LANDFIRE
Vegetation Mapping and Updating

- **Donald Long**
- **USDA Forest Service, Rocky Mountain Research Station**

- **June 13th, 2014**
- **Comparing Existing Ecological Systems Maps for the Eastern USA**
- **Hadley, MA**

Mapping Characteristics

- **Map All Lands & Vegetative Communities**
  - Same level of detail
    - (Federal & Non-Federal lands)
    - Forestlands, Shrublands, and Grasslands

- **Repeatable**
  - Quick and affordable

- **Target Map Accuracies:**
  - 60 to 80 percent map accuracy
  - 30m resolution

- **Consistent for the Nation**
  - Map units mean the same thing in Florida as they do in Colorado

Map Unit Requirements

✓ **Identifiable**

- **from field or plot data**

✓ **Map-able**

- **30 meter resolution**
- **60-80% accurate**

✓ **Model-able**

- **provide required model inputs**

✓ **Scalable**

- **link with existing classifications**

LANDFIRE at 10 Years
Listening, Evolving, Improving, Serving

LANDFIRE National V1.0.0

- **CONUS**
- **Alaska**
- **Hawaii**
- Free, available online for download
- 20+ 30 meter spatial data layers
- Regional or national level application scale
- Transparent
- Repeatable
- Scientifically based

LANDFIRE 2001 V1.0.5

- **CONUS**
- **Alaska**
- **Hawaii**
- Filled gaps along international borders
- Modified Western BpS layers using new SSURGO data
- Modified the extent of wetlands and riparian areas, barren and water classes

LANDFIRE 2008 V1.1.0

- **CONUS**
- **Alaska**
- **Hawaii**
- Updates to V1.0.5 for landscape change from 2001 - 2008
- Incorporated known treatments and disturbances along with remote sensing
- Added burnable AG and Urban classes

LANDFIRE 2010 V 1.2.0

- **CONUS**
- **Alaska**
- **Hawaii**
- **Insular Areas**
- Updates to V1.0.5 for landscape change from 2001 – 2010
- Refined AG classes using NASS crop data and burnability
- Refined wetlands using NWI

LANDFIRE 2012 V1.3.0

- **CONUS**
- **Alaska**
- **Hawaii**
- Updates to V1.0.5 for landscape change from 2001 – 2012
- Incremental delivery beginning in the Central States Summer 2014
- Continued incorporation of new and better supporting data sets
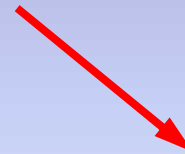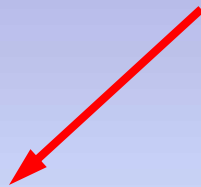
LANDFIRE DELIVERABLES

Vegetation Characteristics
   Existing vegetation
   Existing vegetation structure
   Bio-physical Settings

Fire behavior
Fire behavior fuel models
Canopy bulk density
Canopy base height
Canopy cover
Canopy height
FCC Fuelbeds
Fuel Loading Models

Fire ecology
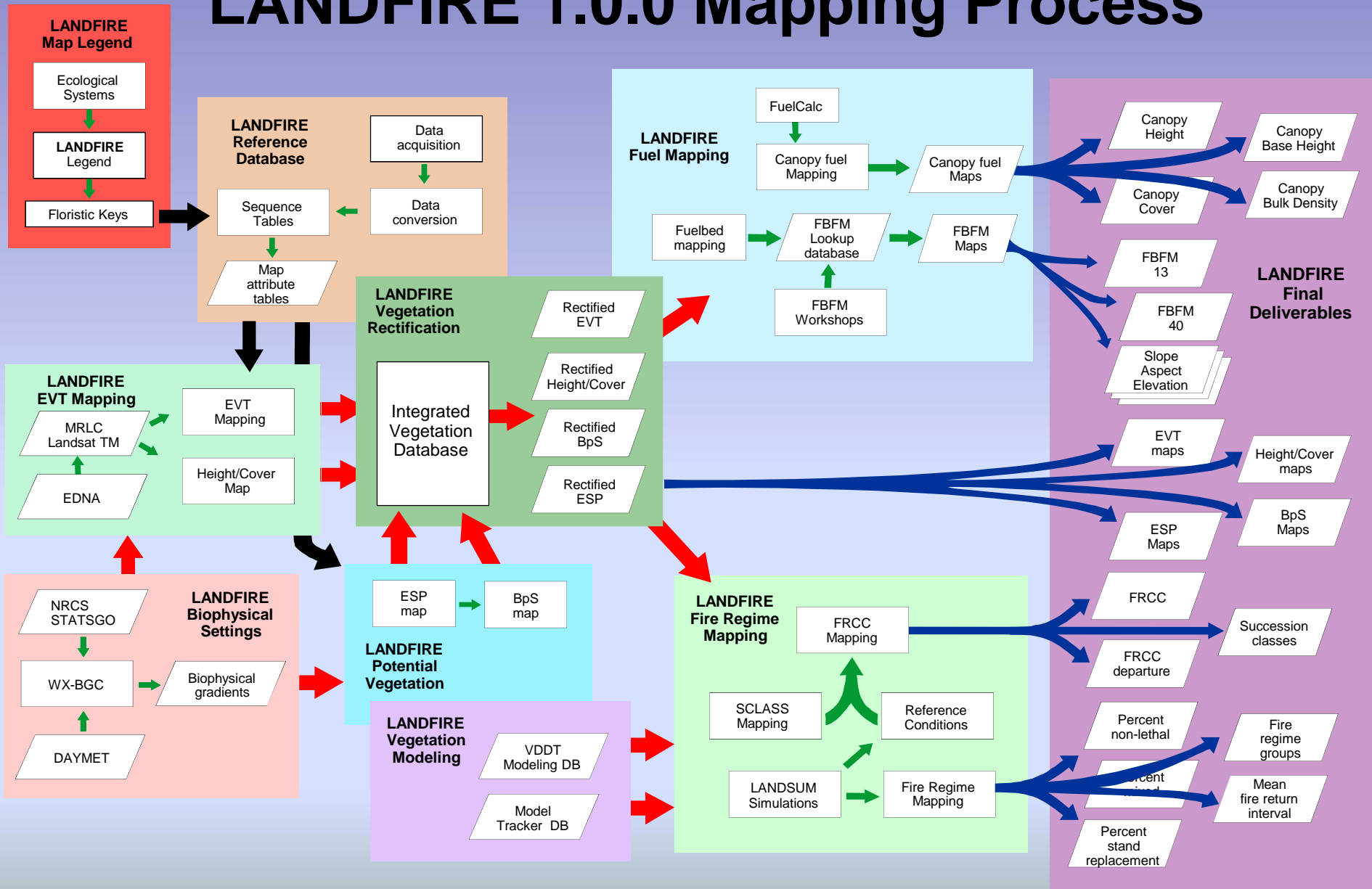Historical fire return interval
Historical fire severity
Historical fire regime
Current Succession Class
Vegetation departure
Fire Regime Condition Classes

LANDFIRE 1.0.0 Mapping Process

LANDFIRE Map Legend
- Ecological Systems
- LANDFIRE Legend
- Floristic Keys

LANDFIRE Reference Database
- Data acquisition
- Data conversion
- Sequence Tables
- Map attribute tables

LANDFIRE Vegetation Rectification
- Integrated Vegetation Database
- Rectified EVT
- Rectified Height/Cover
- Rectified BpS
- Rectified ESP

LANDFIRE Fuel Mapping
- FuelCalc
- Canopy fuel Mapping
- Canopy fuel Maps
- Fuelbed mapping
- FBFM Lookup database
- FBFM Maps
- FBFM Workshops

LANDFIRE Final Deliverables
- Canopy Height
- Canopy Cover
- Canopy Base Height
- Canopy Bulk Density
- FBFM 13
- FBFM 40
- Slope Aspect Elevation
- EVT maps
- ESP Maps
- Height/Cover maps
- BpS Maps
- FRCC
- FRCC departure
- Succession classes
- Percent non-lethal
- Percent mixed
- Percent stand replacement
- Fire regime groups
- Mean fire return interval

LANDFIRE EVT Mapping
- MRLC Landsat TM
- EDNA
- EVT Mapping
- Height/Cover Map

LANDFIRE Biophysical Settings
- NRCS STATSGO
- WX-BGC
- DAYMET
- Biophysical gradients

LANDFIRE Potential Vegetation
- ESP map
- BpS map

LANDFIRE Vegetation Modeling
- VDDT Modeling DB
- Model Tracker DB

LANDFIRE Fire Regime Mapping
- FRCC Mapping
- SCLASS Mapping
- Reference Conditions
- LANDSUM Simulations
- Fire Regime Mapping

Mapping Methods

- **Use Sequence Table to assign reference data**
- **Extract data for each predictor variable for each reference plot**
- **Randomly select ~ 2% of plots from each dataset for independent accuracy assessment later across "super-zones"**
- **Winnow predictor variables**
- **Model stratifications, then each map unit**
- **Use 10-fold cross-validation for zone accuracy**
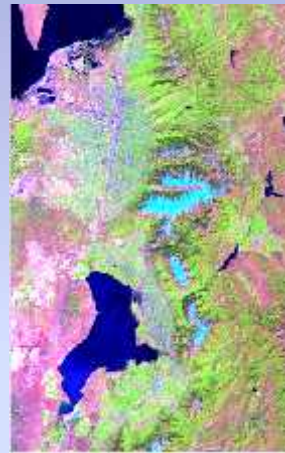- **Apply rules in the GIS to the produce**

MRLC 2000 Map Zones

Lower 48 states/66 Map Zones

Landsat Data Acquisition and Processing
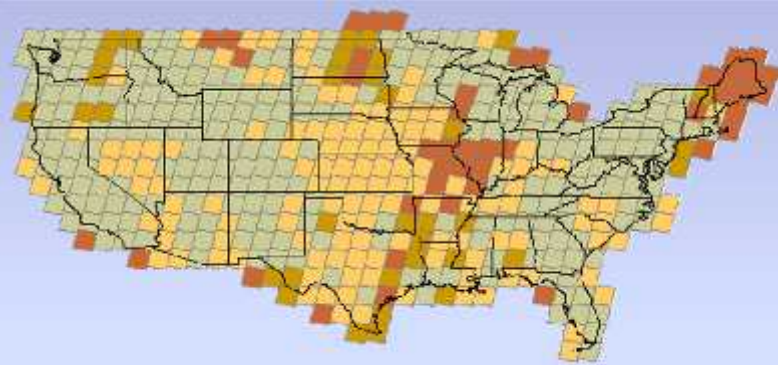
May 28, 2000   Aug. 14, 1999   Oct. 17, 1999

> ➤ **At least three dates per pixel**

> ➤ **Strict processing standards for radiometric and illumination calibrations**

> ➤ **From radiance to TOA reflectance**

Breaking Landscape Down to 9 Elements

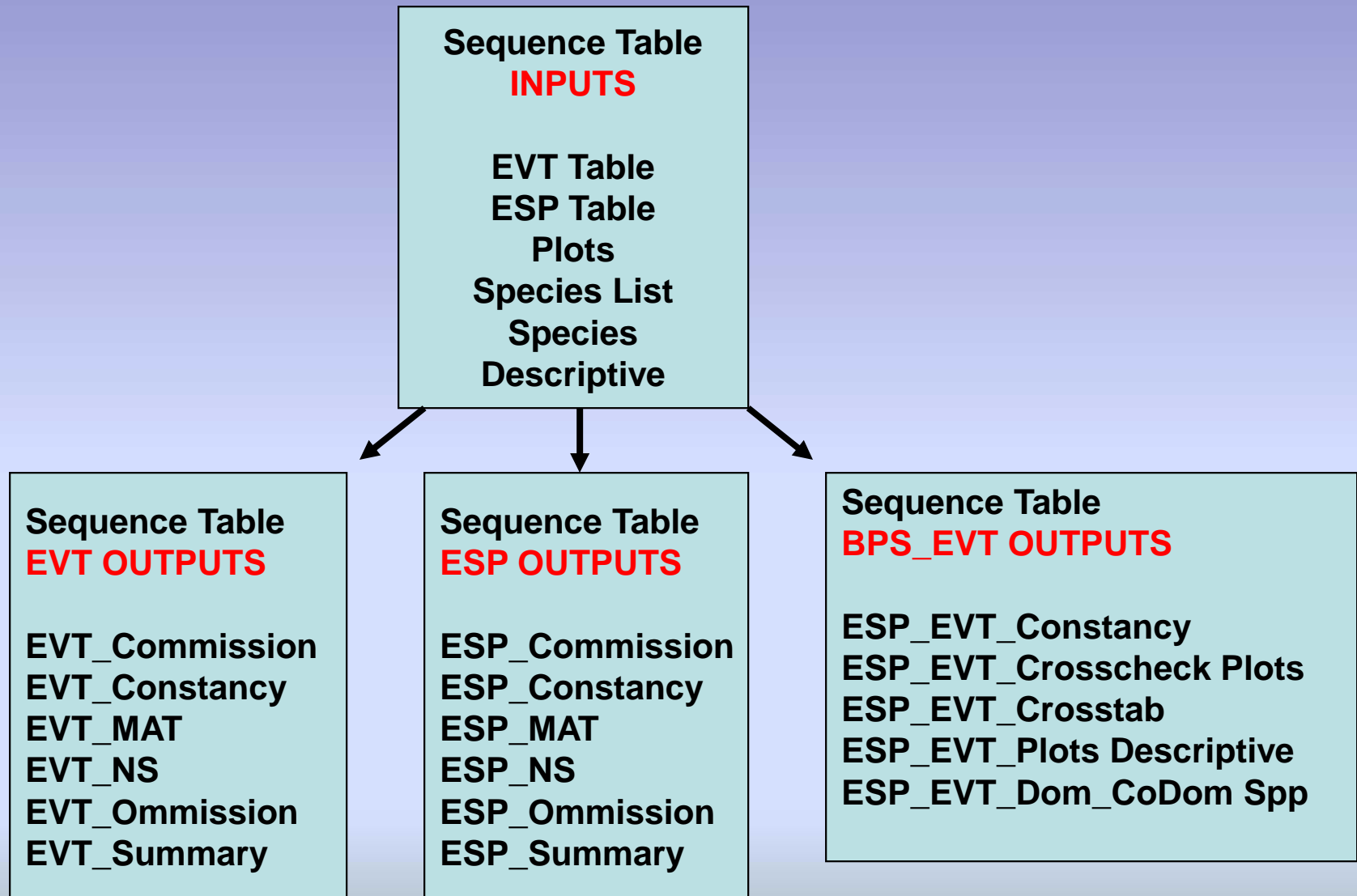| Cover Types	Canopy Cover	Height
Forest	Forest	Forest
Shrub	Shrub	Shrub
Herbaceous	Herbaceous	Herbaceous

THE PROCESS
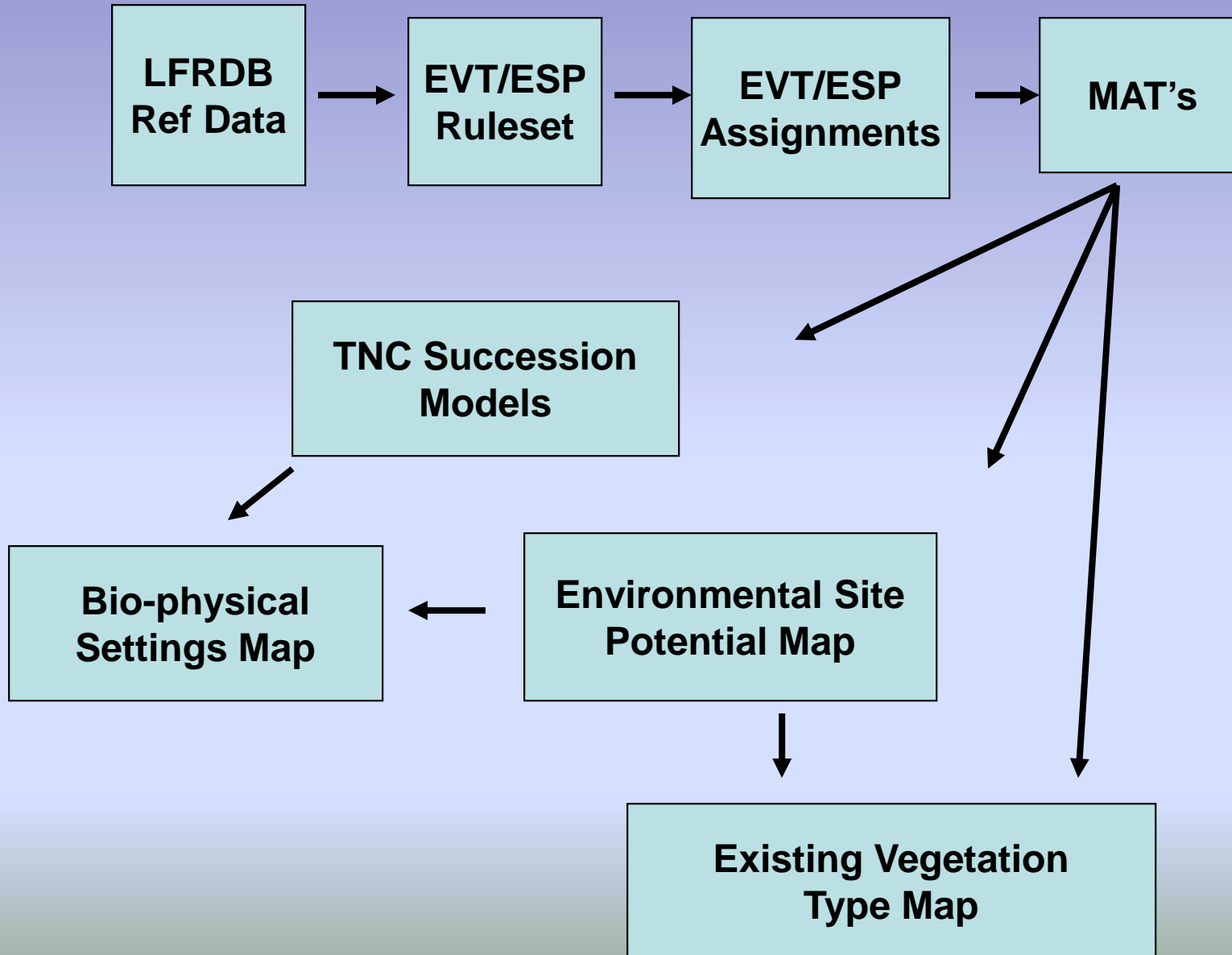
Sequence Tables

✓ **Automation**

- **ESP_EVT_Key_Classifier**
  - **Python**
  - **Works w/ Access MDB**
  - **Dominance / Codominance for EVT**
  - **Indicators for ESP**

SEQUENCE TABLES

Sequence Table
INPUTS

EVT Table
ESP Table
Plots
Species List
Species
Descriptive

Sequence Table
EVT OUTPUTS

EVT_Commission
EVT_Constancy
EVT_MAT
EVT_NS
EVT_Ommission
EVT_Summary

Sequence Table
ESP OUTPUTS

ESP_Commission
ESP_Constancy
ESP_MAT
ESP_NS
ESP_Ommission
ESP_Summary

Sequence Table
BPS_EVT OUTPUTS

ESP_EVT_Constancy
ESP_EVT_Crosscheck Plots
ESP_EVT_Crosstab
ESP_EVT_Plots Descriptive
ESP_EVT_Dom_CoDom Spp

Existing Vegetation

• Used directly for predicting current vegetation composition

• Augmented with canopy and height information

• Framework for mapping current fuel distribution and loadings

• Framework for mapping succession classes for use in departure mapping

Existing Vegetation Type
the current distribution of an Ecological system

1. **Characteristic vegetative physiognomy and composition**

2. **Physiognomic modifiers using canopy density and/or height**

3. **Geographic modifiers using Ecological Divisions or nested Provinces that describe the distribution of the type.**

4. **Environmental modifiers using moisture and temperature gradients ie "dry-mesic" or "subalpine"**

EVT Rule-sets

- ✓ **Criteria**
  - Absolute cover for lifeforms
    - Tree / Tree-Savanna
    - Shrub / Shrub Steppe
    - Herbaceous / Grassland
  - Relative cover of floristic criteria generally indicating dominance
  - Environmental modifiers – floristic
  - Geographical modifiers – floristic

EVT Criteria
Forest Examples

Key Criteria	EVT
ABLA and/or PIEN > 50% RC **and** ABCO, PSME, PIPU, mesic shrubs present	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
ABLA and/or PIEN > 50% RC **and** Mesic indicators NOT present	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
ABCO and/or PSME and/or PIPU > 50% RC **and** PIEN, POTR, ACGL, ACGR, etc. present	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
ABCO and/or PSME and/or PIPU > 50% RC **and** Mesic indicators NOT present	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland

Environmental Site Potential
the potential distribution of an Ecological system

1. Indicators of the characteristic vegetative physiognomy and composition

2. Indicators of the physiognomic modifiers using canopy density and/or height

3. Geographic modifiers using Ecological Divisions or nested Provinces that describe the distribution of the type.

4. Environmental modifiers using moisture and temperature gradients ie "dry-mesic" or "subalpine"

Environmental Site Potential (ESP)

- Foundation for predicting current vegetation composition; used in EVT probabilities

- Framework for mapping current fuel distribution and loadings

- Succession without disturbance

Biophysical Settings (BpS)

- Foundation for historical fire regimes modeling

- Framework for mapping departure from historical condition

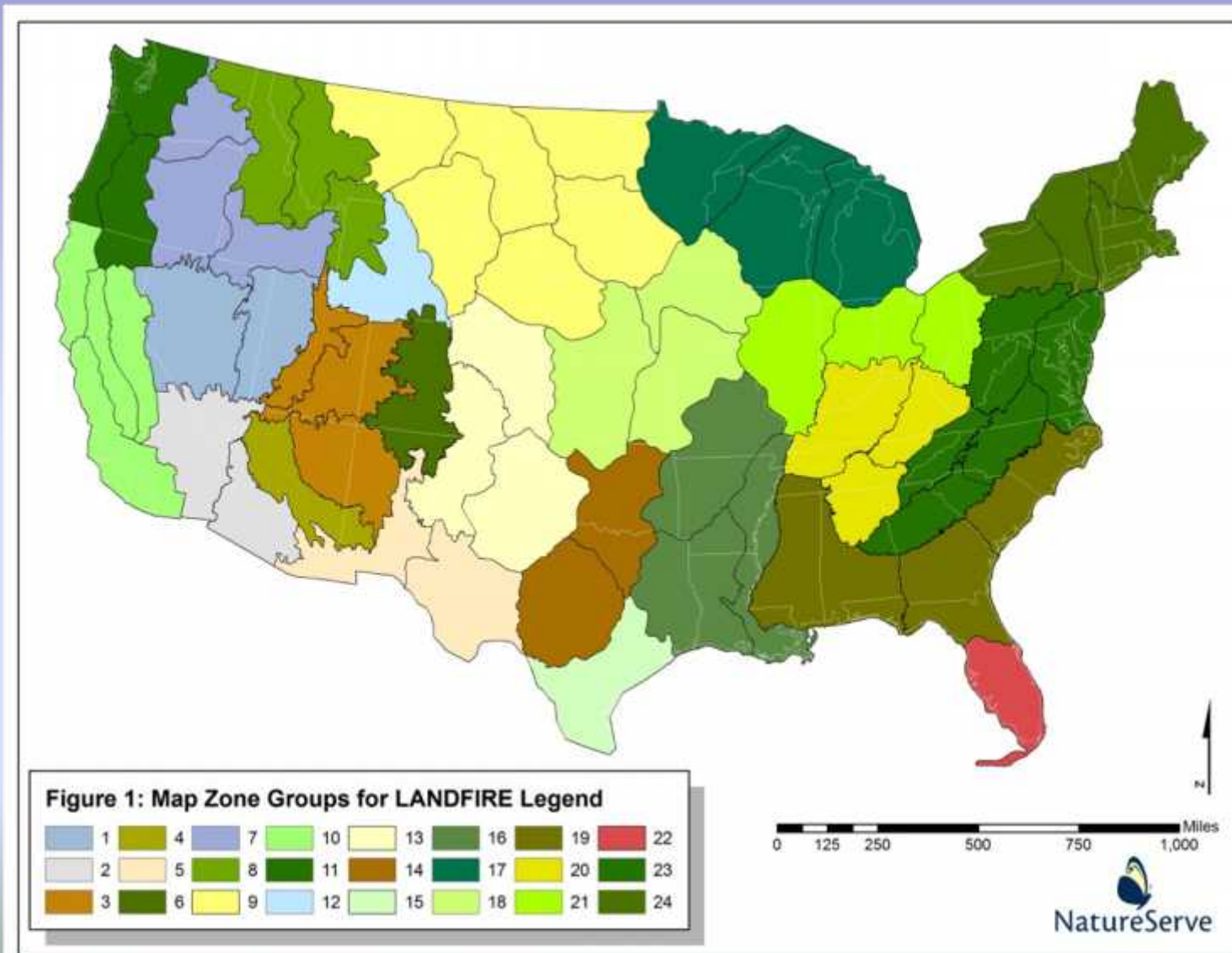- Succession with disturbance

ESP Rule-sets

✓ **Criteria**

- **Absolute cover for lifeforms**
  - **Tree / Tree-Savanna**
  - **Shrub / Shrub Steppe**
  - **Herbaceous / Grassland**
- **Relative cover of floristic criteria generally indicating "presence"**
- **Environmental modifiers - floristic**
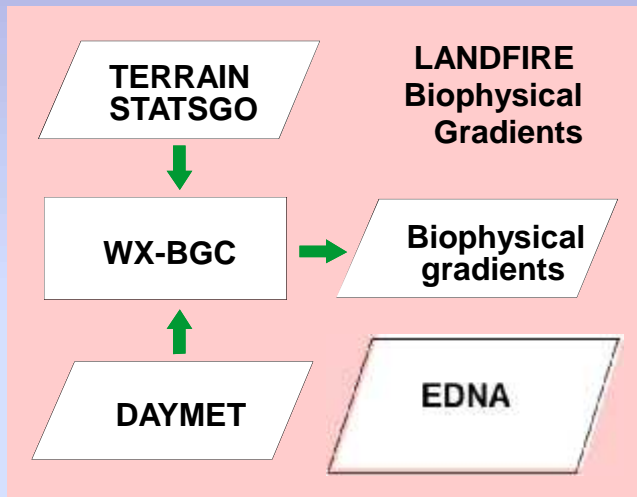- **Geographical modifiers - floristic**

ESP Criteria
Forest Examples

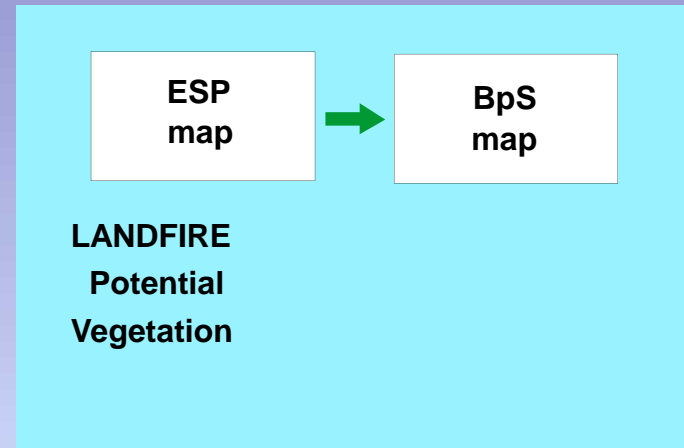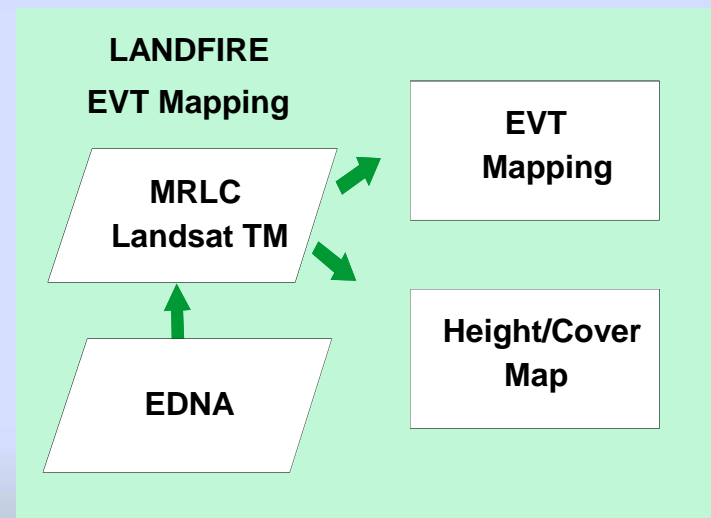| Key Criteria	ESP
ABLA and/or PIEN and/or ABLA > 10% RC **and** ABCO, PSME, PIPU, mesic shrubs present	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
ABLA and/or PIEN and/or ABLA > 10% RC **and** Mesic indicators NOT present	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
ABCO and/or PSME and or PIPU > 10% RC **and** PIEN, POTR, ACGL, ACGR, etc. present	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
ABCO and/or PSME and or PIPU > 10% RC **and** Mesic indicators NOT present	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland

Auto Key Regions

Figure 1: Map Zone Groups for LANDFIRE Legend

1	4	7	10	13	16	19	22
2	5	8	11	14	17	20	23
3	6	9	12	15	18	21	24

NatureServe

LANDFIRE Mapping Process

Potential Vegetation:
the potential distribution of an Ecological system

Plots

ESP map → **BpS map**

LANDFIRE Potential Vegetation

LANDFIRE Biophysical Gradients

TERRAIN STATSGO → **WX-BGC** → **Biophysical gradients**

DAYMET → **WX-BGC**

EDNA

LANDFIRE EVT Mapping

MRLC Landsat TM → **EVT Mapping**

MRLC Landsat TM → **Height/Cover Map**

EDNA → **MRLC Landsat TM**

Plots

Existing Vegetation:
the current distribution of an Ecological system

LANDFIRE Existing Vegetation

EVT   EVH   EVC

Generating Lifeform Mask

Use only DEM & derivative and imagery as predictors

Exclude tree plots with < 20% canopy cover

Pseudoplots ?

Master_ID	asp	dem	posidx	slpp	offb9	offdate	offb1	offb2	offb3	offb4	offb5	offb6	offtc1	offtc2	offtc3	onb9	...	LF_Code
6000571	344	2562	38	54	129	4	34	27	24	38	40	24	35	87	116	175	...	1
6000572	142	2537	34	35	167	4	40	40	46	96	92	52	83	102	81	184	...	1
6000583	143	2521	15	58	174	4	67	73	87	119	151	122	137	59	30	200	...	2
6000584	156	2498	6	17	171	4	58	59	66	108	136	98	115	76	43	196	...	1
6000586	284	2580	39	20	146	4	29	21	20	53	38	24	38	103	116	171	...	1
6000591	329	2538	42	28	138	4	26	20	13	47	12	5	26	109	138	164	...	1
6000592	248	2515	34	16	150	4	36	30	32	65	54	37	54	97	105	183	...	1
6000593	91	2984	47	9	169	4	43	45	63	106	140	81	105	90	42	182	...	3
6000596	64	2340	44	21	150	4	29	20	16	52	27	16	33	107	126	185	...	1

See5

Iterative process

Apply tree to spatial data to create mask
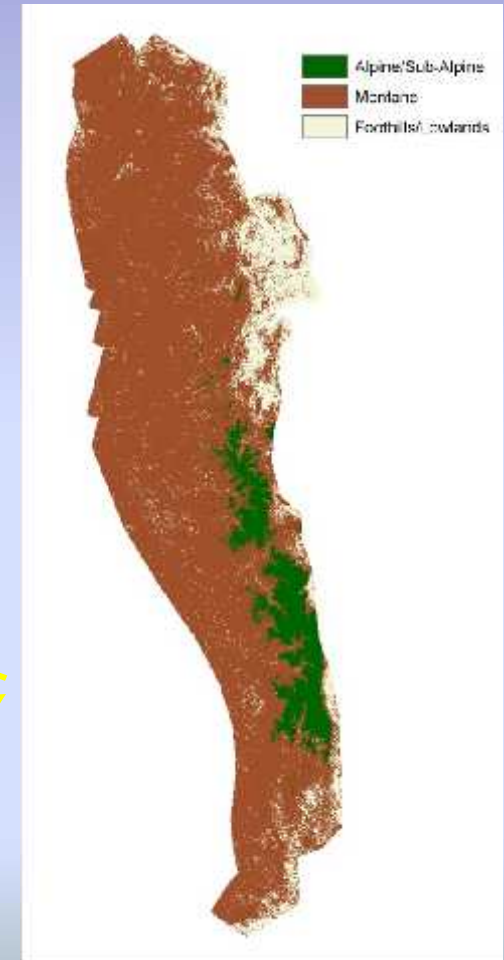
10 % NLCD mask

Tree
Shrub
Herbaceous

Generating Lifezone Mask

Use only DEM & derivative and imagery as predictors

Pseudoplots ?

Master_ID	asp	dem	posidx	slpp	offb9	offdate	offb1	offb2	offb3	offb4	offb5	offb6	offtc1	offtc2	offtc3	onb9	...	LZ_Code
6000315	254	2969	64	7	161	4	43	43	49	79	87	63	78	84	80	199	...	1
6000321	223	3076	33	11	169	4	48	50	60	94	137	93	102	77	40	194	...	1
6000329	-1	2602	0	0	176	4	42	41	52	88	140	87	93	83	37	187	...	1
6000331	187	2484	66	71	169	4	39	37	38	85	79	53	73	100	86	203	...	2
6000345	33	2389	55	44	152	4	30	19	16	43	24	14	28	102	128	202	...	2
6000355	258	1447	43	29	161	4	31	25	16	80	37	13	49	125	124	175	...	2
6000372	146	1322	29	17	188	4	44	37	41	84	87	59	77	94	80	208	...	3
6000385	175	2825	52	31	175	4	44	43	49	84	114	77	86	83	58	198	...	1
6000386	136	2582	56	23	169	4	42	41	48	94	105	69	88	94	66	206	...	3
6000387	134	2135	85	9	171	4	49	48	54	71	92	68	80	71	76	223	...	2

See5

Iterative
process

Apply tree to spatial
data to create mask

Alpine/Sub-Alpine
Montane
Foothills/Lowlands

Generating LF-LZ Mask

Lifeform Mask

Lifezone Mask

Combined Lifeform/ Lifezone Mask

+

=
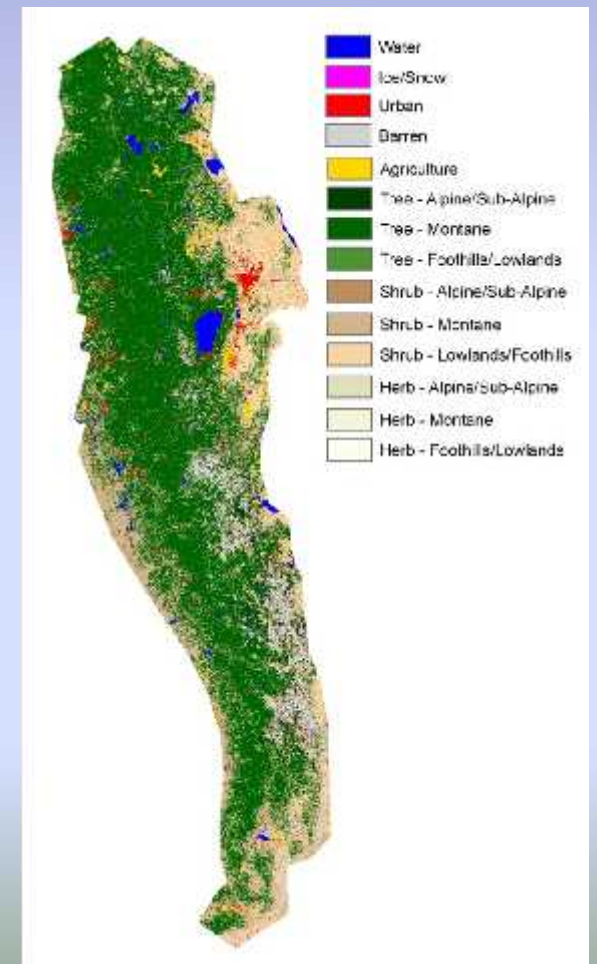
Current Methodology: EVT

Partial table of modeling groups in Zone 6 (Sierra Nevada)

Modeling Group	EVTCode	LF_EVT
11	2033	Mediterranean California Subalpine Woodland
11	2044	Northern California Mesic Subalpine Woodland
11	2058	Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland
11	2229	Pinus albicaulis Woodland Alliance
12	2011	Rocky Mountain Aspen Forest and Woodland
12	2021	Klamath-Siskiyou Lower Montane Serpentine Mixed Conifer Woodland
12	2022	Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland
12	2027	Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland
12	2028	Mediterranean California Mesic Mixed Conifer Forest and Woodland
12	2029	Mediterranean California Mixed Oak Woodland
12	2030	Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland
12	2031	California Montane Jeffrey Pine Woodland
12	2032	Mediterranean California Red Fir Forest and Woodland
12	2043	Mediterranean California Mixed Evergreen Forest
12	2061	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
12	2062	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland
12	2114	California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna
12	2230	Pinus sabiniana Woodland Alliance
12	2231	Sequoiadendron giganteum Forest Alliance
13	2017	Columbia Plateau Western Juniper Woodland and Savanna
13	2019	Great Basin Pinyon-Juniper Woodland
13	2034	Mediterranean California Mesic Serpentine Woodland and Chaparral
21	2067	Mediterranean California Alpine Fell-Field
21	2071	Sierra Nevada Alpine Dwarf-Shrubland
22	2098	California Montane Woodland and Chaparral
22	2126	Inter-Mountain Basins Montane Sagebrush Steppe
22	2220	Artemisia tridentata ssp. vaseyana Shrubland Alliance

See5* → Spatial Output

See5* → Spatial Output

See5* → Spatial Output

* **See5 predictor variables include imagery, DEM & derivative, gradient, and probability data**

Current Methodology: EVT

ERDAS Model

EVT MAP

Group 11 Spatial Output

Group 12 Spatial Output

Group 13 Spatial Output

Group 21 Spatial Output

Group 22 Spatial Output

Group … Spatial Output

Add riparian and sparse masks and spatial outputs

Existing Vegetation Cover

Existing Vegetation Height

Herbaceous	Shrubs	Trees
0-0.5 meters	0-0.5 meters	0-5 meters
0.5-1.0 meters	0.5-1.0 meters	5-10 meters
> 1 meter	1.0-3.0 meters	10-25 meters
	> 3.0 meters	25-50 meters
		> 50 meters

Mapzone 61

- Plot Data

- Final EVT

LANDFIRE Rectification Process

- Overlay ESP/EVT - export into Access
- Eliminate small combos with < 500 pixels
  - On the map and in the database
- Attribute ESP and EVT
- Overlay ESP/EVT w/ EVC/EVH - export into Access
- Review and re-assign combinations
- Export back into GIS and "remap
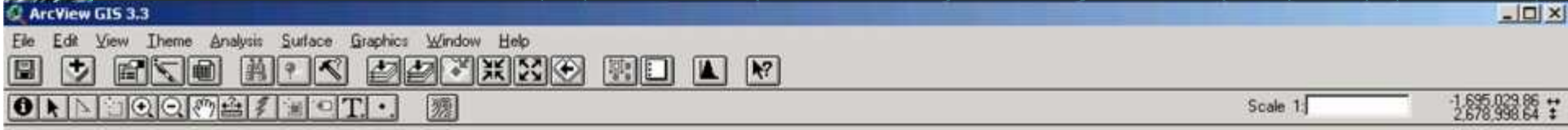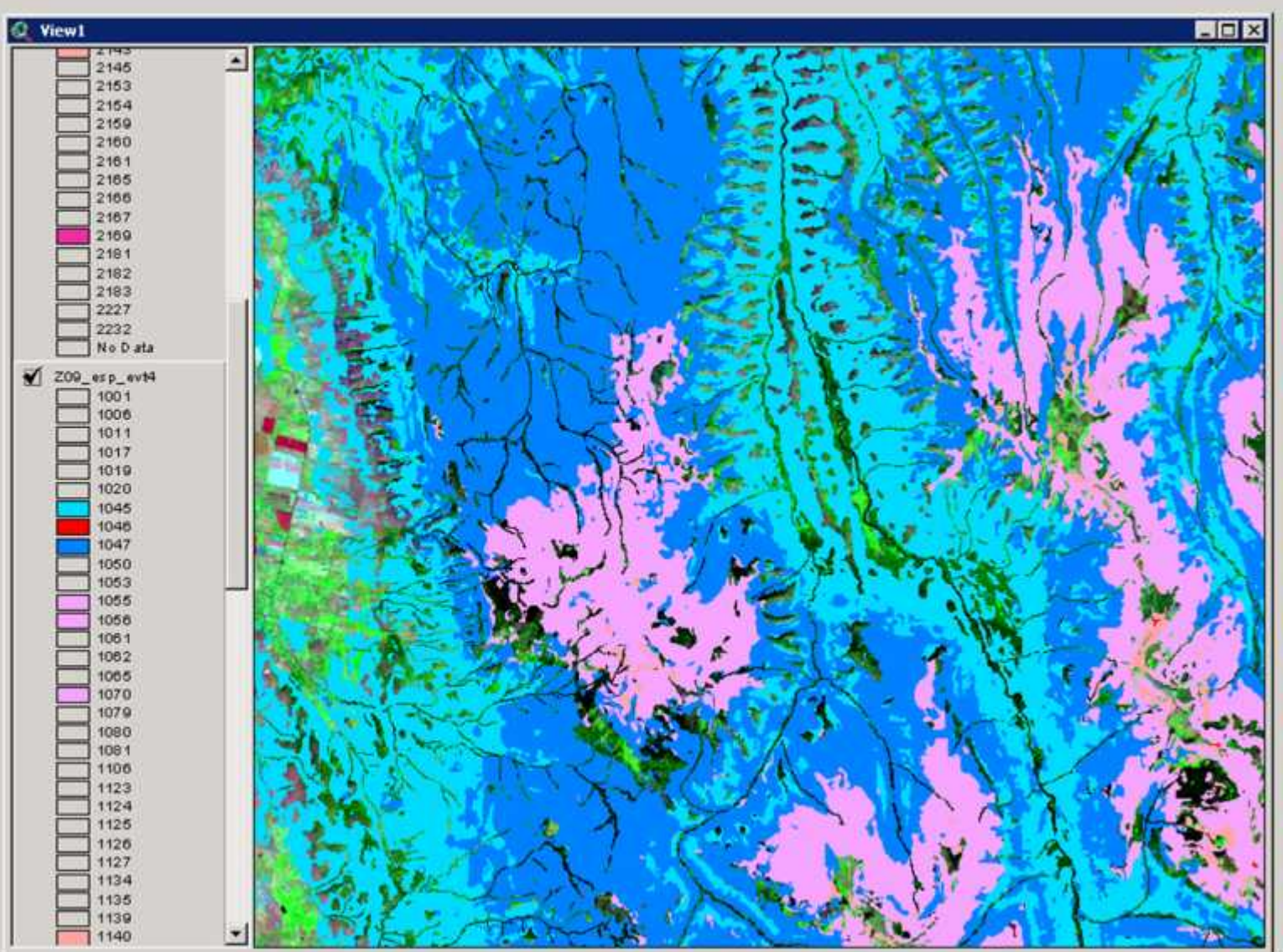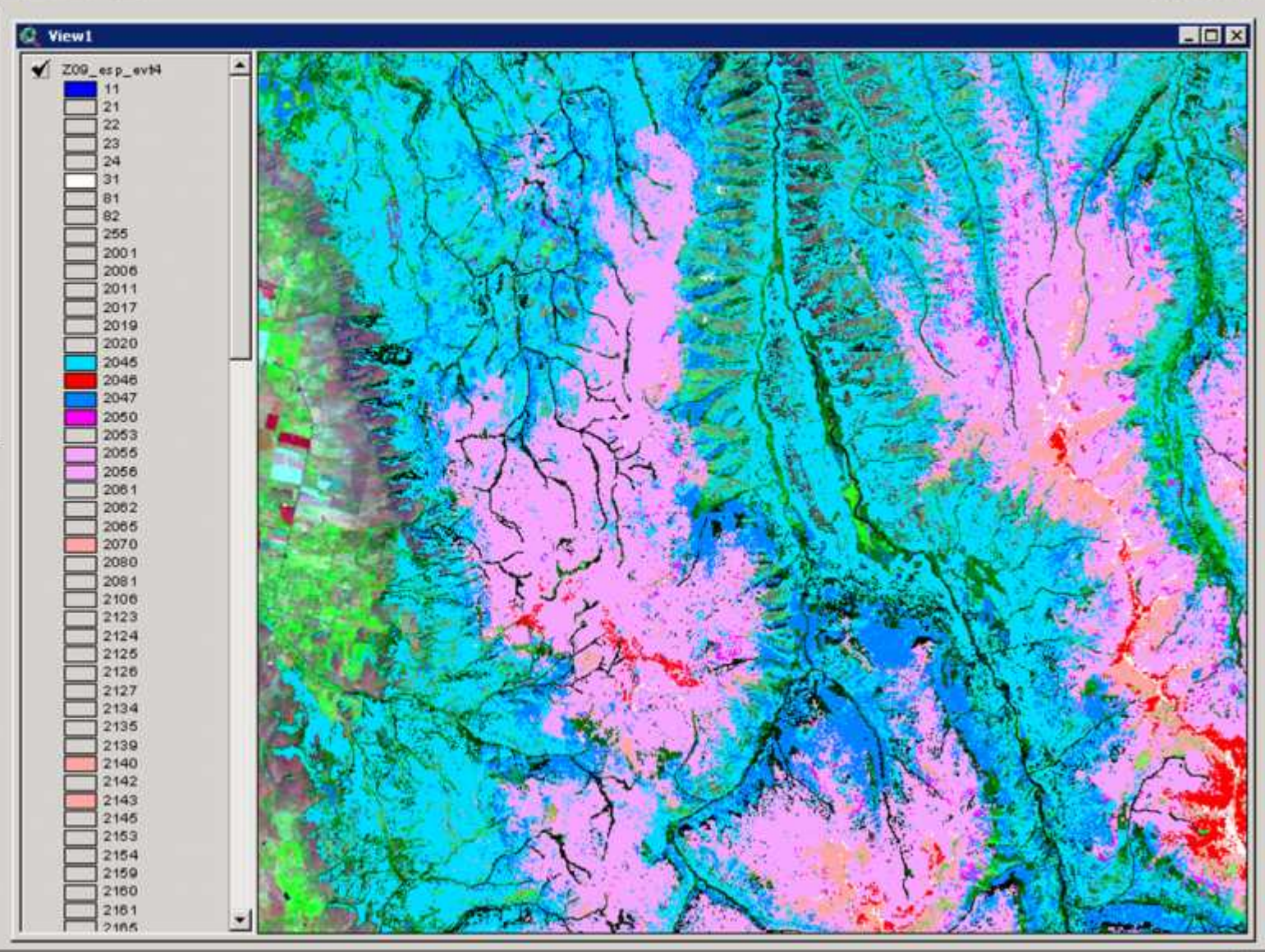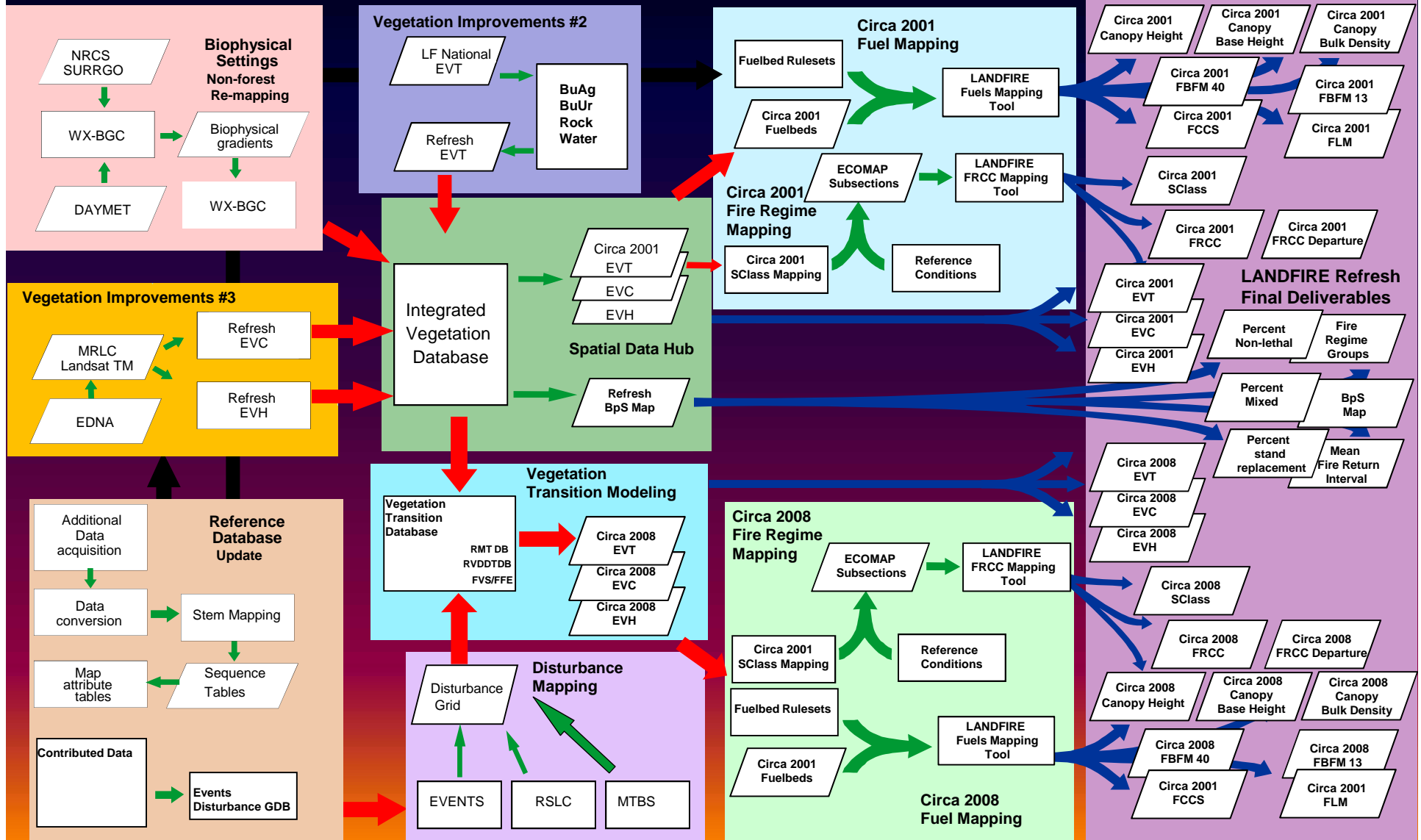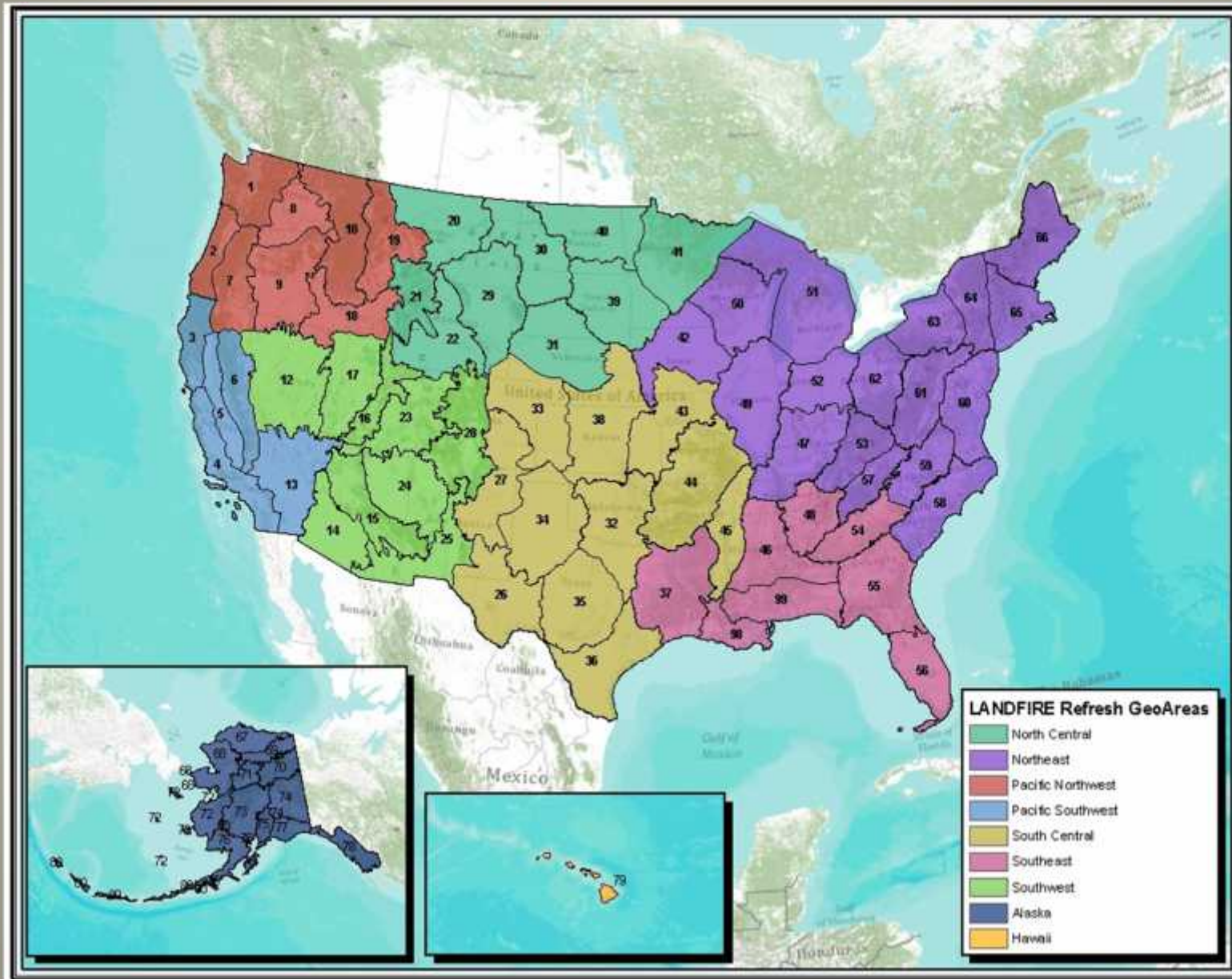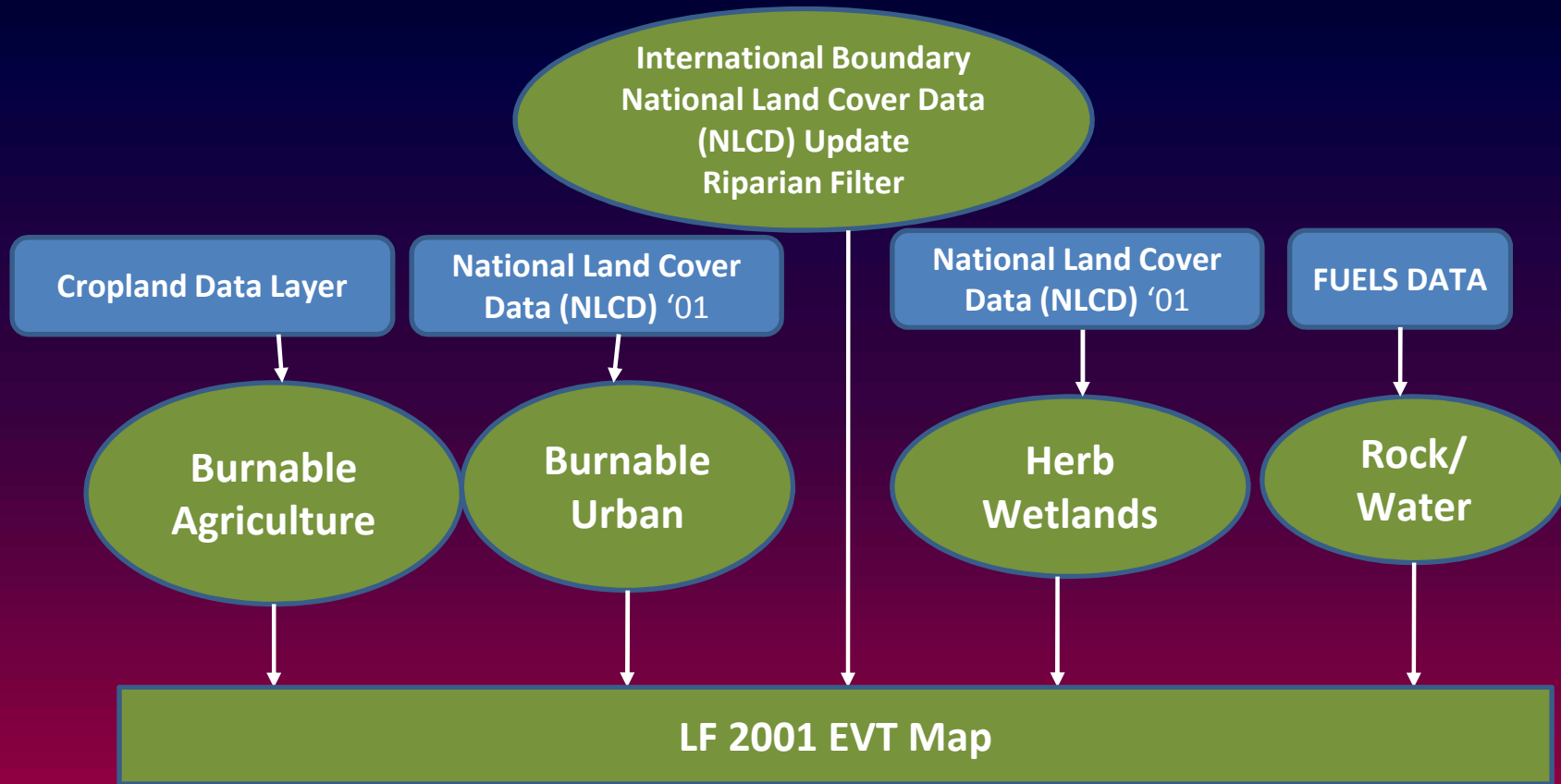
LANDFIRE 1.0.5 / 1.1.0

LF 2001 Improvements

LANDFIRE National
Existing Vegetation Height (EVH)

- Height is mapped by lifeform with decision tree models

- Modeling data include:
  - Contributed plot data
  - Landsat imagery
  - DEM & derivatives
  - Ancillary data

CONUS & Hawaii EVH Legend

Herbaceous	Shrub	Tree
0 - 0.5 m	0 - 0.5 m	0 - 5 m
0.5 - 1.0 m	0.5 - 1.0 m	5-10 m
> 1 m	1.0 - 3.0 m	10 - 25 m
	> 3.0 m	25 - 50 m
		> 50 m

USGS

Fire Modeling Institute
FireLab

LANDFIRE

LANDFIRE National
Existing Vegetation Cover (EVC)

- LANDFIRE National 2001 forest canopy cover values obtained from NLCD
- Shrub and herb cover estimated from field data representing average values at 30 m
- Regression tree modeling
- Binned into 10% class

End user observations

- Forest height values tended to be too low
- Forest canopy cover values tended to be too high
- Significant impact on fire behavior modeling systems

Remap of forest height and canopy cover for the conterminous US

LANDFIRE Refresh

- Regression tree models using FIA-derived values of forest height and canopy cover, Landsat imagery, and terrain data

- Incorporated SRTM BAW height metric (Kellndorfer *et al*. 2004 RSE)

FIA data for canopy cover

- Stem map-derived values of canopy cover (Toney et al. 2009)
  - IW-FIA used line intercept method to measure canopy cover for trees   1" diameter
  - Apply regression equations to predict crown width from stem diameter (5" diameter)
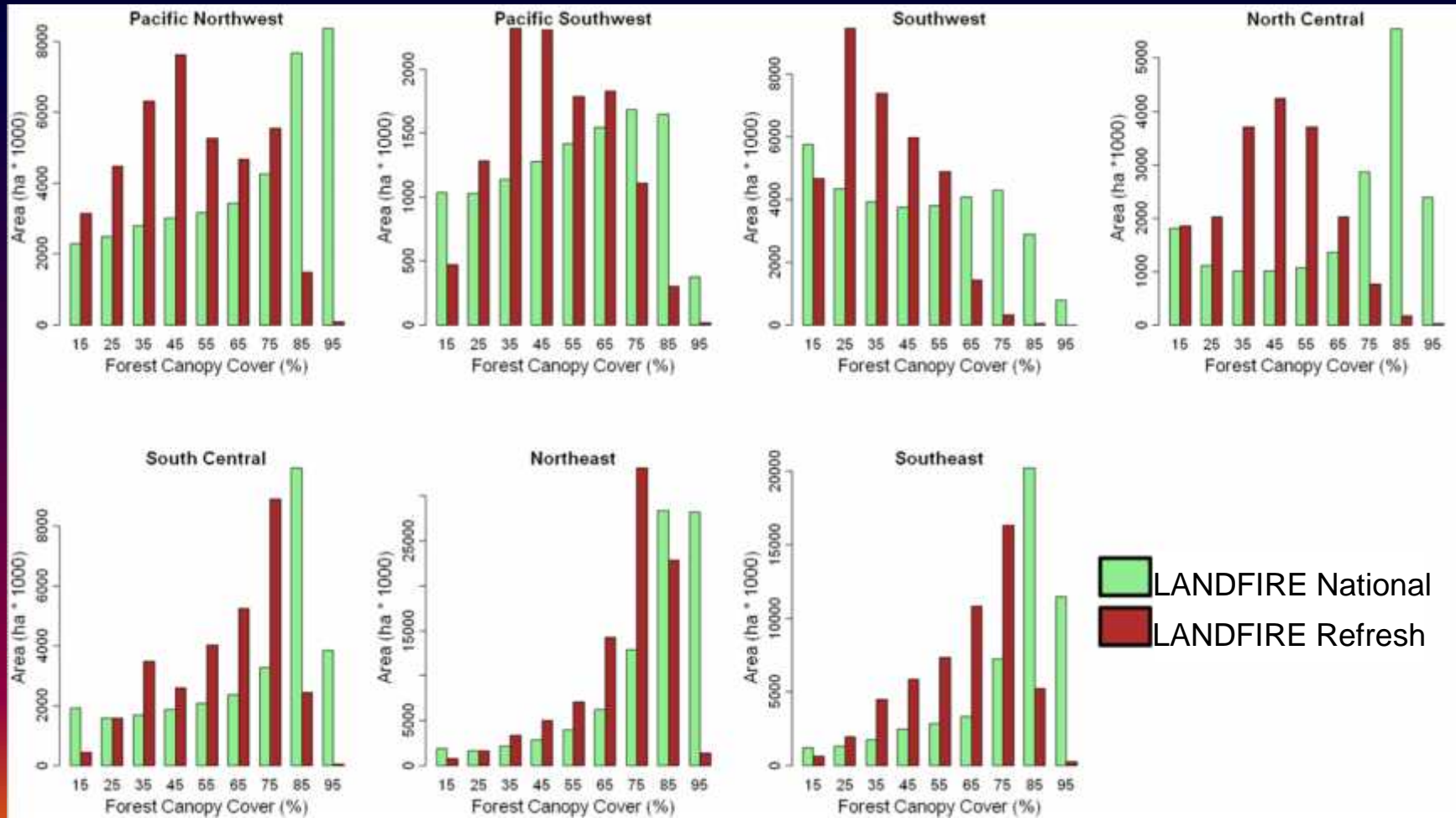 - Geometric model to estimate canopy cover from predicted tree crowns
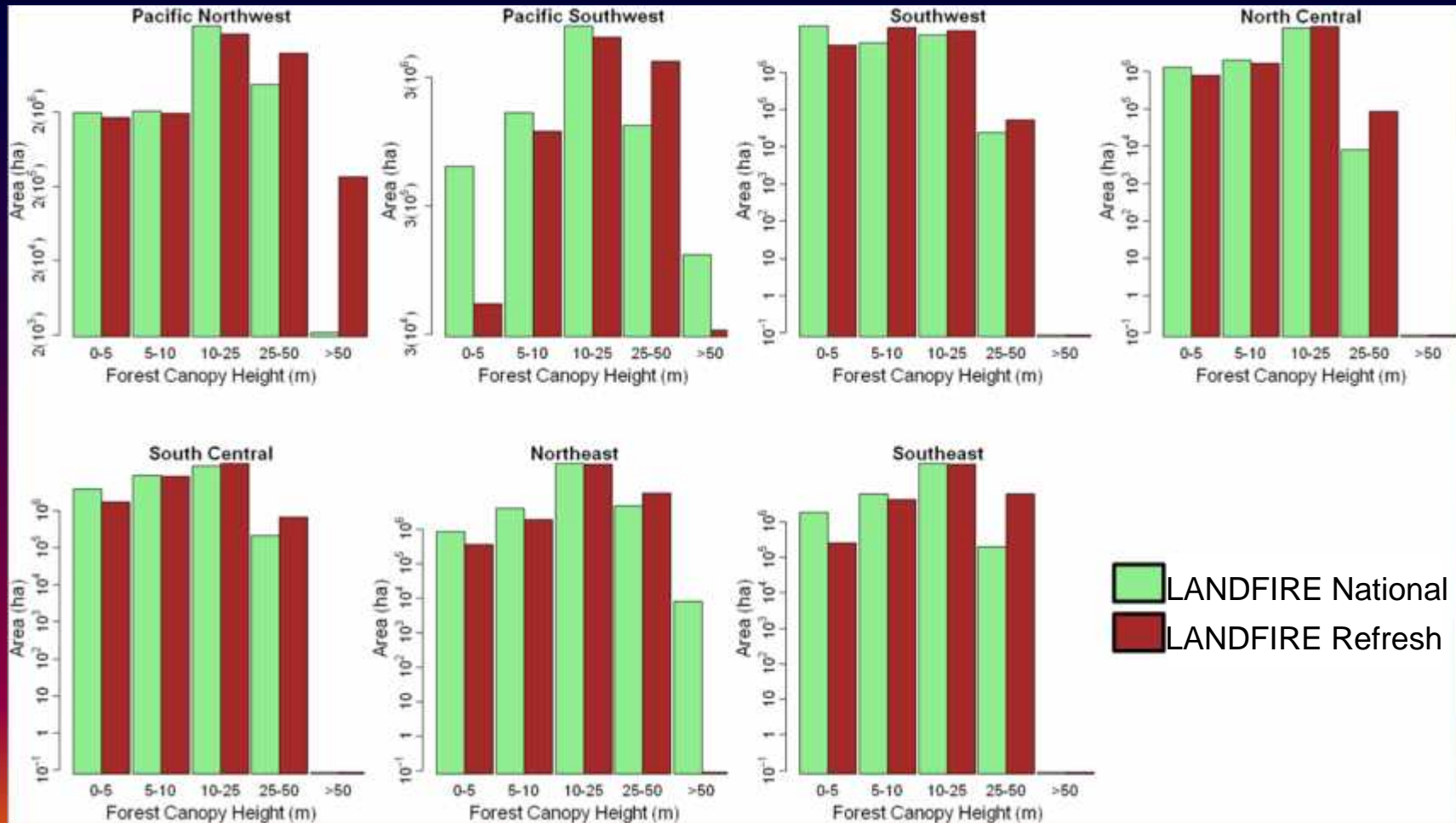
Impacts: EVH

Impacts: EVC

Updating to 2008

- Annual disturbance layers: Landsat-derived and contributed

- Existing structure updated based on pre-determined vegetation transitions

  - For forests, used FVS and FIA data to model 10 years of growth for vegetation/disturbance combinations

- FVS also implemented without incorporating disturbances to determine vegetation transitions in undisturbed areas

Updating to 2008: Data Process

- **Integrated Disturbance (VDIST)**
    - Type
    - Time Since Disturbance
- **Vegetation Transition Databases (VTDB)**
    - Forest
    - Non-forest
- **Veg Transition (VEGTRA)**
    - Combine LF 2001 EVT/EVH/EVC w/ VDIST
    - Create LF2008 EVT/EVC/EVH products

LF 2008 DISTURBANCE INTEGRATION

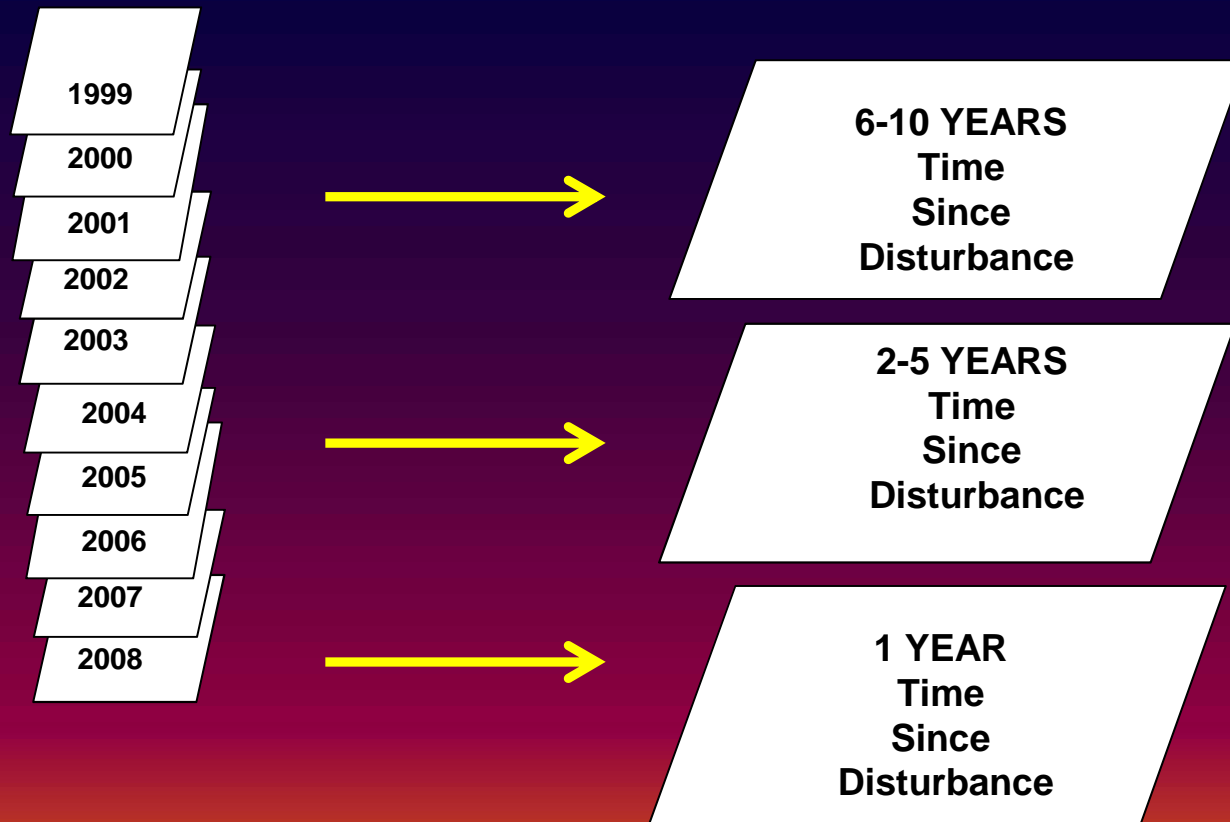| Event Code	Event Description
1	Development
2	Clearcut
3	Harvest
4	Thinning
5	Mastication
6	Other Mechanical
7	Wildfire
8	Wildland Fire Use
9	Prescribed Fire
10	Wildland Fire
11	Weather
12	Insecticide
13	Chemical
14	Insects
15	Disease
16	Insects/Disease
17	Herbicide
18	Biological

- **Disturbance Type**
  - Fire
  - Mechanical Remove
  - Mechanical Add
  - Windthrow
  - Insects and Disease
  - Chemicals
  - Herbicide

LF 2008 DISTURBANCE INTEGRATION

1999
2000
2001
2002
2003
2004
2005
2006
2007
2008

6-10 YEARS
Time
Since
Disturbance

2-5 YEARS
Time
Since
Disturbance

1 YEAR
Time
Since
Disturbance

USGS

Fire Modeling Institute
FireLab

LANDFIRE

Non-forest VTDB

- Non forest EVT succession to forest EVT, EVH, EVC
- High severity fire, mechanical remove to non-forest EVT, EVH, EVC
- Non-forest EVT fire (shrub to grass, grass to grass)
- Non-forest EVT mechanical add & remove
- Non-forest EVT chemical/herbicide
- VDDT SClass A EVC/EVH
- Mapzone summaries drive rules

Forest VTDB

- Run all plots through FVS-FFE
- Acquire new cover and height
- Bin into EVC and EVH classes
- Group output at 2 levels of EVT
- Find majority outcome
- Make forest tables
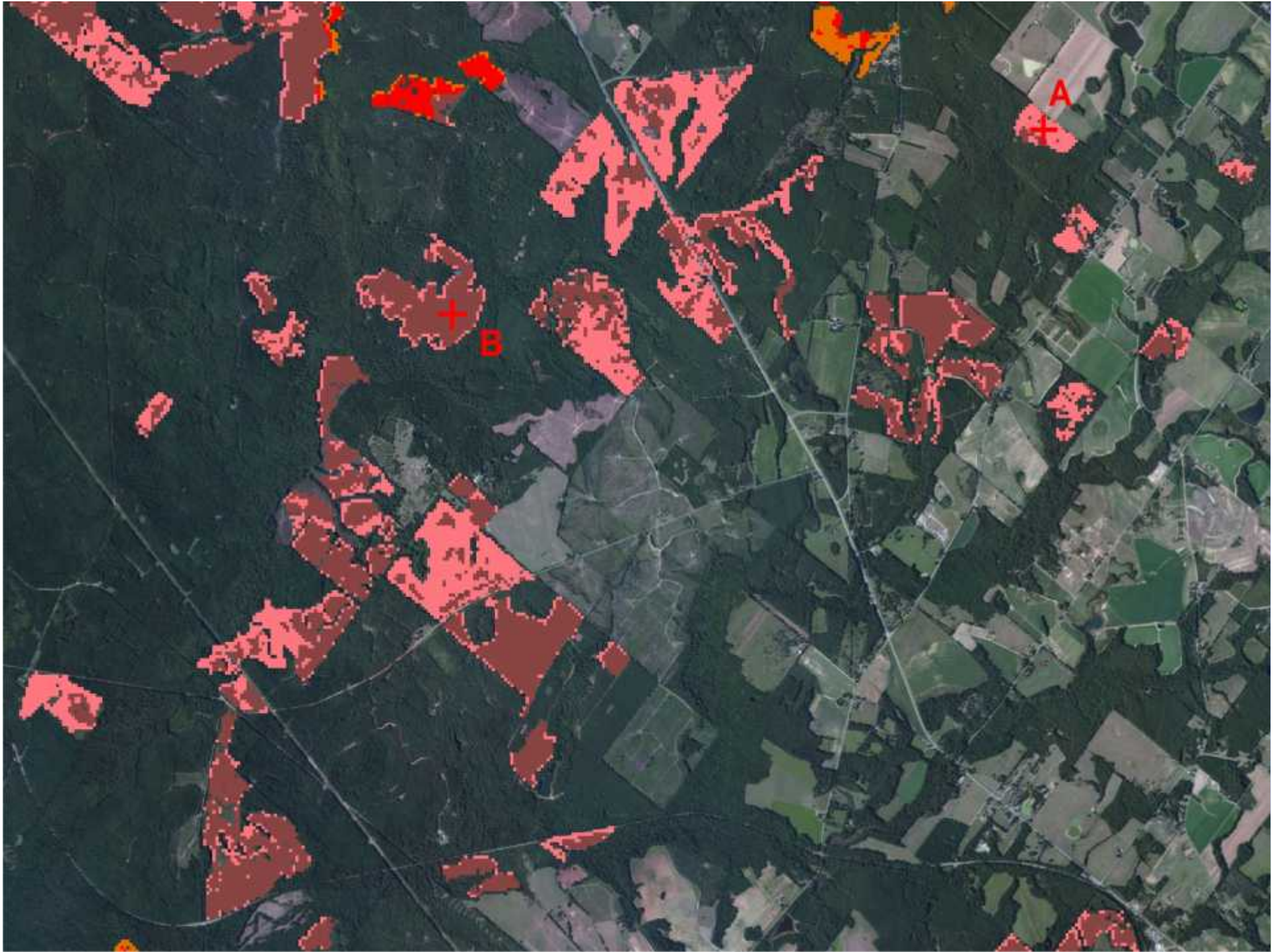
FVS/FFE SIMULATION PARAMETERS

- **Mechanical Remove**
  - **High: Clearcut and burn**
  - **Moderate: Remove 35% stand density; pile and burn**
  - **Thin from below in 0-6"; pile and burn**
- **Mechanical Add**
  - **Cut 90%, 75%, and 55% of 0-8" then masticate**
- **Fire**
  - **Target 95%, 75%, and 45% mortality**
- **Insects and Disease**
  - **85%, 55%, and 10% fixed mortality**
- **Windthrow**
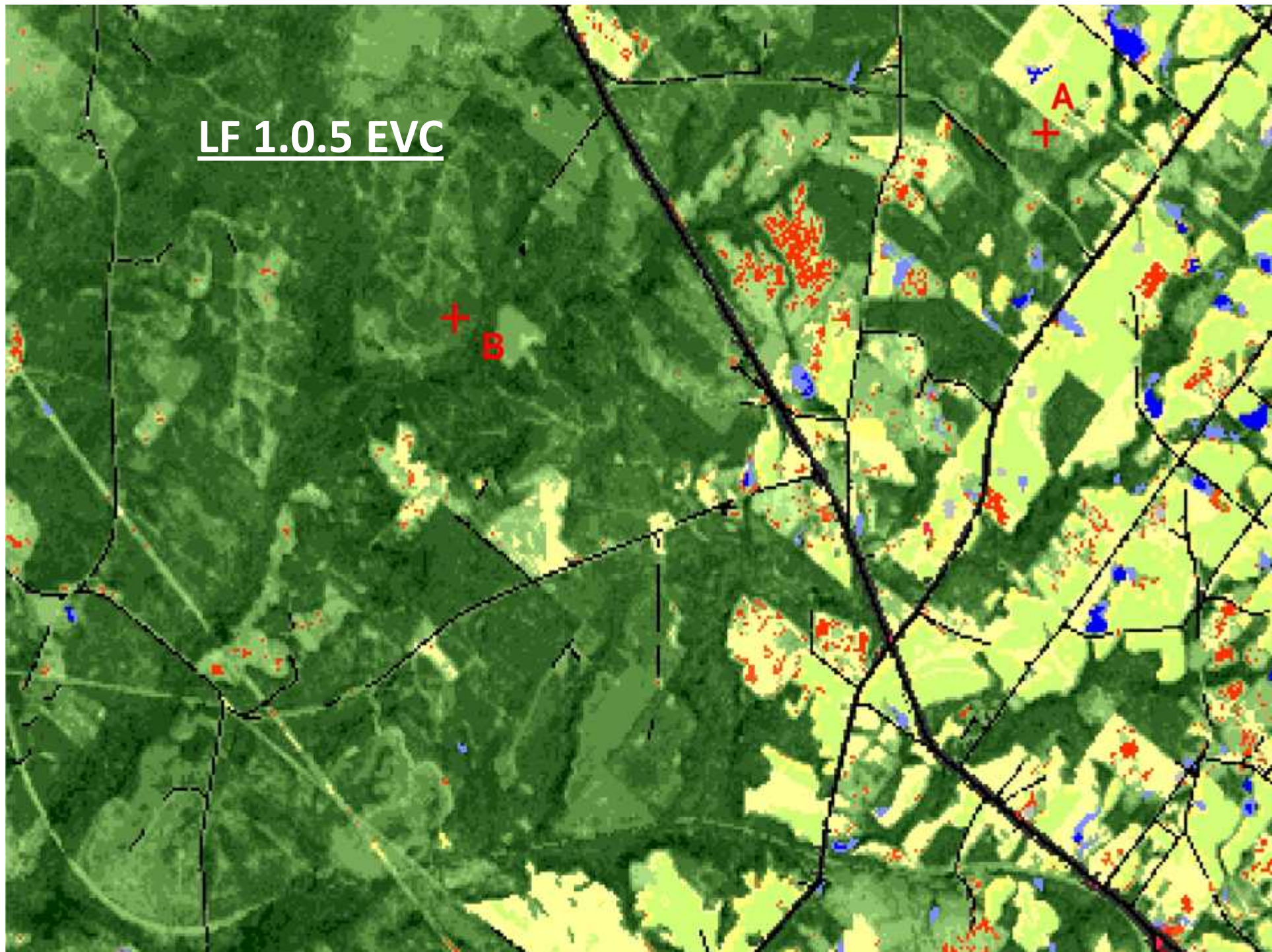 - **Thin 85%, 55%, and 10% of stand and leave on the ground**

- **VEGTRA process**
  - **Overlay VDIST w/2001 Veg**
  - **Import overlay data**
  - **Import non-forest tables**
  - **Import forest tables**
  - **Format & test update queries**
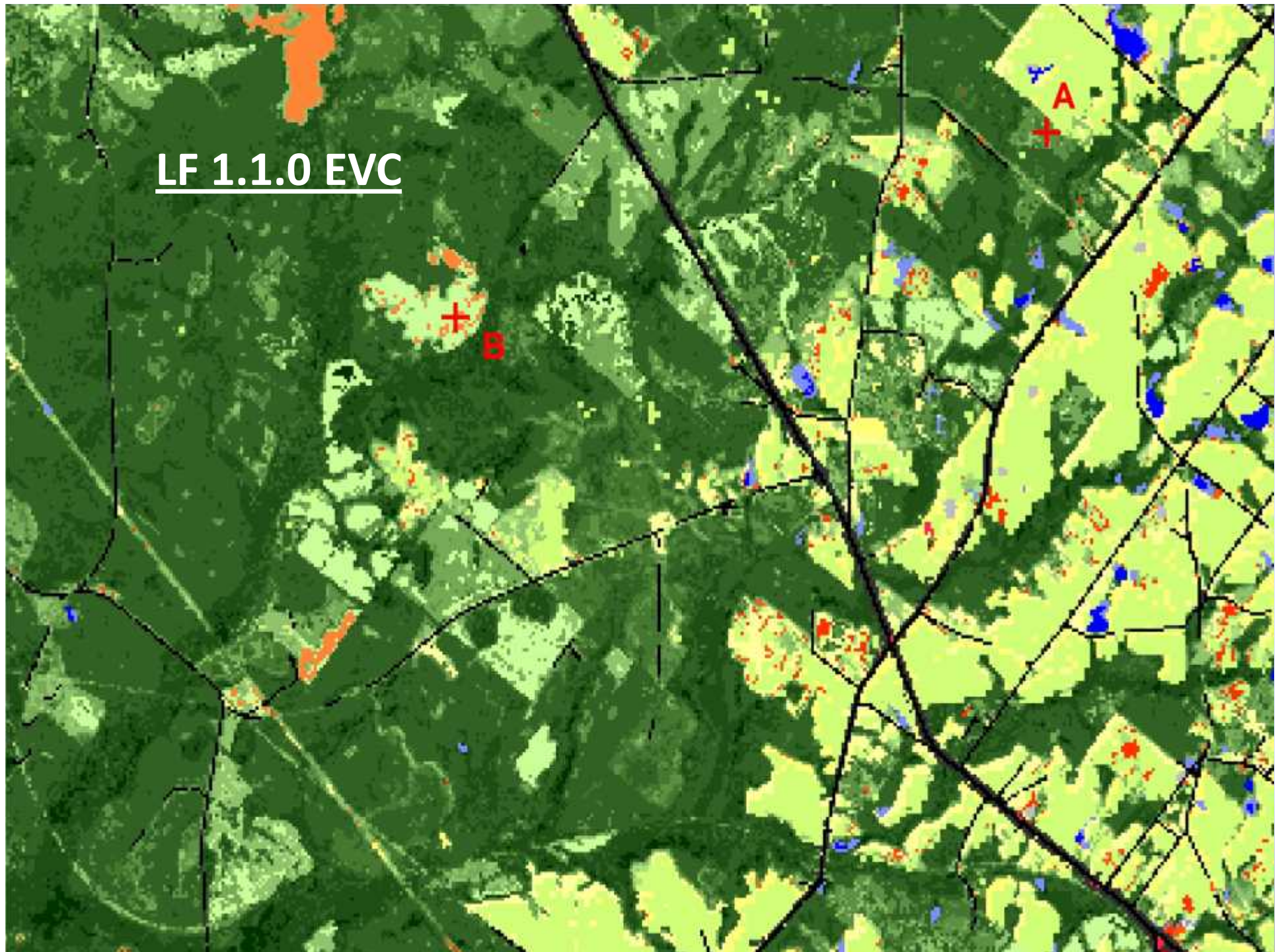 - **Run update queries**
  - **Export vegtrans dbf**
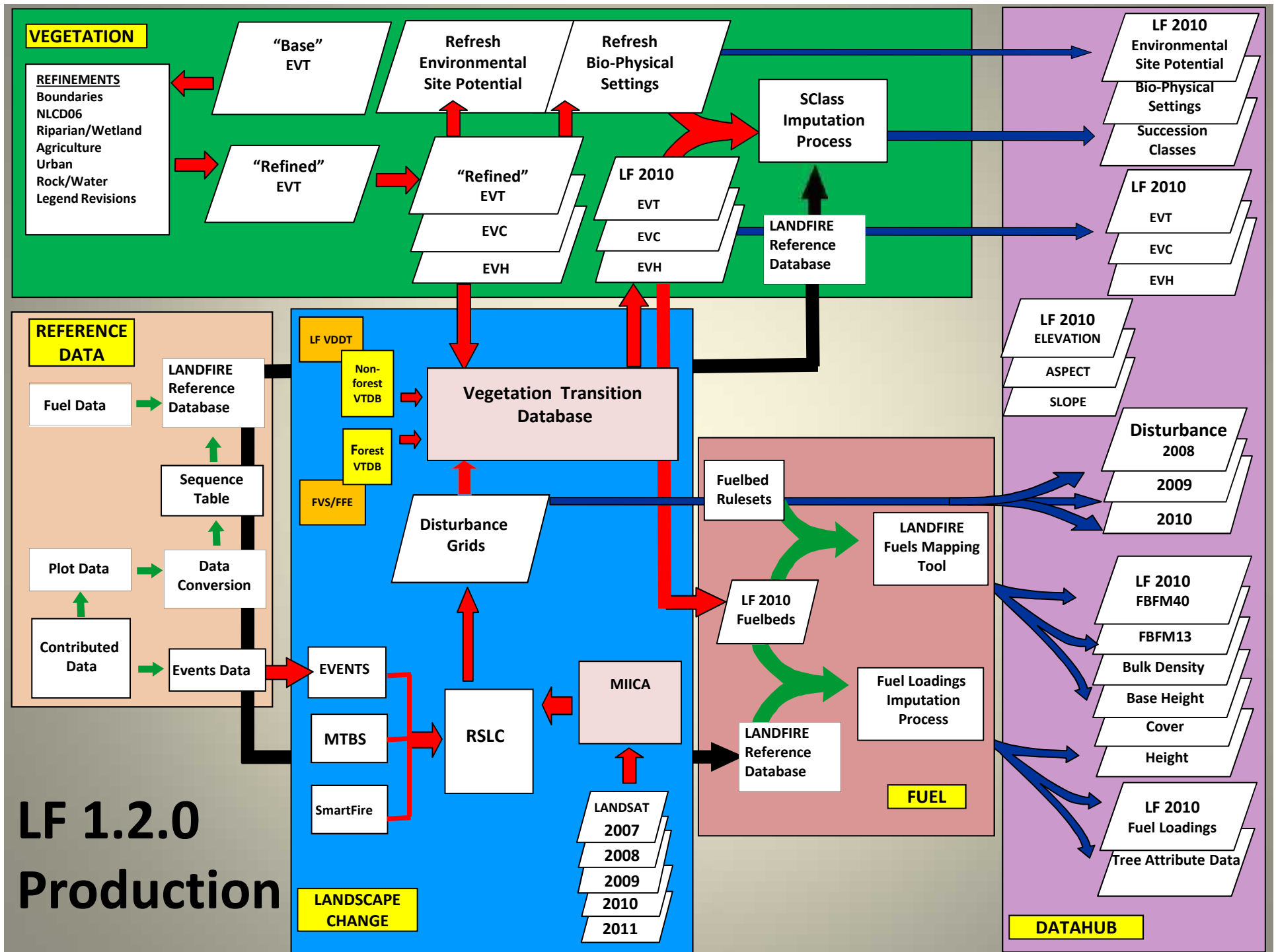 - **Create EVEG08 grids**
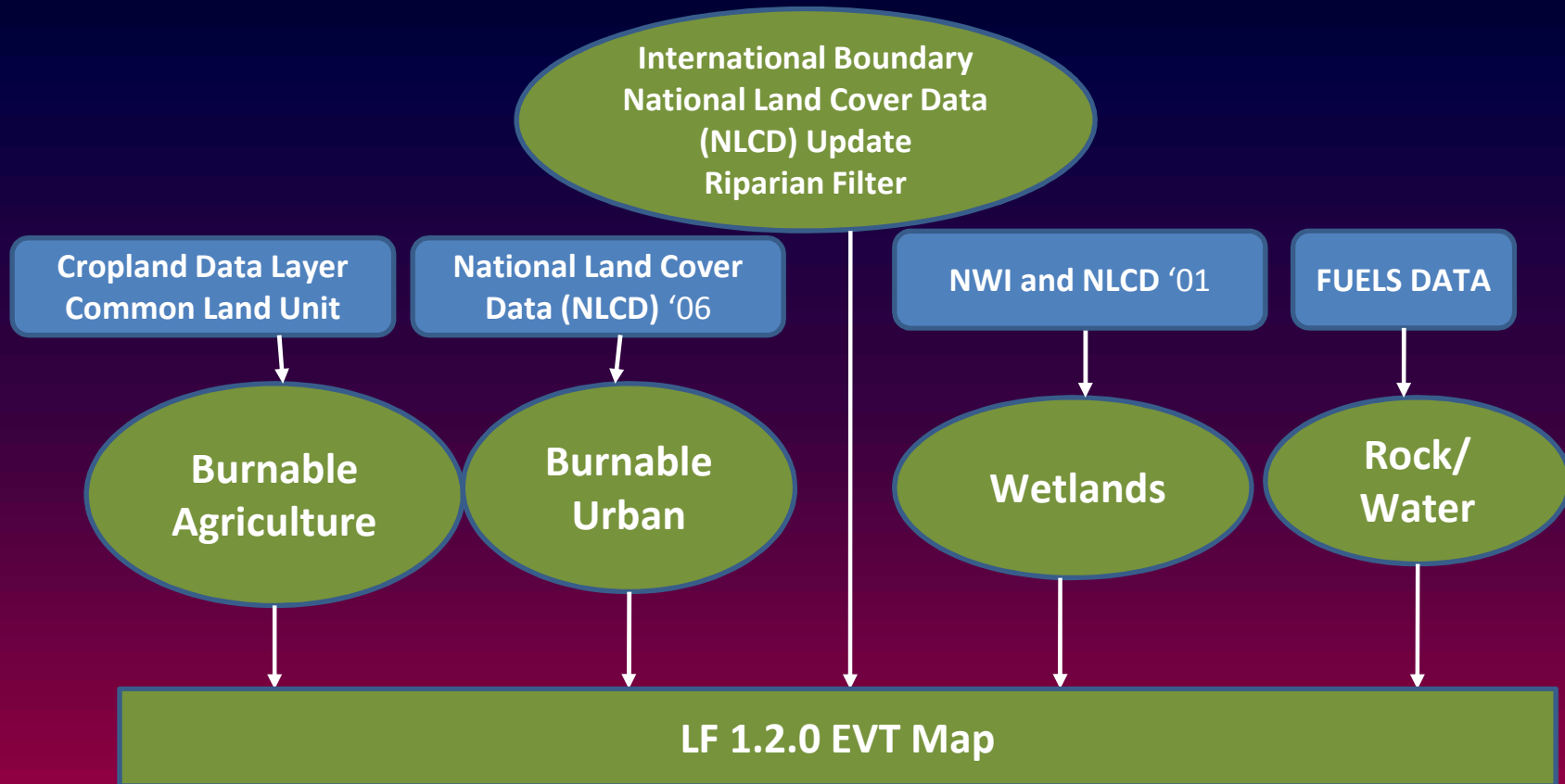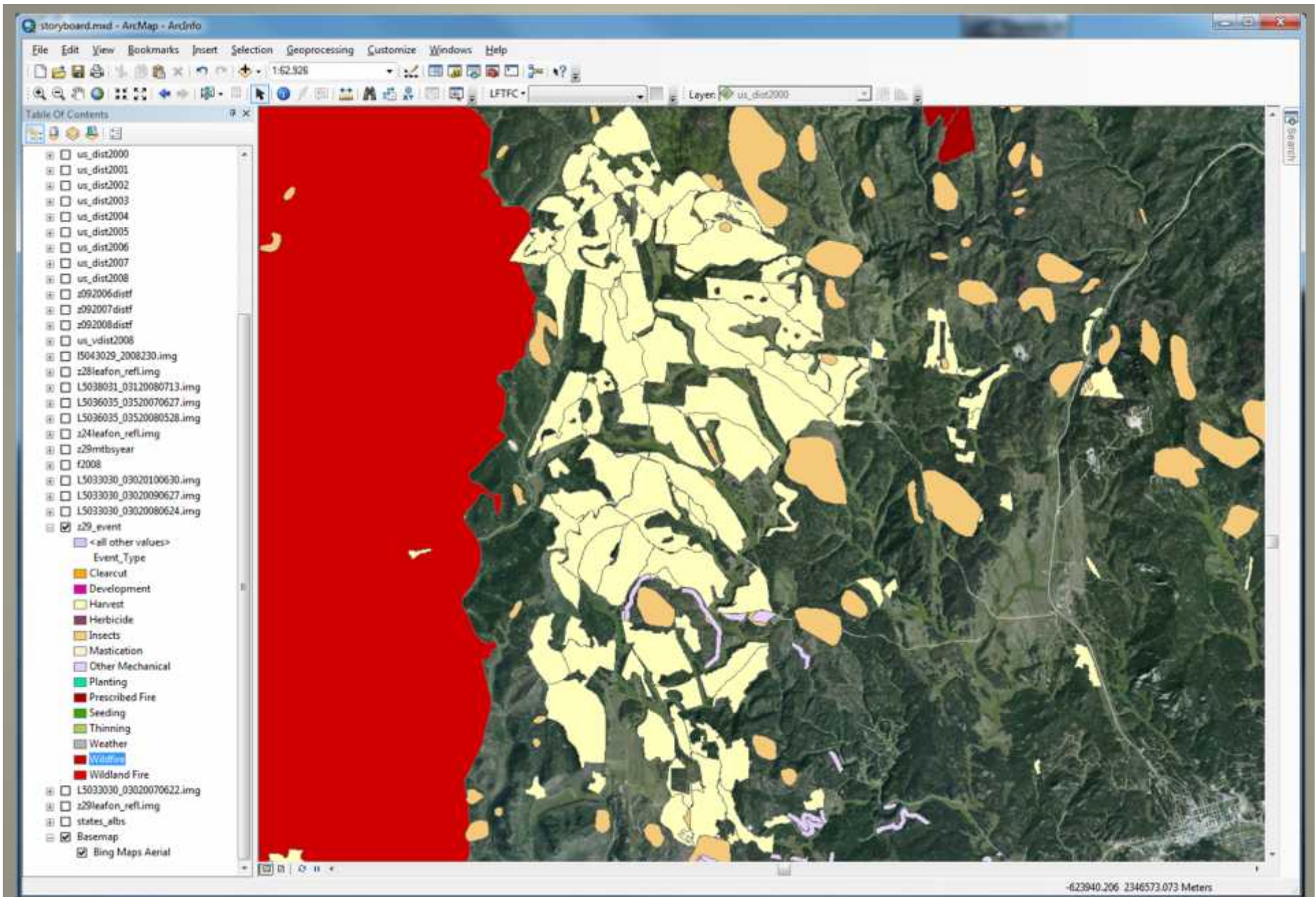
LF 1.0.5 EVC

LF 1.1.0 EVC

LF 1.2.0 Production — LANDFIRE data production workflow diagram

VEGETATION

"Base" EVT

REFINEMENTS
Boundaries
NLCD06
Riparian/Wetland
Agriculture
Urban
Rock/Water
Legend Revisions

"Refined" EVT

Refresh Environmental Site Potential

Refresh Bio-Physical Settings

"Refined" EVT / EVC / EVH

LF 2010 EVT / EVC / EVH

SClass Imputation Process

LANDFIRE Reference Database

REFERENCE DATA

Fuel Data

LANDFIRE Reference Database

Sequence Table

Plot Data

Data Conversion

Contributed Data

Events Data

LANDSCAPE CHANGE

LF VDDT

Non-forest VTDB

Forest VTDB

FVS/FFE

Vegetation Transition Database

Disturbance Grids

EVENTS

MTBS

SmartFire

RSLC

MIICA

LANDSAT
2007
2008
2009
2010
2011

FUEL

Fuelbed Rulesets

LF 2010 Fuelbeds

LANDFIRE Fuels Mapping Tool

LANDFIRE Reference Database

Fuel Loadings Imputation Process

DATAHUB

LF 2010
Environmental Site Potential
Bio-Physical Settings
Succession Classes

LF 2010
EVT
EVC
EVH

LF 2010
ELEVATION
ASPECT
SLOPE

Disturbance
2008
2009
2010

LF 2010
FBFM40
FBFM13
Bulk Density
Base Height
Cover
Height

LF 2010
Fuel Loadings
Tree Attribute Data

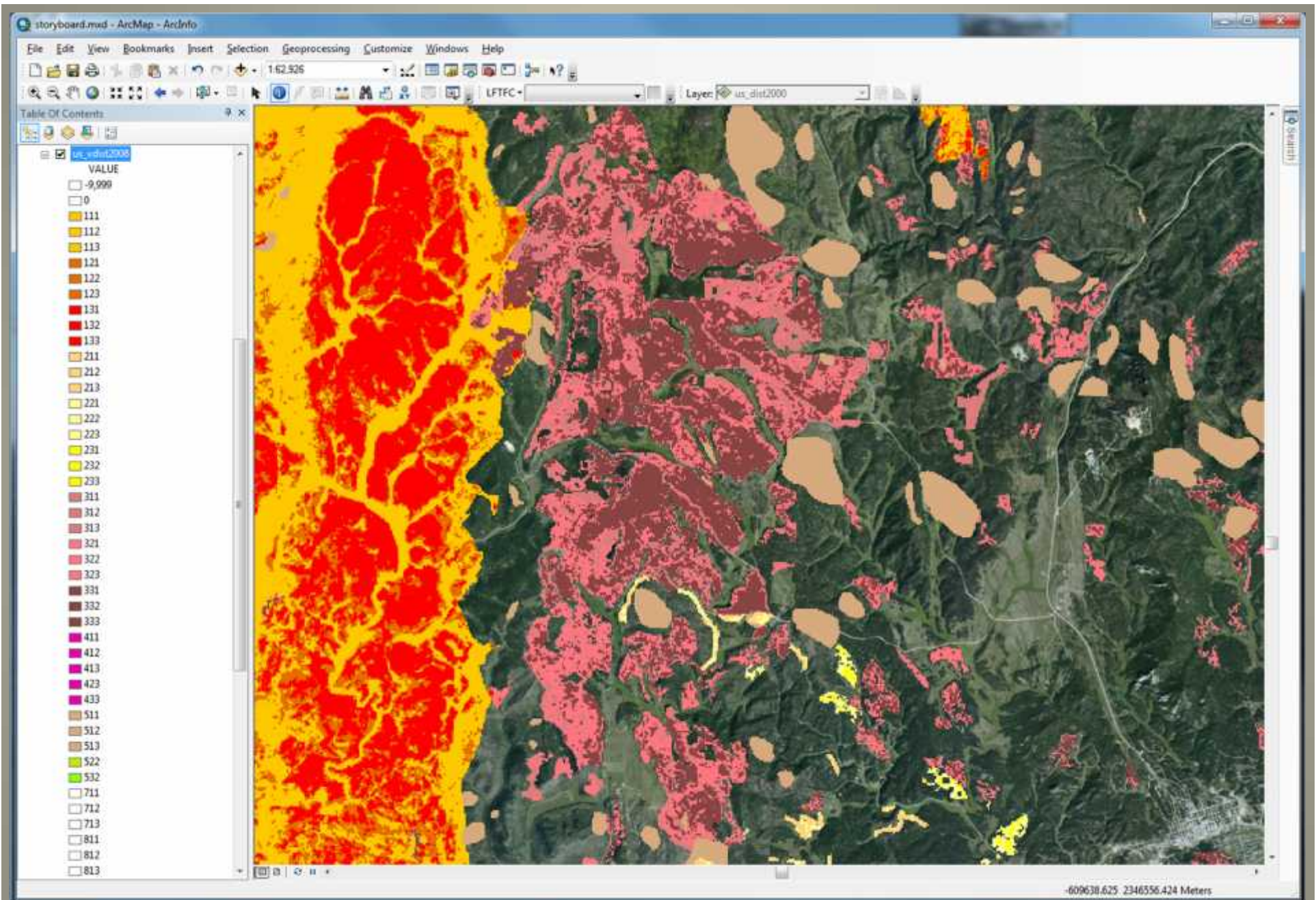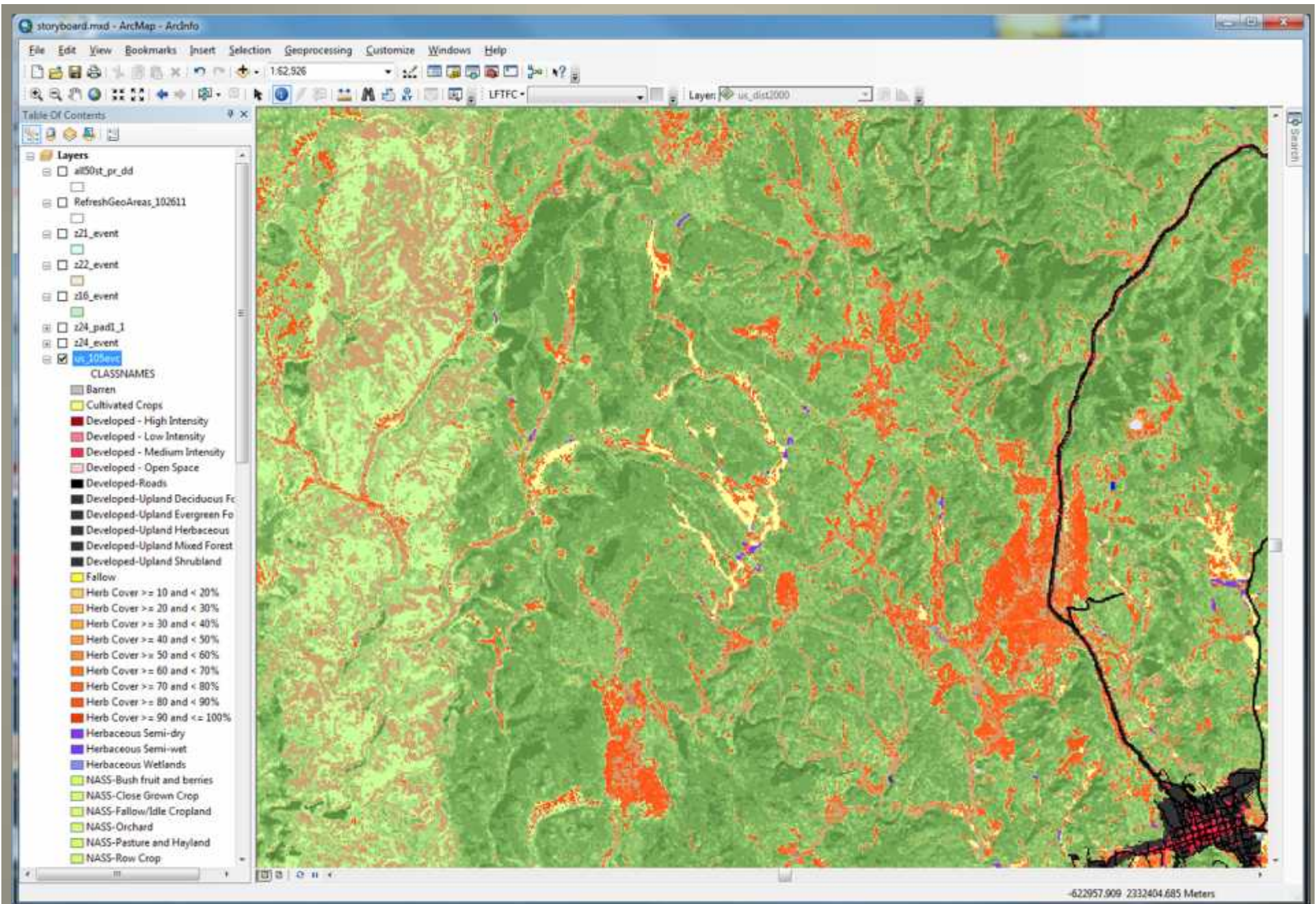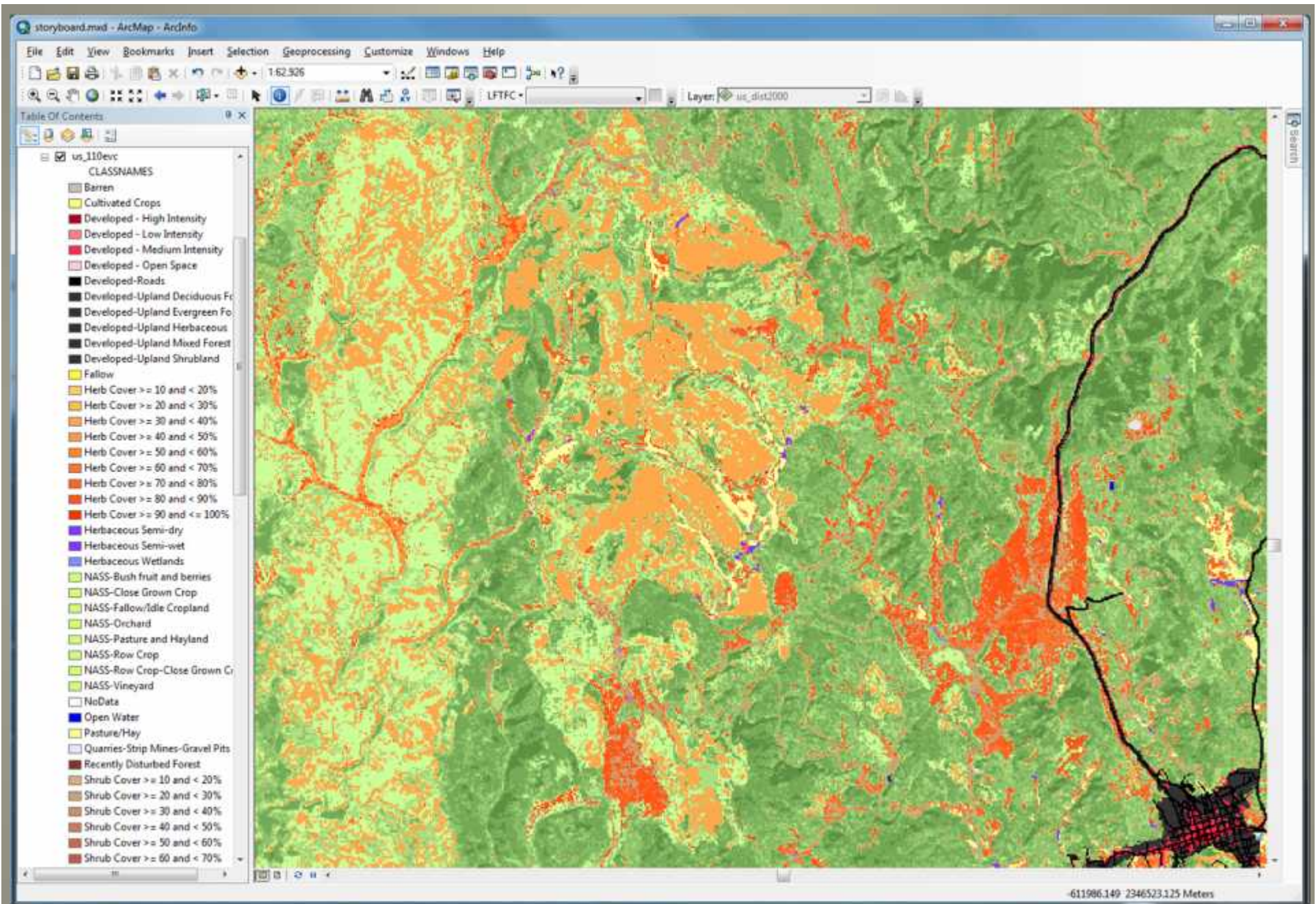# LF 1.2.0

Events data – Fire (red), Harvest (yellow) and Insect (brown)

VegDist – with severity association

EVC - 01

EVC -08

LANDFIRE REMAP
Historical and Future Context

LANDFIRE National Project

$39 Million Six Years

Prototype → Map Zone Production

Data Distribution

Tech. Transfer, Communication

Informal O&M

Approved O&M Program

LANDFIRE PROGRAM

Data Distribution & Access

Technical Transfer, User Support, Communication

Rapid Refresh

Updates to LF National

LF 2001 / 2008

LF 2010

LF 2012

$7.4 Million Two Years

$6.5 Million Two Years

Estimate $4 Million 1.5 Years

LANDFIRE REMAP?

FY03   FY05   FY07   FY09   FY11   FY13   FY15   FY17

May 2014, D. Oates

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