43	194.39	59.87
Polygon	20000723	2	1405.96	1193.04	13976.87	559.03	978.55	139.76	24.25	412.91	127.14
Polygon	20000724	3	507.43	430.58	5045.04	201.79	353.22	50.45	8.75	148.93	45.86
Polygon	20000725	4	279.11	236.85	2747.16	109.83	192.31	27.41	5.02	85.76	26.39
Polygon	20000726	5	369.67	313.70	3638.03	145.45	254.67	36.30	6.64	113.67	34.97
Polygon	20000727	6	1745.52	1481.25	16980.60	678.65	1188.58	169.16	32.89	563.56	173.26
Polygon	20000728	7	1348.01	1143.88	13218.12	528.51	925.36	132.08	24.77	420.50	129.39
Polygon	20000729	8	2596.24	2204.47	25706.25	1029.16	1799.11	256.33	46.02	777.14	239.45
Polygon	20000730	9	3941.51	3345.01	38927.66	1557.10	2725.00	389.03	70.37	1192.03	366.86
Polygon	20000731	10	1900.38	1612.83	18724.91	748.97	1310.80	187.21	34.36	580.45	178.59
Polygon	20000801	11	870.13	738.49	8560.28	342.40	599.21	85.49	15.82	267.72	82.38
Polygon	20000802	12	155.81	132.22	1544.08	61.76	108.09	15.43	2.74	46.41	14.29
Polygon	20000803	13	26.86	22.79	267.21	10.69	18.71	2.67	0.46	7.87	2.42
Polygon	20000804	14	17.94	15.23	174.06	6.96	12.18	1.72	0.34	5.87	1.81
Polygon	20000805	15	1059.44	899.00	10539.46	421.58	737.78	105.38	18.28	310.17	95.53
Polygon	20000806	16	58.18	49.38	569.89	22.80	39.88	5.67	1.07	18.27	5.62
Polygon	20000807	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polygon	20000808	18	10.17	8.64	97.42	3.90	6.82	0.96	0.20	3.50	1.08

- **Temporally referenced polygons**
- **Polygon processing is possible whenever and wherever there is adequate input data…**


Thank You!