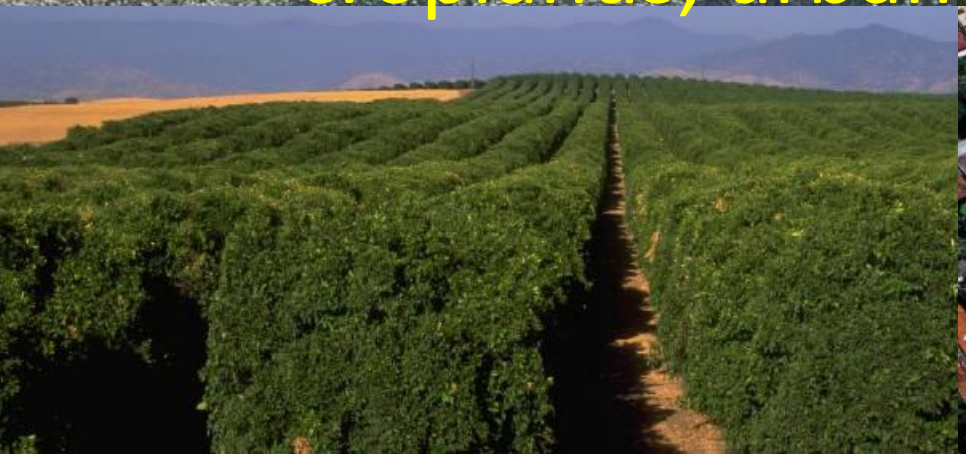
# Natural & Working Lands Update

Ecosystem carbon stocks,
stock-change + attribution
for forests and other lands
& work in progress:
croplands, urban forests, and soils




# Today's Menu

- Natural Lands (NL) inventory results for Scoping Plan
  - sources and methods
  - results
- Inventory publication
- Other work in progress (to support SB 859)
  - croplands, urban forests, soils
- Discussion

# Natural & Working Land (N&WL) Inventory Design Principles

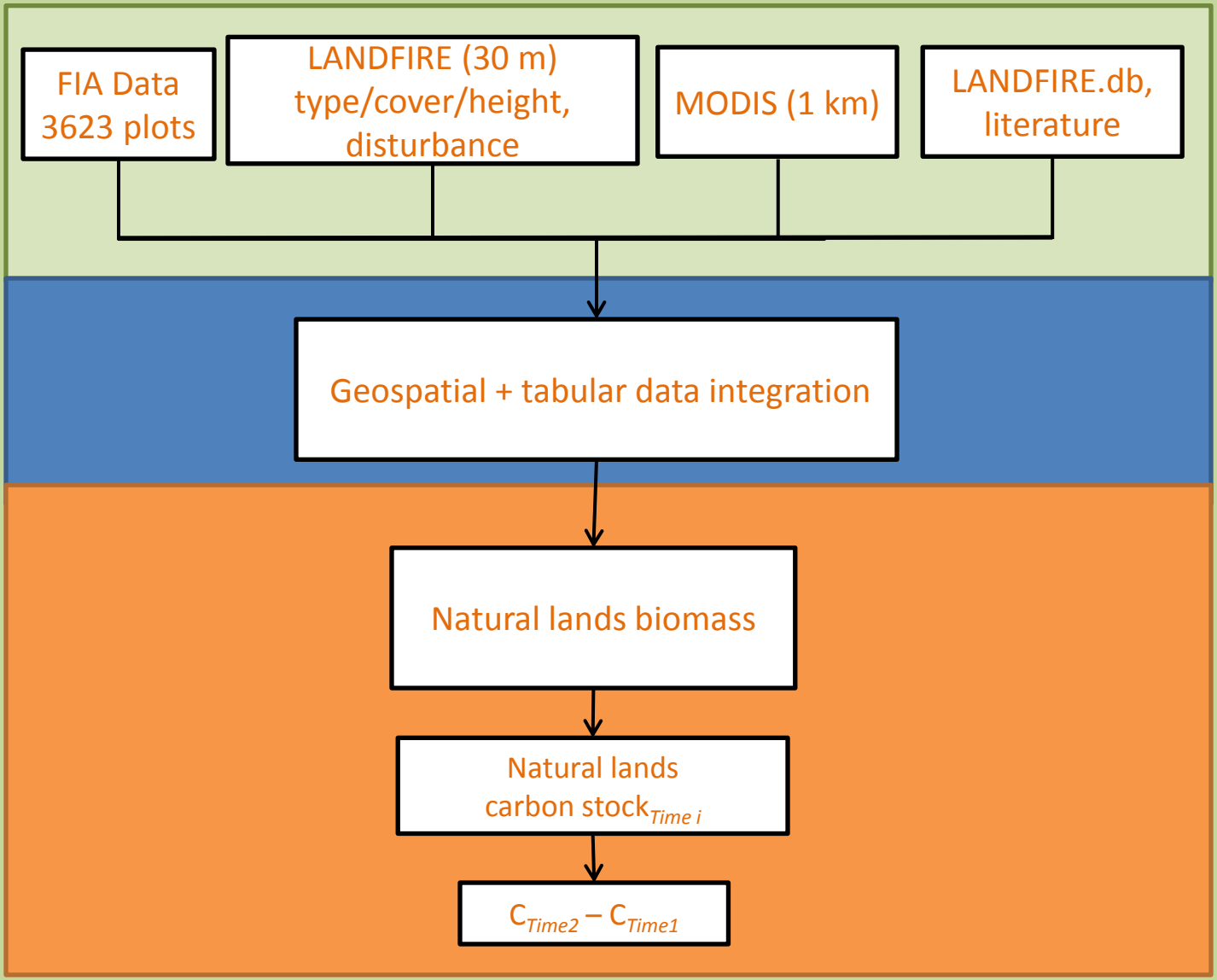
- Explicit geospatial coverage of land base statewide
- Repeat observations to detect change over time
- Continuity of data into the future
- Publically available data
- Moderate to fine spatial resolution
- Transferable (in-house use, other states)
- IPCC framework & categories for AFOLU* sector

* AFOLU = IPCC Sector 3: Agriculture, Forestry and Other Land Use

# Natural Lands Approach

- Adapted from Gonzalez et al. (2015)
- Analysis period 2001 - 2010
- Spatial data: LANDFIRE, MODIS NPP
  - Vegetation type
  - Vegetation canopy cover
  - Height
- Forest biomass: USDA-FS FIA plots
- Non-forest biomass: LANDFIRE, literature
- ARB enhancements:
  - account for forest growth undetected by satellite
  - stock-change attribution by disturbance process
  - default carbon densities (croplands)
  - harvested wood products

# NL Inventory Data & Methods Overview



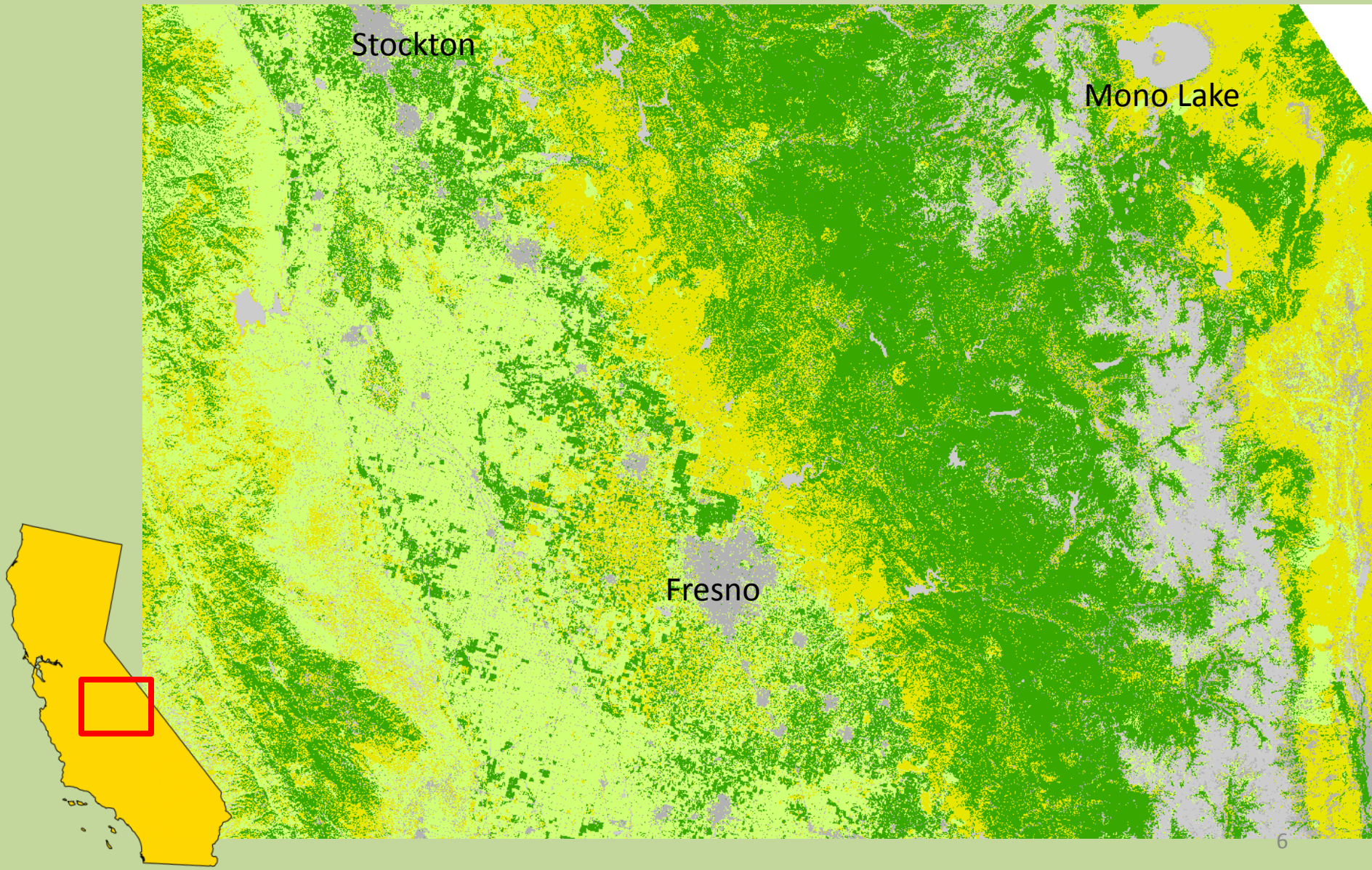

**Data**

**Methods**

*Gonzalez et al. 2015, LandfireC (ARB)*

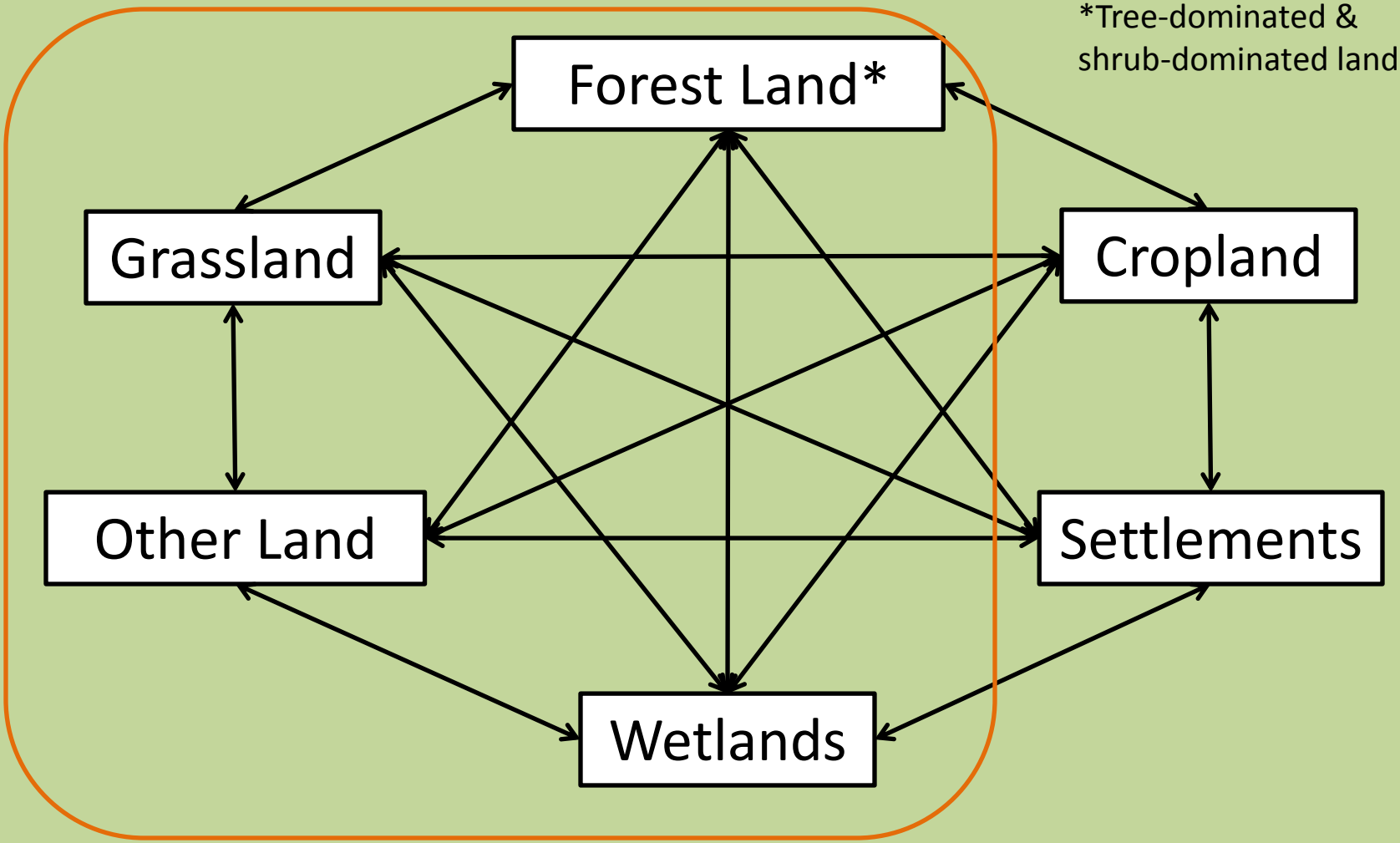
**Products**

# LANDFIRE Vegetation Layer: Vegetation Type



# IPCC Conceptual Framework:

## stasis vs transition

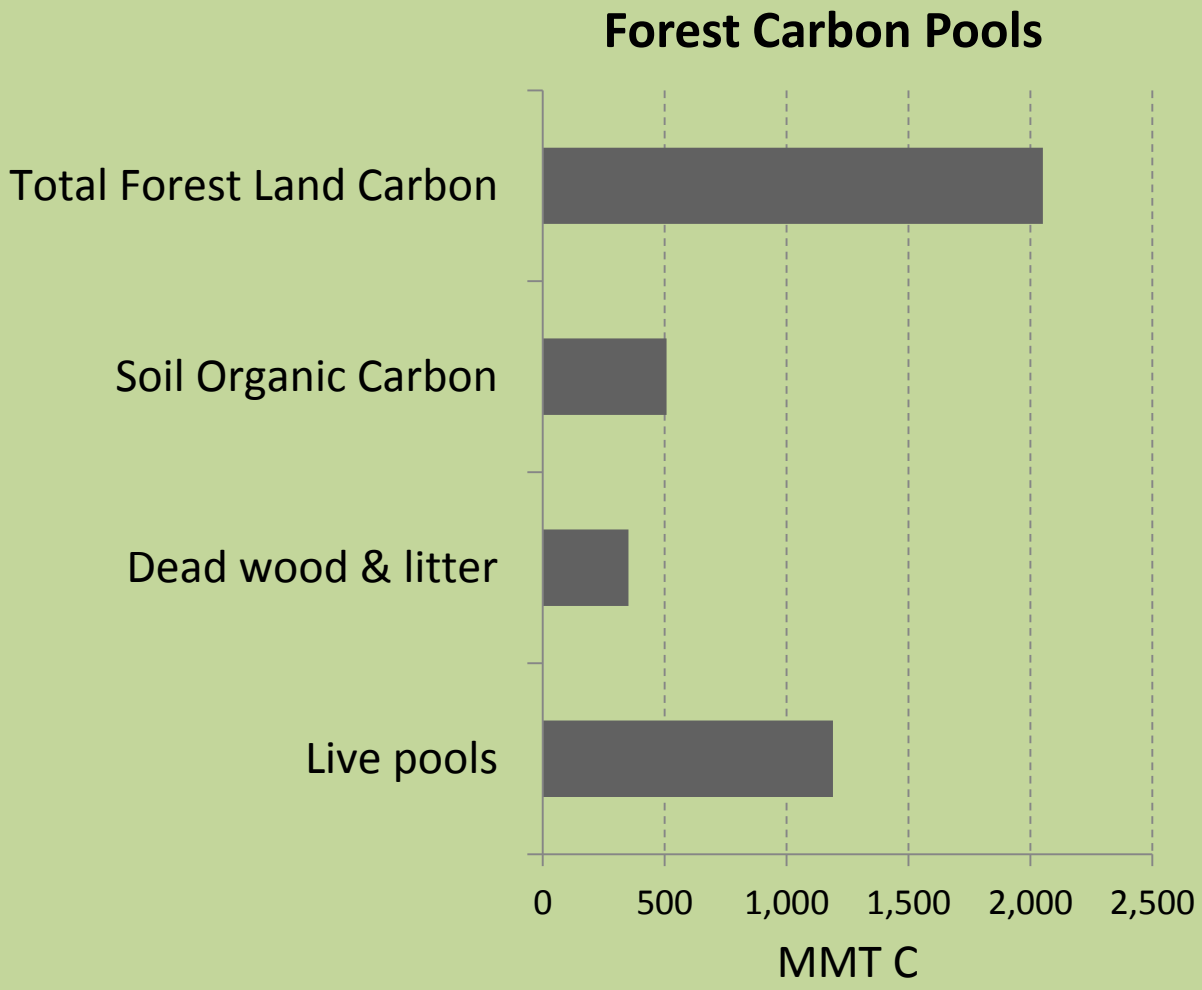



35 categories + 4 natural biomass burning (3C) + wood products (3D)

# Carbon Pools

Above-ground biomass
- Mature trees
- Understory trees
- Shrubs
- Grasses and herbs

Below-ground biomass
Dead wood
Litter
Soil organic matter
Wood products




*Forest Carbon Estimation. On-line query http://www.fia.fs.fed.us/forestcarbon/default.asp

# IPCC AFOLU Categories

Carbon stock change due to changes in land use and land cover type →

**3B Land**
3B1 Forest Land*
3B2 Cropland
3B3 Grassland
3B4 Wetlands
3B5 Settlements
3B6 Other Land
**includes land dominated by shrubs*

Emissions from wildfire & prescribed fire →

**3C Aggregate Sources and Non-$CO_2$ Emissions Sources on Land**
*includes (natural lands) biomass burning*

Wood product →

**3D Other Agriculture, Forestry and Land Use**
*includes wood product emissions*

**Reference: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Agriculture, Forestry and Other Land Use. National Greenhouse Gas Inventories Programme. Eggleston H., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds). Institute for Global Environmental Strategies, Hiyama, Japan.**

# Stock-difference Method

carbon stocks, *Time 1*

100 Mg

carbon stocks, *Time 2*

1000 Mg

$$C\ stocks_{Time2} - C\ stocks_{Time1}$$

$$= 1000 - 100 = 900\ Mg$$

# Natural Lands: Results

# Forest Land Carbon Stocks

## Above Ground Live

| MMT C | 95% CI | Source | Vintage |
|---|---|---|---|
| 840* | ± 210 | Gonzalez et al. (2015) | 2010 |
| 891.7* | ± 223 | LandfireC (ARB) | 2010 |
| | | | |
| **Other estimates** | | | |
| **MMT C** | **95% CI** | **Source** | **Vintage** |
| *948.6*** | *± 237* | LandfireC (ARB)* | 2010 |
| 990 | *not reported* | USDA-FS[1] | 2014 |
| 1,014.4 | ± 26.3 | USDA-FS[2] | *Decadal Average* 2001-2010 |

*Gonzalez & LandfireC estimate assumes biomass C fraction = 0.47 ± 0.0235 (McGroddy et al. 2004)

**ARB estimate converted to FIA convention (assumes biomass C fraction = 0.5)

[1]Forest Carbon Estimation. On-line query http://www.fia.fs.fed.us/forestcarbon/default.asp

[2]California's Forest Resources: Forest Inventory and Analysis, 2001-2010. (2016) General Technical Report PNW-GTR-913. Table A2-79.

# Natural Lands Stock-Change

## Changes in Above Ground Live carbon stocks (MMT C) 2001 - 2010

| 2001 | 2010 | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Forests | Grasslands | Wetlands | Croplands | Settlements | Other Lands |
| | Forests | 17.5 ± 6* | -35.44 | | -1.54 | -0.11 | -4.65 |
| | Grasslands | 0.38 | 0.34 | | -0.11 | -0.01 | -0.02 |
| | Wetlands | 0.89 | 0.03 | 0.00 | -0.05 | 0.00 | 0.00 |
| | Other Lands | 0.01 | 0.00 | | 0.00 | 0.00 | 0.01 |
| | Croplands, Settlements | TBD | | | | | |

*Ecosystem budget sign convention: gains (+), losses (-)*

*1.9 ± 0.7 MMT C / year, annualized rate

2.6 MMT C / year, 1993-2009 annualized rate (draft FCP, Appendix tables 6 & 7)

-23 MMT C, sum of "forest related"

-39 ± 14 MMT C, western U.S. forests 1986 – 2004

**Powell S., Cohen W., Kennedy R., Healey S., Huang C. (2014) Observations of trends in biomass loss as a result of disturbance in the conterminous U.S.: 1986-2004. Ecosystems (17), 142-157.**

# Natural Lands Stock-Change Categories

Changes in Total* carbon stocks (MMT C) 2001 - 2010

| | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|
| | | Forests | Grasslands | Wetlands | Croplands | Settlements | Other Lands |
| 2001 | Forests | -16.8** | -112.49 | | -7.54 | -0.52 | -22.46 |
| | Grasslands | 3.45 | 1.75 | | -0.19 | -0.02 | -0.09 |
| | Wetlands | 4.19 | 0.14 | 0.00 | 0.12 | 0.03 | -0.01 |
| | Other Lands | -0.07 | | -0.01 | 0.02 | | 0.03 |
| | Croplands, Settlements | TBD | | | | | |

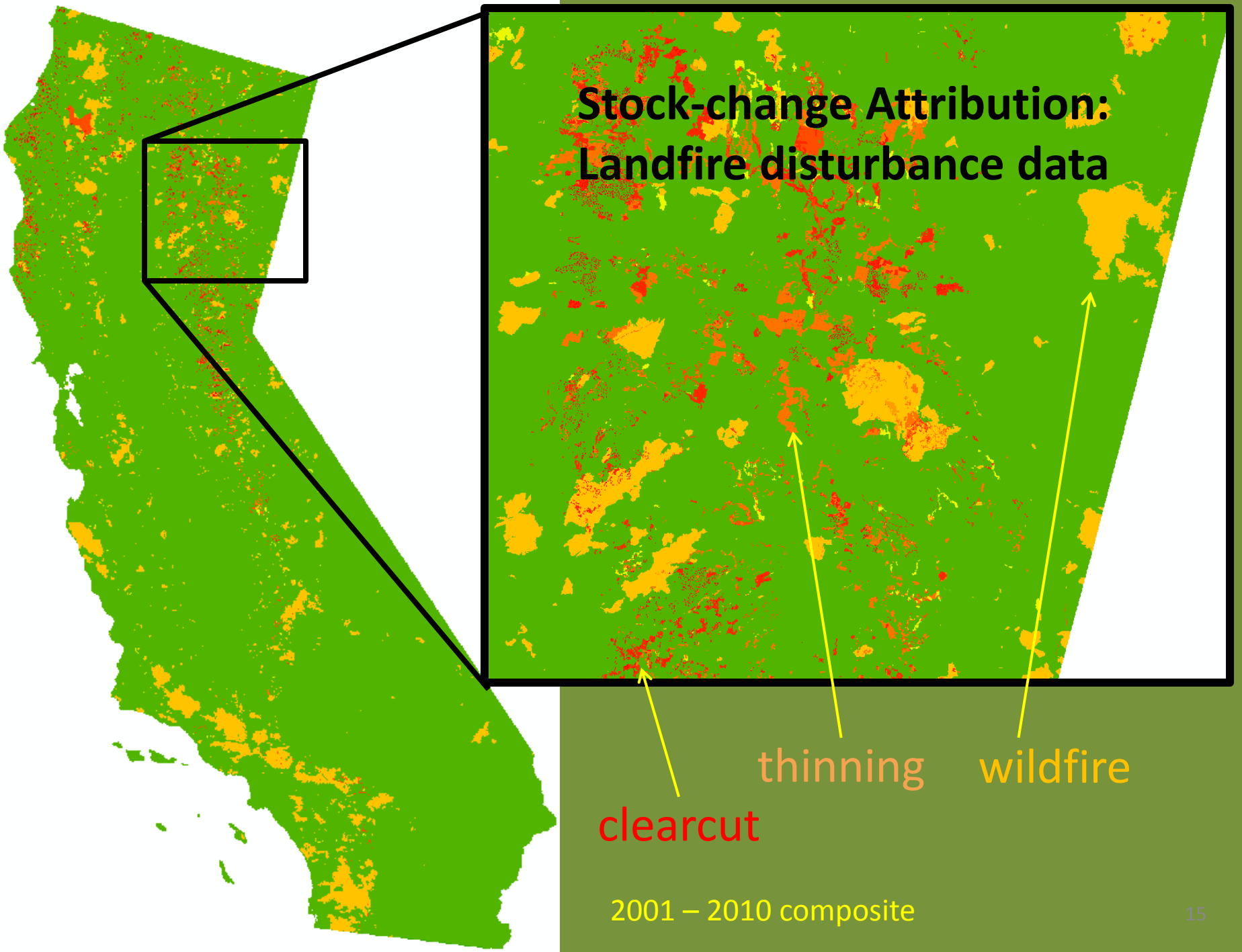
*Ecosystem budget sign convention: gains (+), losses (-)*

**Annualized rate: -1.9 MMT C / year

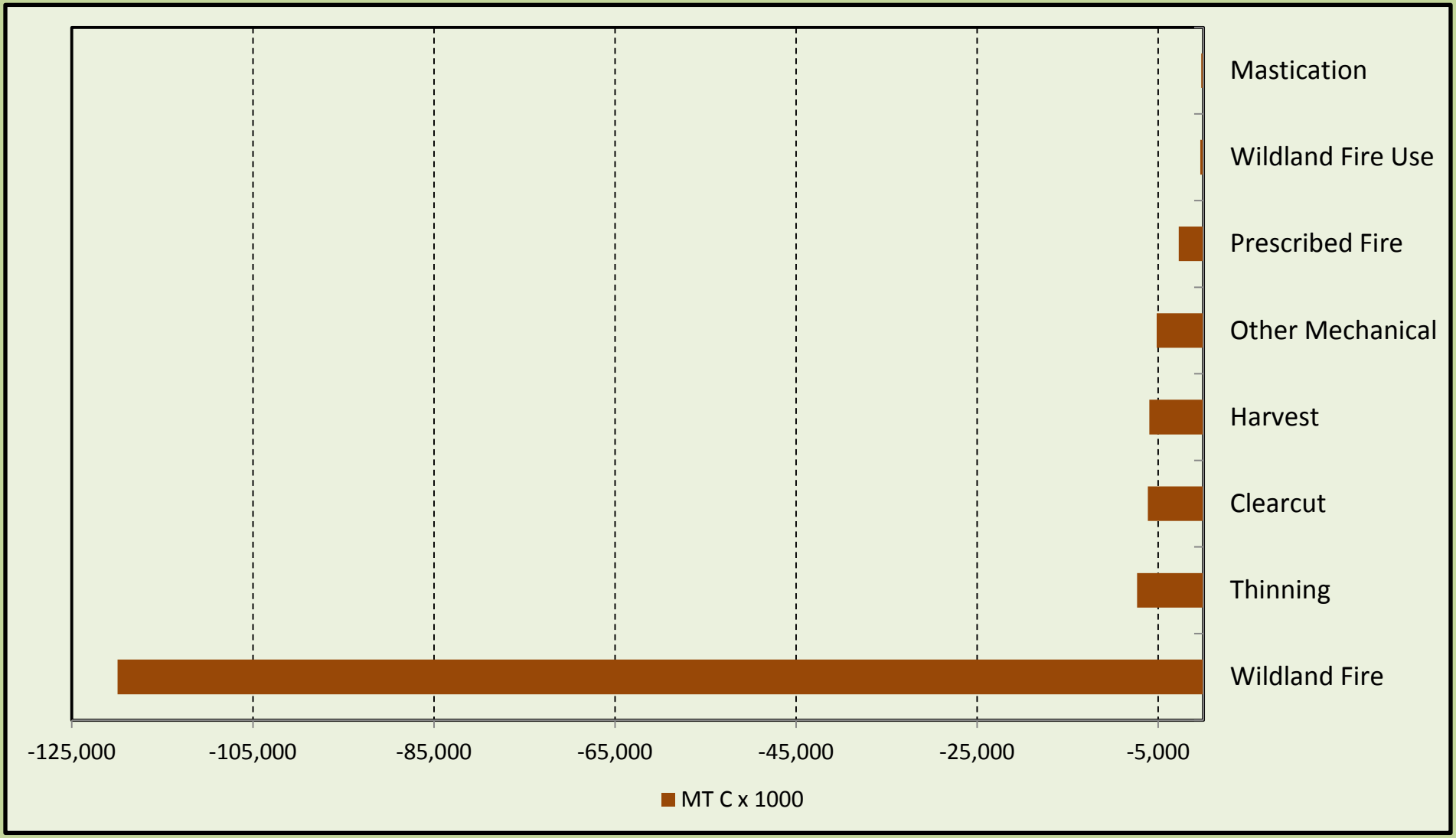
Tree → Tree
Shrub → Tree
Shrub → Shrub
Tree → Shrub

} Forest Remaining Forest (IPCC 3B1a)

**includes Above- and Below-ground Live Tree, Standing Dead, Dead Downed, Litter, Understory, Shrub, Grass/Herbaceous - not including soil*


Stock-change Attribution:
Landfire disturbance data
clearcut
thinning
wildfire
2001 – 2010 composite

# Natural Lands Stock-Loss Attribution, Total stocks*
## 2001 - 2010




*Not including soil carbon

# Natural Lands Inventory

## Next Steps

- Publish the NL Inventory in November
  - Inventory tables: C stocks, stock change, GHG flux
  - Figures and maps
  - Technical Support Document
    - Sources and methods
    - Results (C stocks, stock-change, GHG fluxes)
    - Future work
- Scoping Plan N&WL chapter
- SB 859
  - Directs ARB to complete a NWL inventory by 2018, in consultation with CNRA

# Natural & Working Lands inventory

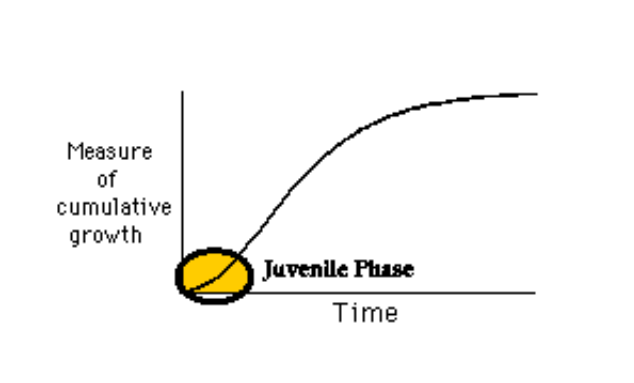
future improvements/research needs

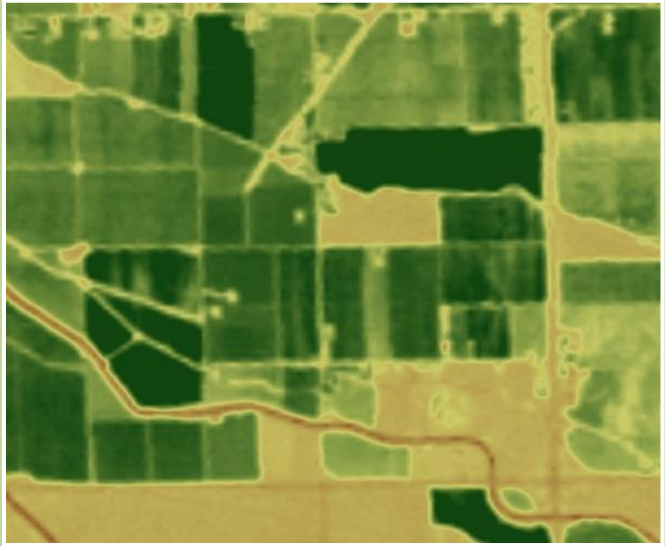
- LandfireC tool
  - Biomass, carbon → updates to vegetation type, cover, height data
  - LiDAR can be used to better inform vegetation height estimates
  - Post-fire carbon pools (killed trees)
  - Reporting categories
    - Standard IPCC
    - “Forest Land” → disaggregate Tree- vs Shrub-dominated
    - Alternative schemes (Landfire hierarchies)
- Orchard trees
  - Allometrics, establishment/removal cycles
- LandTrendr-Google Earth Engine
- Projections: land use/land cover (LULC) change

# Work in Progress: Croplands

# Croplands Approach

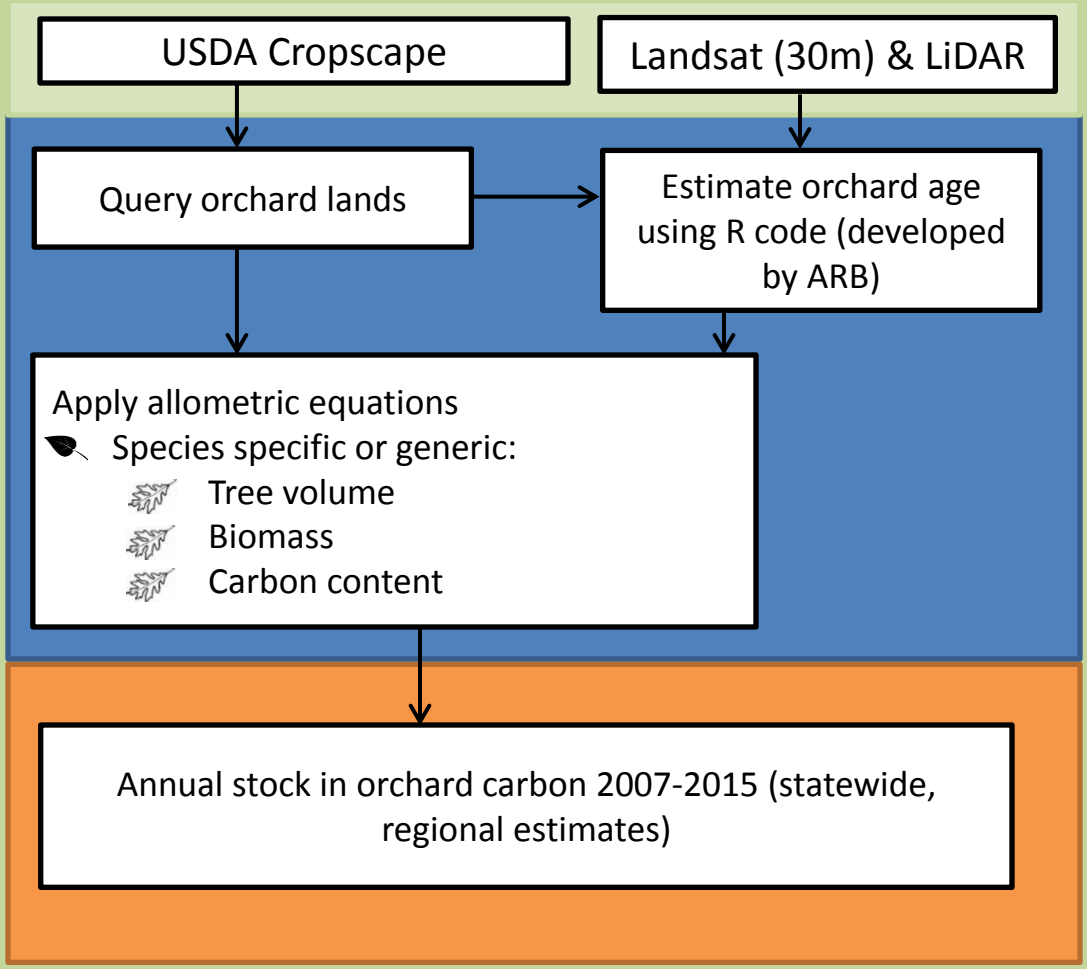
- Developing in-house
  - Data: USDA - NASS, Cropscape, USGS - Landsat and LiDAR
  - Methods:
    - Crop type
    - Orchard tree age
    - Age-height relationship
    - Apply allometric equations to estimate biomass/ carbon
- Analysis period 2007 – 2015; annually



Landsat

# Croplands Data & Methods Overview




**Data**

**Methods**

**Products**



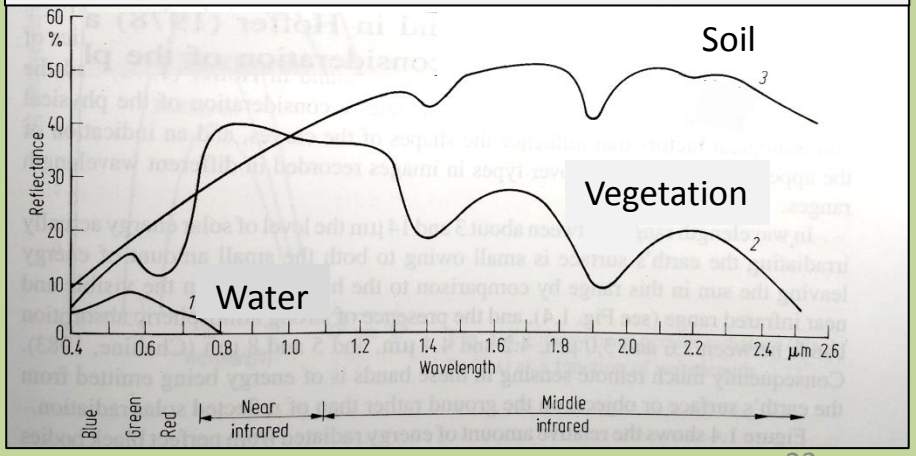
# Work in Progress: Urban Forests

# Urban Forests Approach

- Method: Bjorkman et al. (2015)
  - Data
    - Field plots: Urban FIA, UFORE, Municipal
    - Remote sensing: USDA NAIP, USGS DOQQ
- Analysis period 1995 – 2016; varies/bi-annual
- iTree program
  - Suite of allometric equations for urban trees
  - Tree volume
  - Tree biomass
  - Tree carbon content

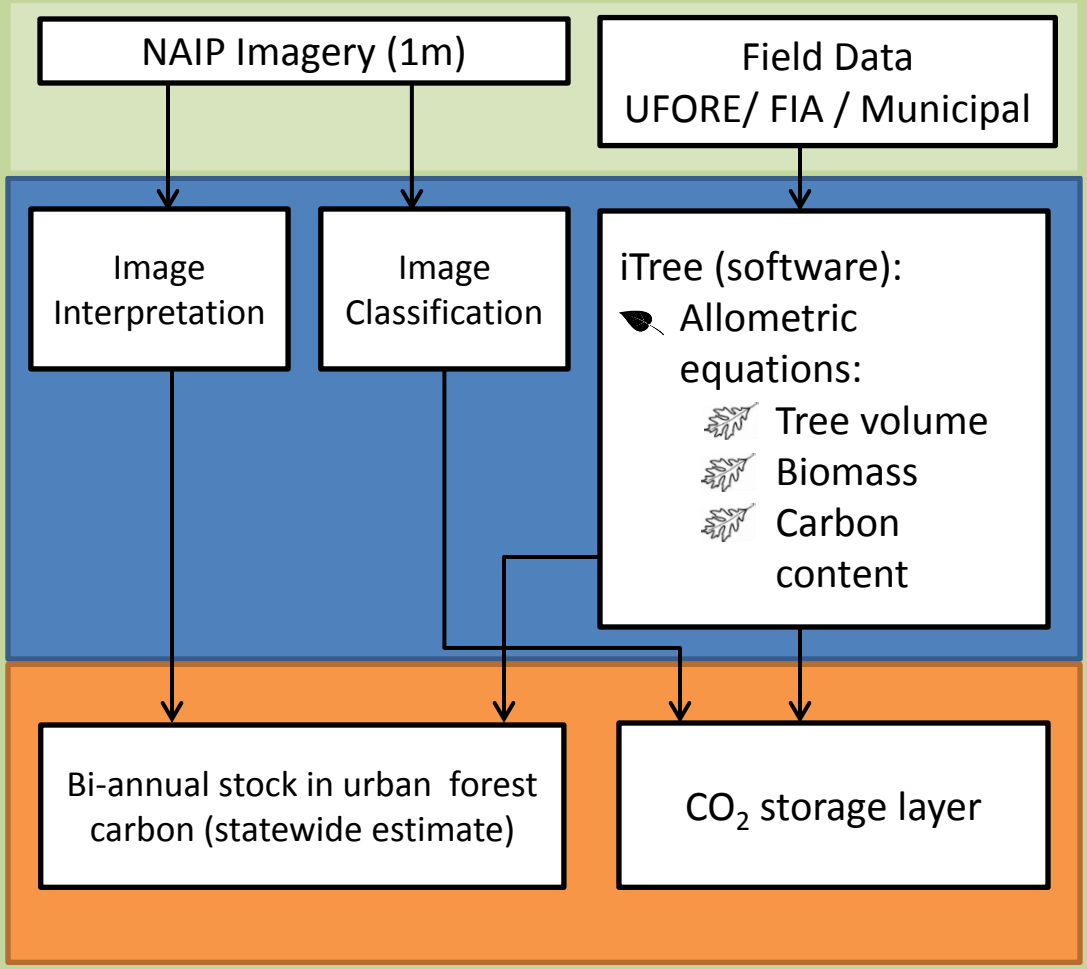
i-Tree
Tools for Assessing and Managing
Forests & Community Trees

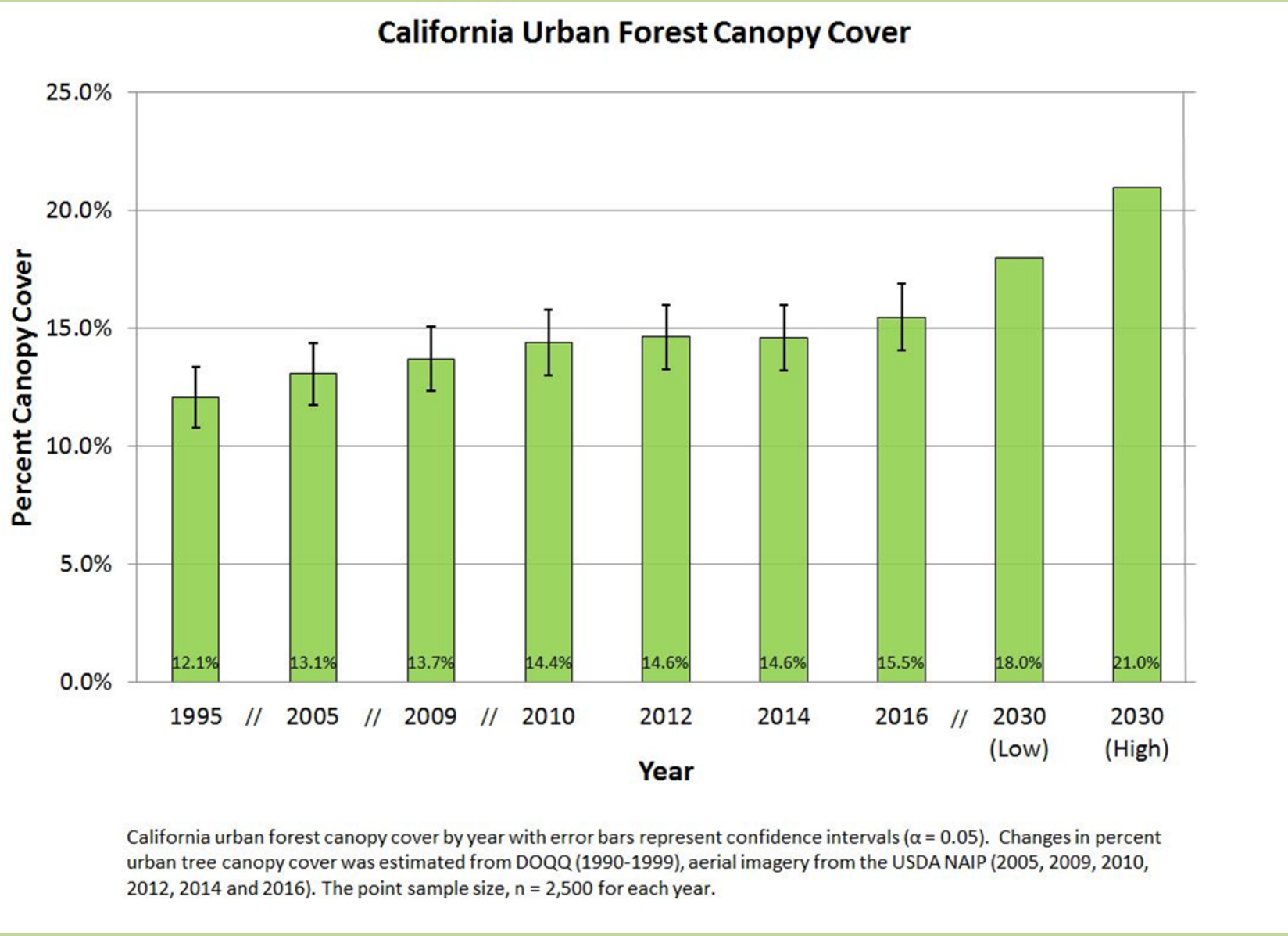
Spectroscopy of Land Cover Types




Richards, John A., and J. A. Richards. *Remote sensing digital image analysis*. Vol. 3. Berlin et al.: Springer, 1999.

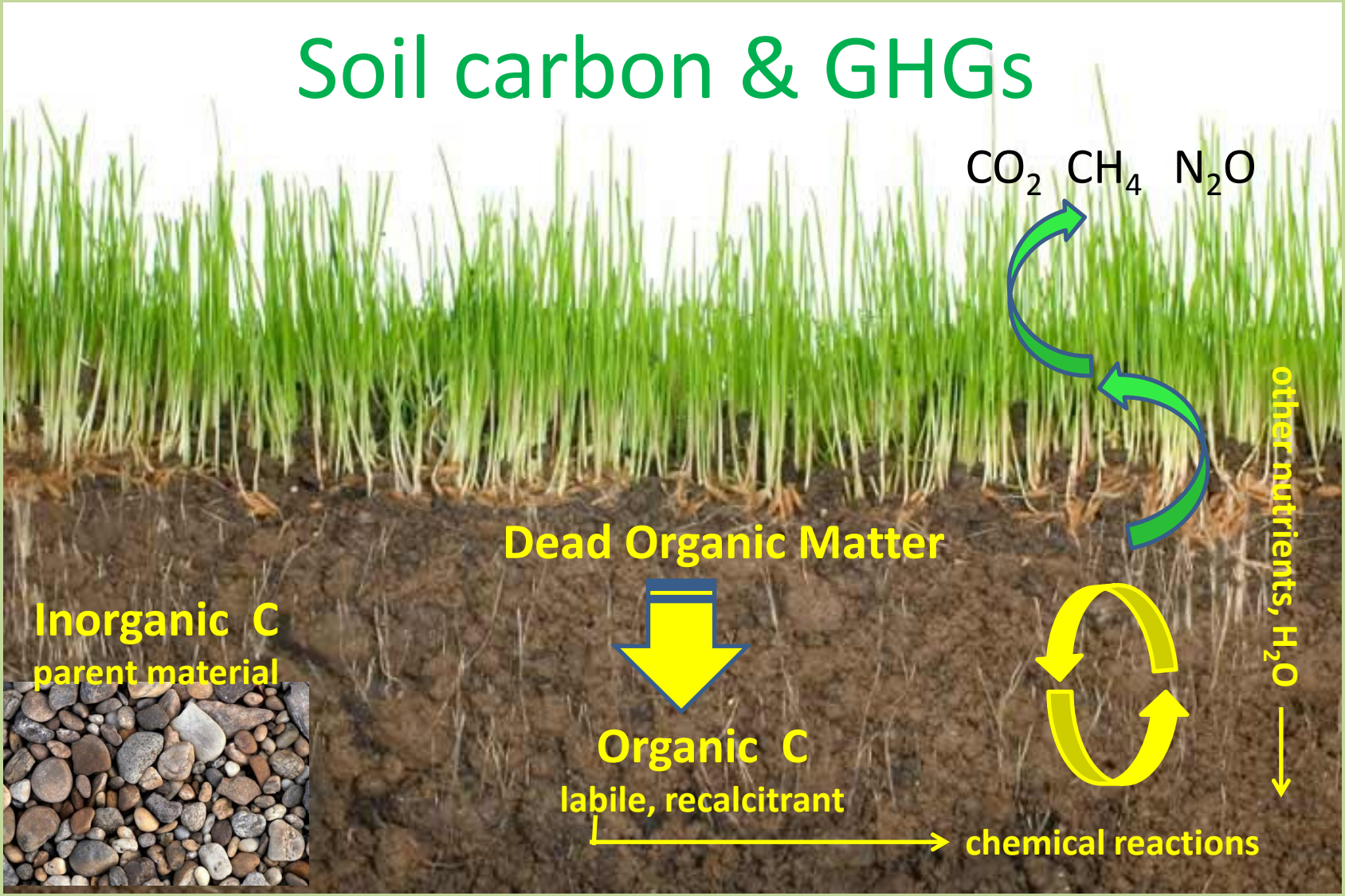
# Urban Forests Data & Methods Overview






California urban forest canopy cover by year with error bars represent confidence intervals ($\alpha = 0.05$). Changes in percent urban tree canopy cover was estimated from DOQQ (1990-1999), aerial imagery from the USDA NAIP (2005, 2009, 2010, 2012, 2014 and 2016). The point sample size, n = 2,500 for each year.

# Soil carbon & GHGs



# Soil Carbon & GHGs

## Sources and Methods

- Data
  - USDA SSURGO, USDA CarbonScapes, FIA
  - Data sources TBD: dead organic matter + other nutrient inputs; soil disturbance; moisture/inundation timing, salinity (wetlands); meteorological
- Methods
  - IPCC Tier 1 (default factors)
  - Models (Century, Daycent, DNDC, CASA, etc.)

# NWL Inventory Timeline

| Land type | Inventory Year* | Target Completion |
|---|---|---|
| **Forest & Other Natural Lands** | 2010 Inventory | Late 2016 |
| | 2012 Inventory | Late 2017 |
| | 2014 Inventory | Mid-2018 |
| **Urban Forest** | 1995-2016 Inventory | Mid-2018 |
| **Croplands** | 2007-2015 Inventory | Mid-2018 |
| **Soil Carbon** | 2001-2015 estimates | Mid-2018 |

* Inventory year depends on the availability of source data that are needed for estimating carbon stock, stock change, and emissions.


End