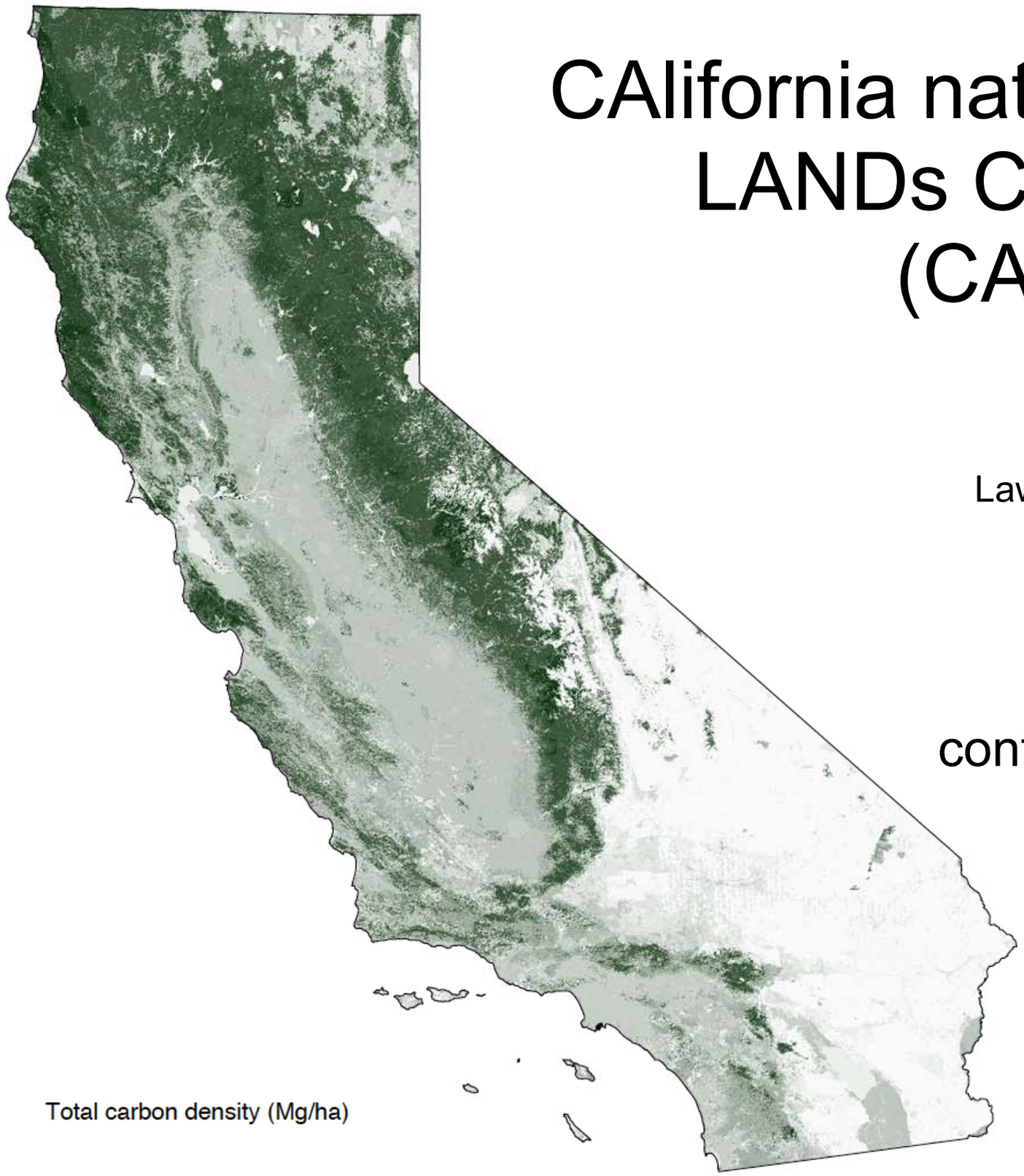
Appendix G

Natural and Working Lands Modeling



Total carbon density (Mg/ha)

CAlifornia natural and working LANDs Carbon Model (CALAND)

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With feedback and contributions from many people

CNRA Public Workshop
14 December 2016

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Overview

- Basic model structure
- Scenarios
- The punchline
- What are the data and sources?
- What does the model do (and not do)?
- Results
- Summary of main points
- Next steps

Model Structure

- Database carbon accounting model (excel, R)
  - Carbon stock and flow - conserves carbon
  - **Purpose: <u>quantify</u> and <u>compare</u> the <u>changes</u> in landscape carbon due to different management options in the context of the entire CA landscape**
- Initial carbon and land use/cover state (2010)
- Parameters/values for carbon dynamics
- Scenarios: annual area

Scenarios

- **Reference <u>historical baseline</u> scenario**
  - Extrapolation of past 10-15 years to 2010 through 2050

- **Target scenarios from CNRA:**
  - <u>Low Protection</u>: 50% of baseline urban area growth by 2050
  - <u>High Protection</u>: 25% of baseline urban area growth by 2050

  - <u>Low management</u>: 2017 through 2030
  - <u>High Management</u>: 2017 through 2030

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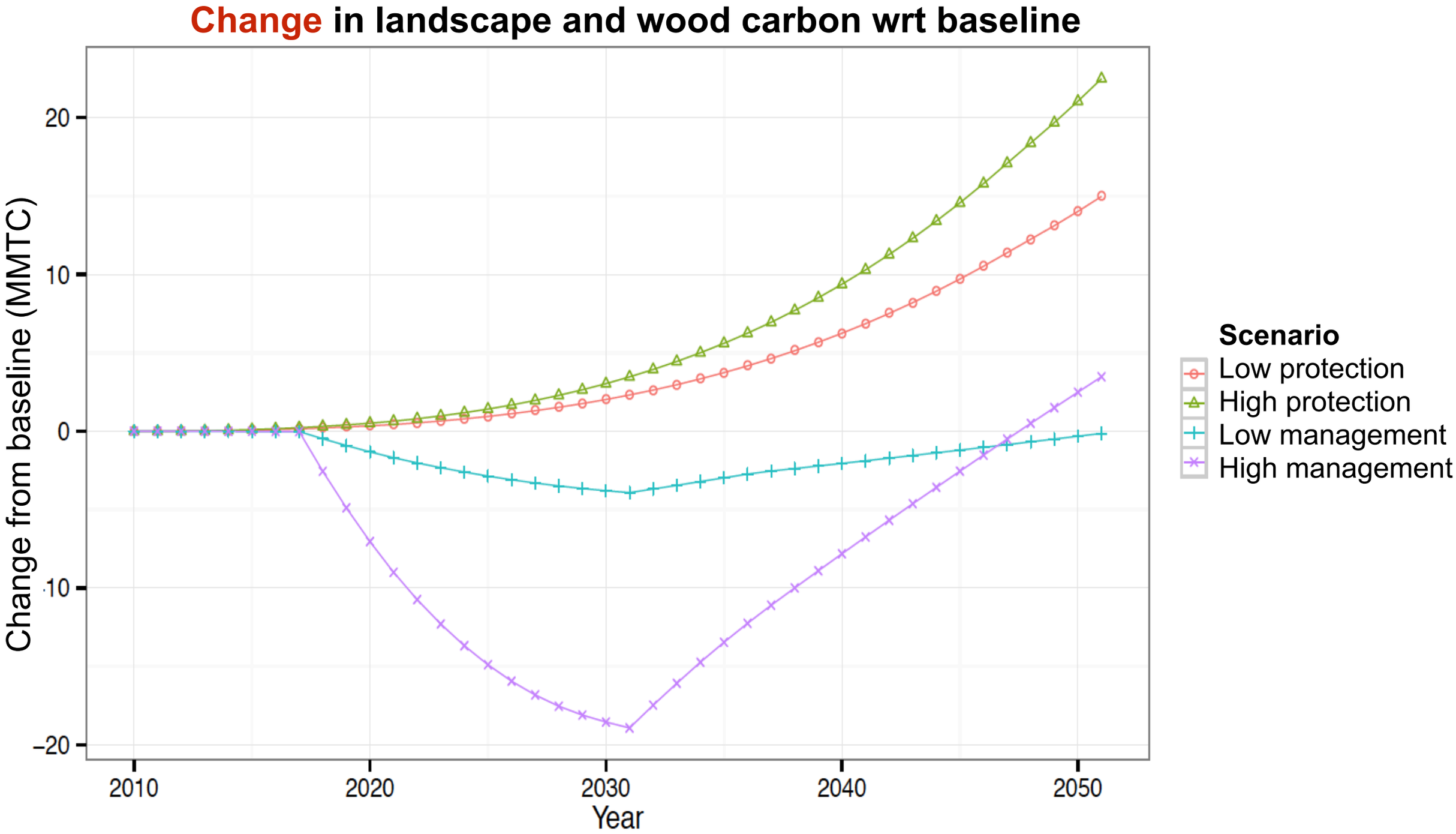
Management scenarios

- **These scenarios are applied to the baseline, from 2017-2030**

Activity	Low management	High management
Forests - fuel reduction, restoration (state/private)	60,000 ac/yr through 2030	175,000 ac/yr through 2030
Forests – reforestation is implicit in the model	Increase rate 15% above BAU by 2030 (assume 15% above BAU rate in each year to 2030)	Increase rate 30% above BAU by 2030 (assume 15% above BAU rate in each year to 2030)
Croplands – conserve soil C (no-till/cover crop)	10,000 ac/yr through 2030	10,000 ac/yr through 2030
Meadow restoration - rangeland (state/private)	10,000 acres by 2030	30,000 acres by 2030
Grasslands – compost amendment (state/private)	10,000 ac/yr through 2030	10,000 ac/yr through 2030
Delta Fresh Wetlands Restoration (state/private)	15,000 acres by 2030	30,000 acres by 2030
Coastal/Tidal wetlands restoration (state/private)	30,000 acres by 2030	60,000 acres by 2030
Urban – Increase urban tree canopy fraction	20% above current by 2030 (same as baseline)	40% above current by 2030
Ocean – restore eelgrass beds	5% above current levels by 2030	10% above current levels by 2030

Scenarios vary considerably



Data

- **Carbon stock**:
  - Vegetation:
    - CA ARB database (Aug 2016) (except urban)
    - Urban: Bjorkman et al. 2015 and ARB personal communication 2016
  - Soil: NRCS GSSURGO (2016) (except rangelands)
  - Grassland/Savanna/Woodland soil: Silver et al. 2010
  - Seagrass: Coastal Conservancy, Ocean Protection Council

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Data

- **Land cover**:
  - CA ARB database (Aug 2016)
    - Landfire remote sensing; 2001-2010

- **Ownership**: CALFIRE-FRAP, USFS, CCED

- **Fire**: CALFIRE

- **Forest management**: Robards and Nickerson 2013; USFS personal communication 2016; Stewart and Nakamura 2012; CALFIRE VTP EIR

- **Parameters/values** for carbon dynamics:
  - Academic literature and agency reports

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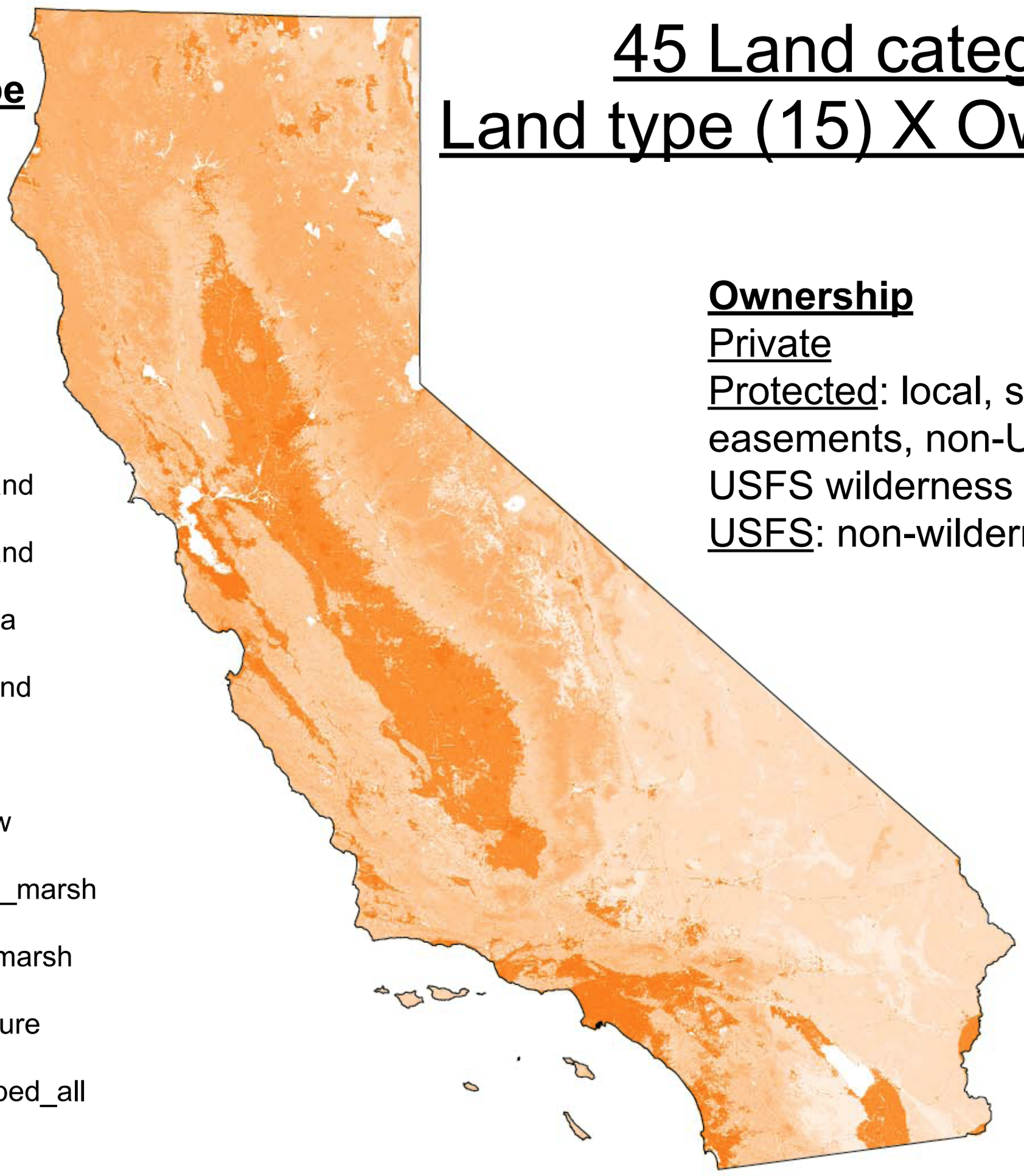
45 Land categories:
Land type (15) X Ownership (3)

Land type

- Water
- Ice
- Barren
- Sparse
- Desert
- Shrubland
- Grassland
- Savanna
- Woodland
- Forest
- Meadow
- Coastal_marsh
- Fresh_marsh
- Agriculture
- Developed_all



Ownership

Private

Protected: local, state, easements, non-USFS federal, USFS wilderness

USFS: non-wilderness

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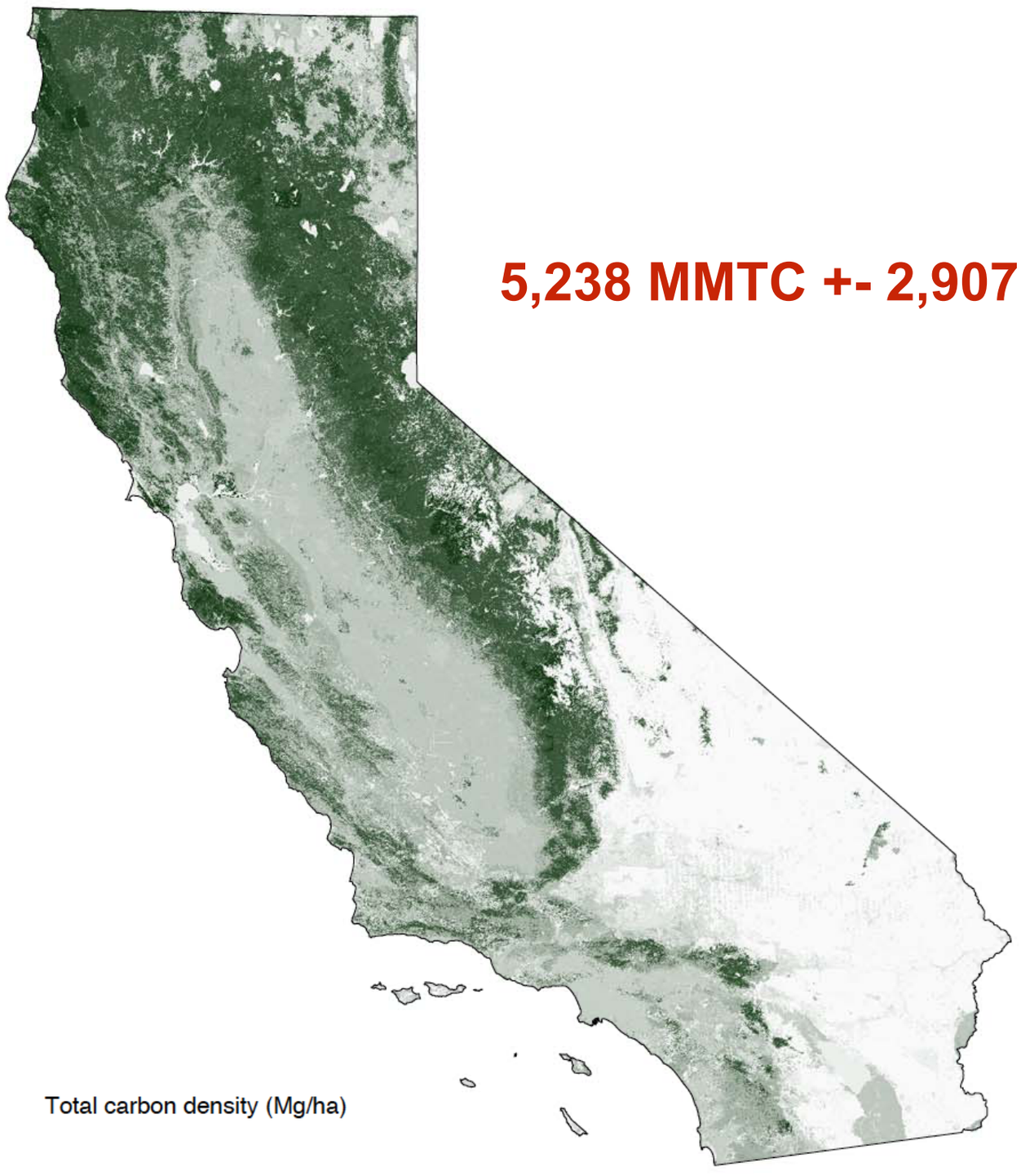
2010 total carbon density (MgC/ha)

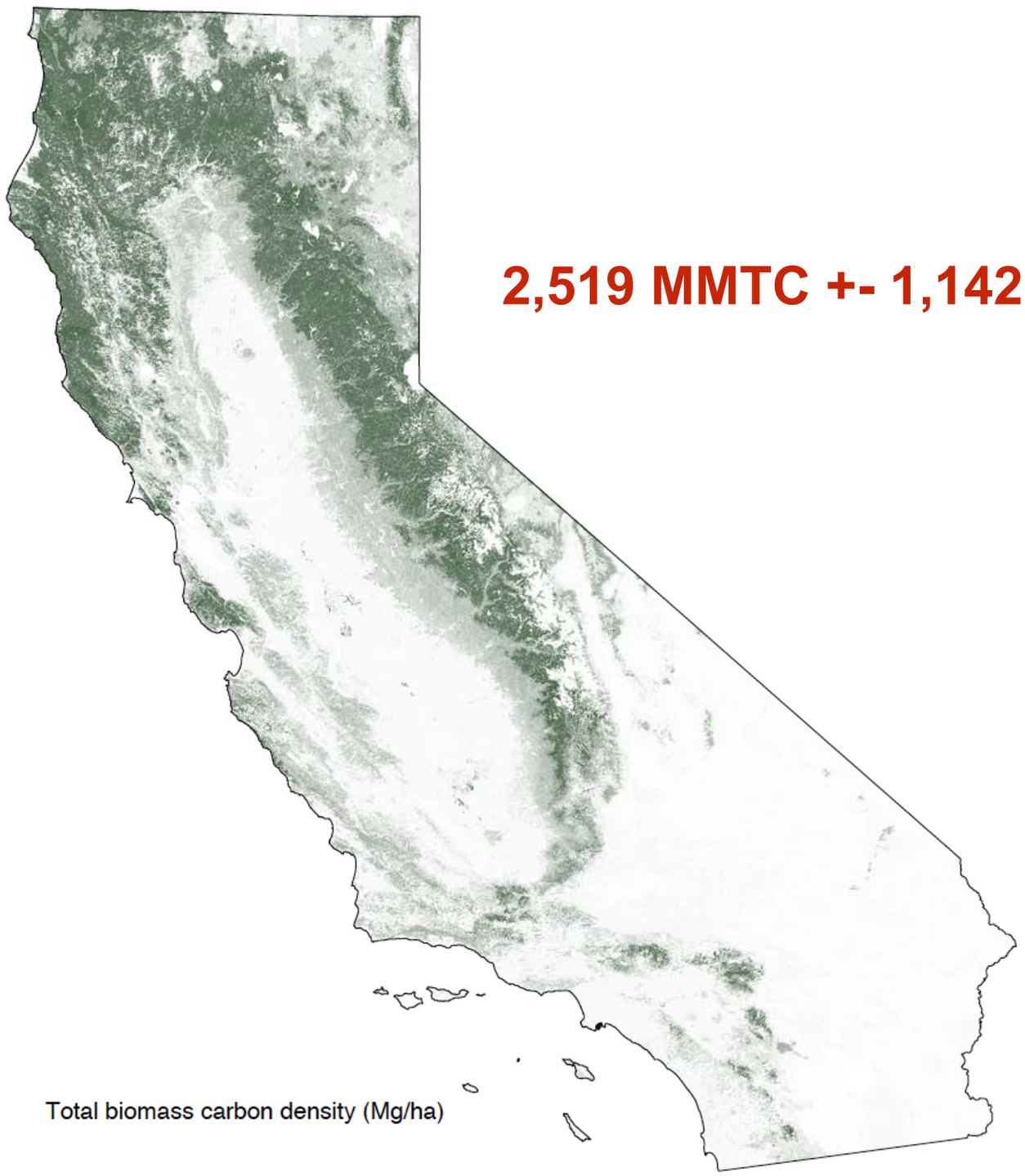


5,238 MMTC +- 2,907

Mean ranges from 3 to 927 MgC/ha

Std Dev ranges from 14 to 1013 MgC/ha

2010 biomass carbon density (MgC/ha)

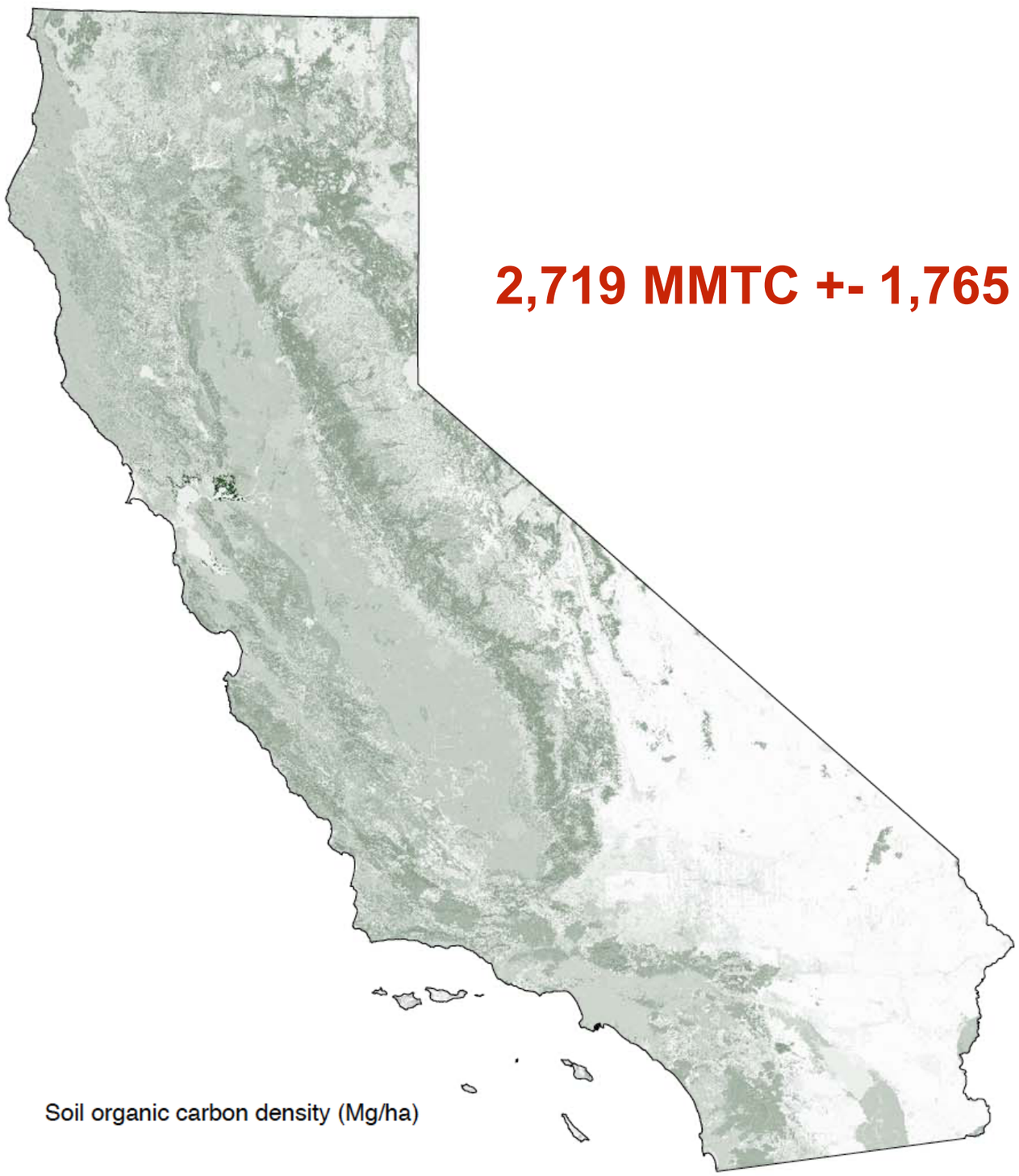


2,519 MMTC +- 1,142

Mean ranges from (0)1 to 238 MgC/ha

Std Dev ranges from 0 to 72 MgC/ha

2010 organic soil carbon density (MgC/ha)



2,719 MMTC +- 1,765

Mean ranges from 3 to 921 MgC/ha

Std Dev ranges from 14 to 1013 MgC/ha

Model Processes

- **Ecosystem carbon accumulation/loss:**
  - with management adjustments and prescribed mortality

- **Management**:

  - Forest:
    - clearcut
    - partial-cut/thinning
    - fuel reduction/thinning
    - brush/weed treatment
    - prescribed burn

  - Agriculture:
    - soil conservation
    - cover-crop/no-till

  - Urban:
    - removal of dead material
    - fraction of urban forest

  - Grassland:
    - compost amendment; high, medium, low

Model Processes

- **Land use/cover change**:
  - Historical baseline
    - ARB-Landfire 2001-2010
  - Restoration (and protection):
    - Coastal marsh, Fresh marsh
    - Meadow, Seagrass
- Land protection
- Afforestation
- **Wildfire**:
  - Annual area
  - No land type change
- **Wood products**:
  - Gain from:
    - management
    - ag/urban conversion
  - Product C emissions

Planned Model Improvements

- **To include by March 2017:**
  - Greenhouse gas species and CO_2 equivalents
    - Methane and black carbon in fire emissions
    - Methane emissions from fresh wetlands
  - Separate Protected ownership into ~3 classes
  - Further delineate land categories by ecoregions

Not Included in the Model

- Root carbon for urban and agriculture
- Woody crop carbon dynamics
- Climate/atmosphere effects
  - ecosystem carbon accumulation
  - wildfire risk - but wildfire area is prescribed
  - post-disturbance reforestation
- Spatially explicit baseline burned area by land category
- Spatially explicit baseline managed private forest area by land category

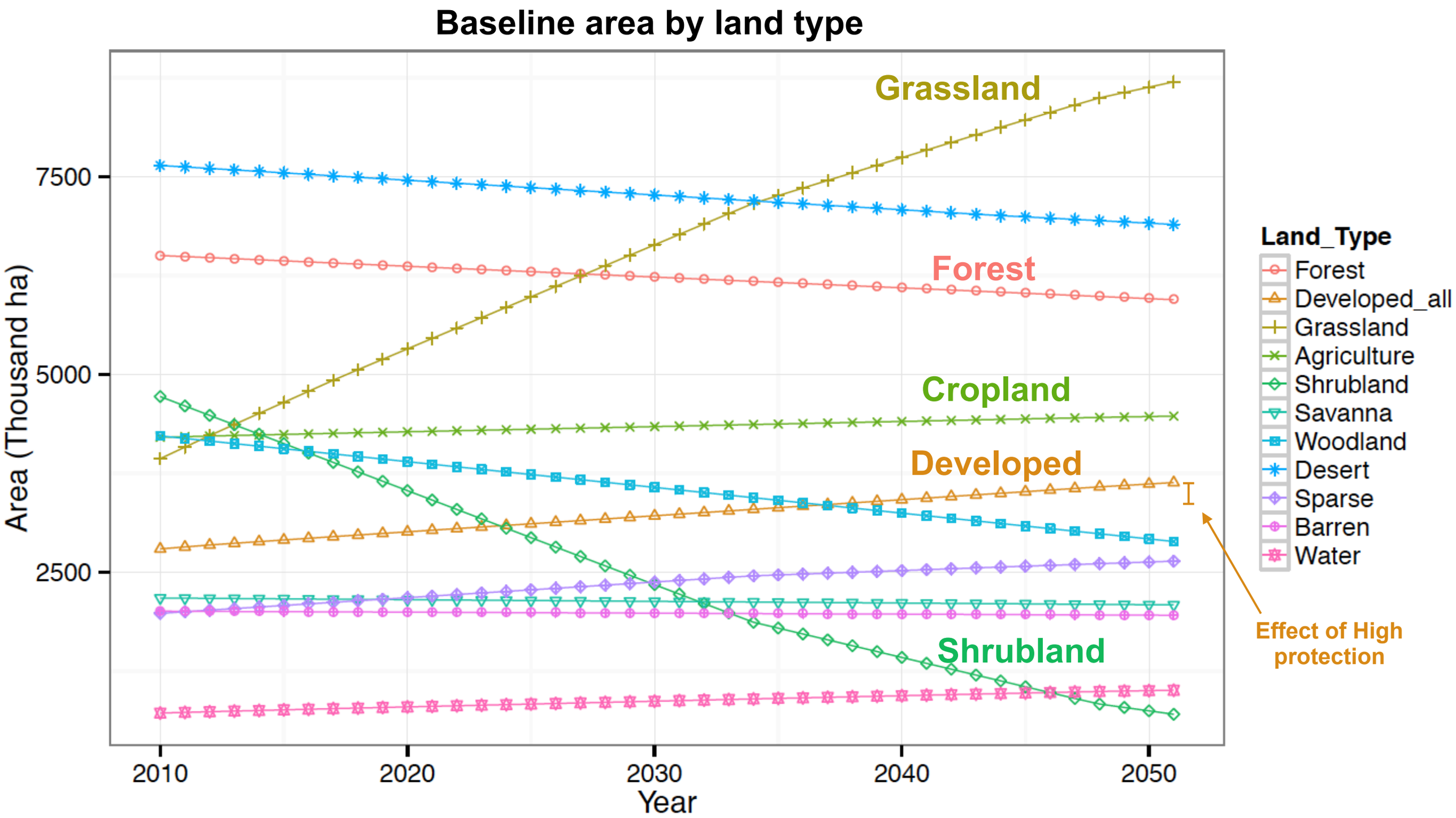
Mean annual ecosystem carbon accumulation rates
Mg C per ha

Land Type	Vegetation Standard	Vegetation Managed	Soil Standard	Soil Managed
Fresh marsh	-	-	3.37	-
Forest, private	2.10	2.10	0.71	1.27
Forest, USFS	1.37	1.64	0.71	1.27
Coastal marsh	-	-	1.44	-
Meadow	-	-	0.95	-
Developed	0.93	Increases with urban forest fraction	-	-
Cropland	-	-	0.31	0.80
Seagrass	-	-	0.43	-
Grassland	-	-	-2.22	-2.09

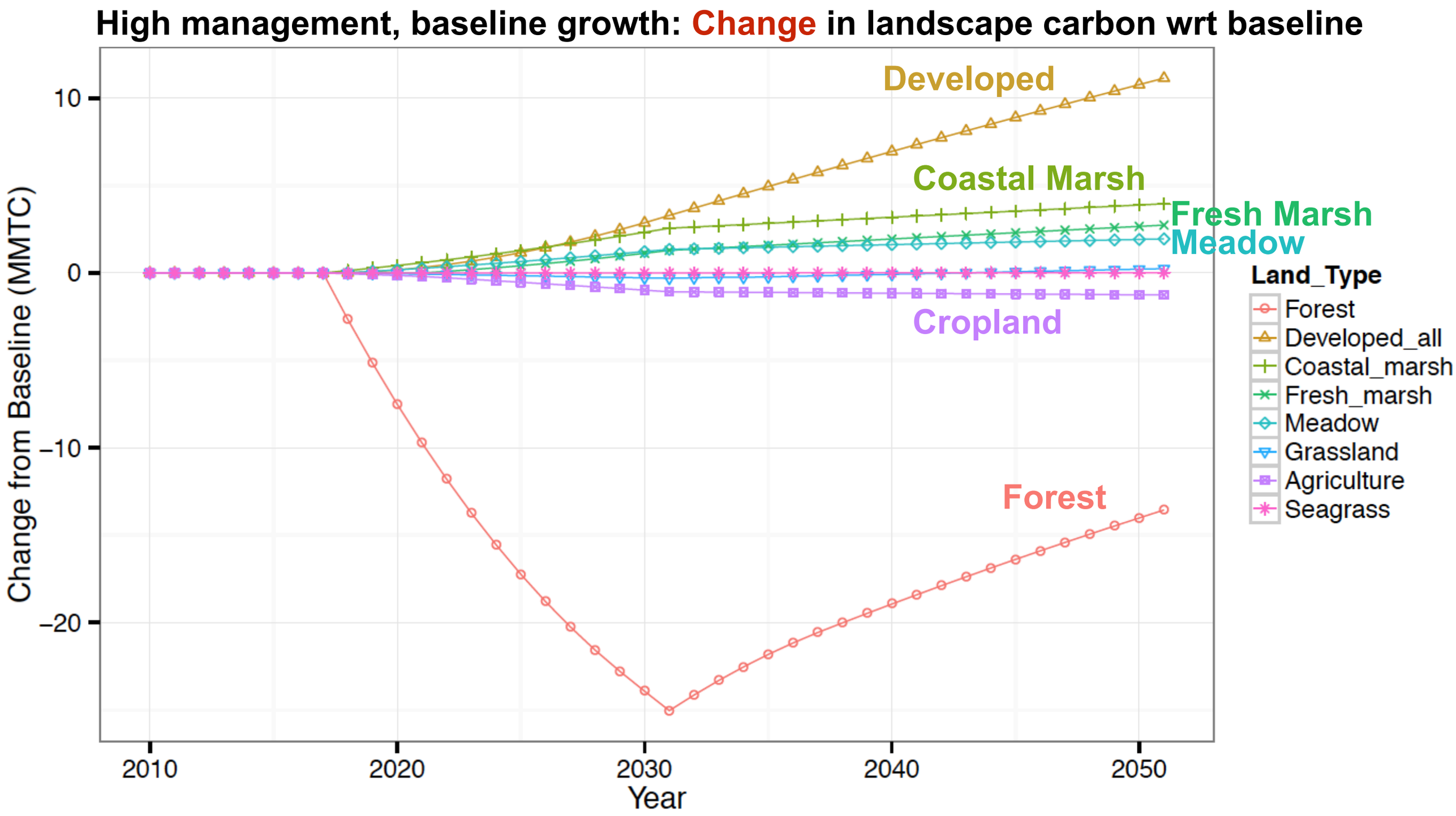
Historical baseline scenario

Activity	Rate	Notes
Private Forests: clearcut, partial cut	152,000 acres/year	partial is ~75% of area
Private Forests: fuel reduction, brush control, prescribed burn	69,000 acres/year	fuel reduction is ~60% of area fuel reduction = thinning
USFS Forests: fuel reduction, brush control, prescribed burn	171,000 acres/year	fuel reduction is ~77% of area fuel reduction = thinning
Fresh marsh restoration: managed Delta wetland	318 acres/year from 2010 through 2020	3,500 acres by end of 2020 this is currently happening
Urban forest: canopy fraction of urban land	0.001619/year increase	this value is the actual increase in urban forest canopy fraction
Grassland expansion	360,000 acres/year	Largely due to fire
Urban area expansion	61,000 acres/year	
Sparse expansion	51,000 acres/year	
Water and Ice expansion	21,500 acres/year	21,000 water; 500 ice
Agricultural expansion	20,000 acres/year	
Coastal marsh expansion	5,000 acres/year	Mostly USFS; protected decreases
Shrubland loss	-294,000 acres/year	Largely due to fire
Woodland loss	-81,000 acres/year	Mostly USFS
Meadow loss	-57,000 acres/year	Mostly private and protected
Desert loss	-46,000 acres/year	
Forest loss	-33,000 acres/year	Mostly USFS; private increases
Savanna loss	-5,000 acres/year	Mostly USFS; private increases
Barren loss	-3,000 acres/year	Mostly private

19 Grassland and shrubland dominate land change



Management has definite impacts on carbon



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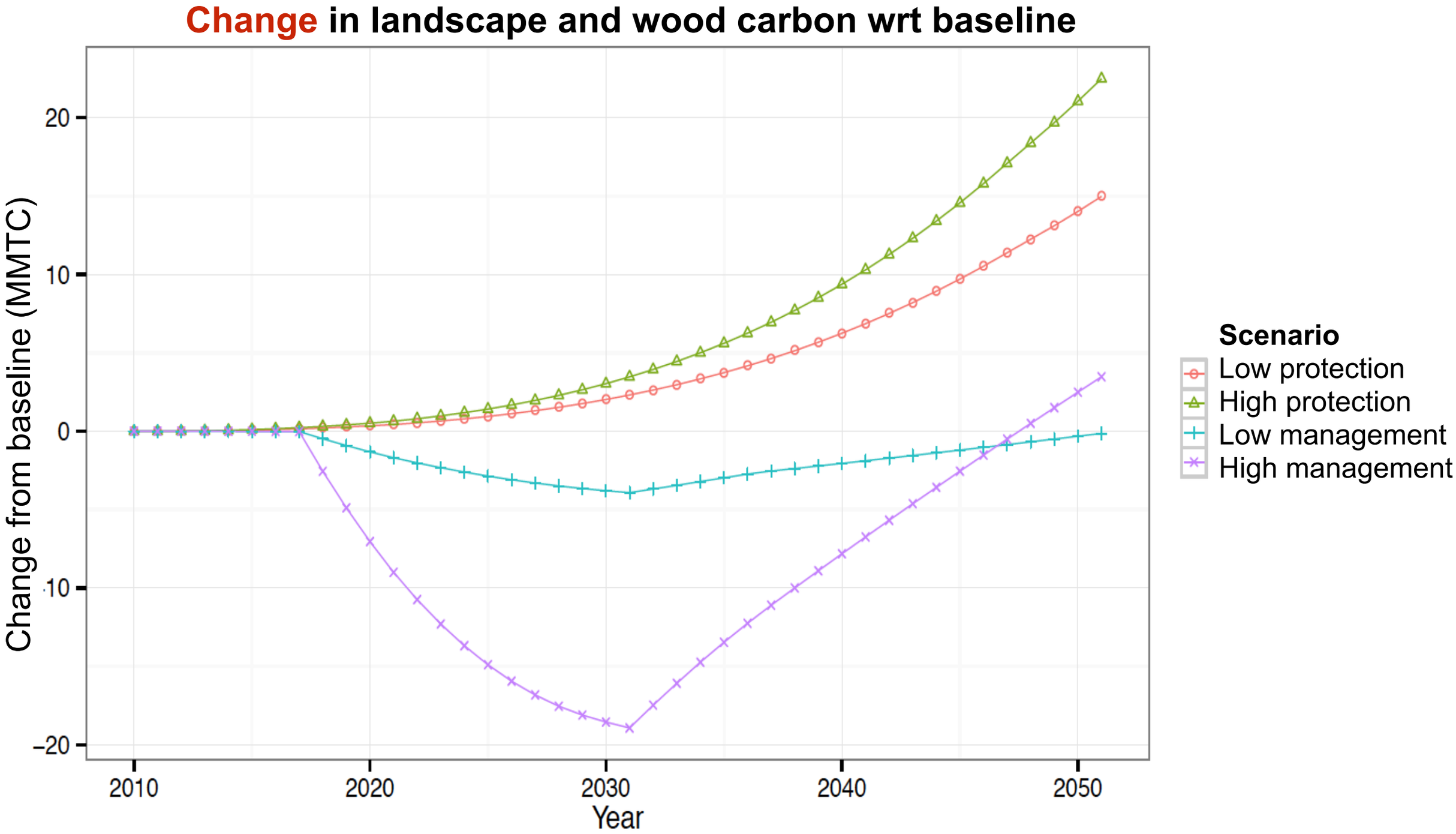
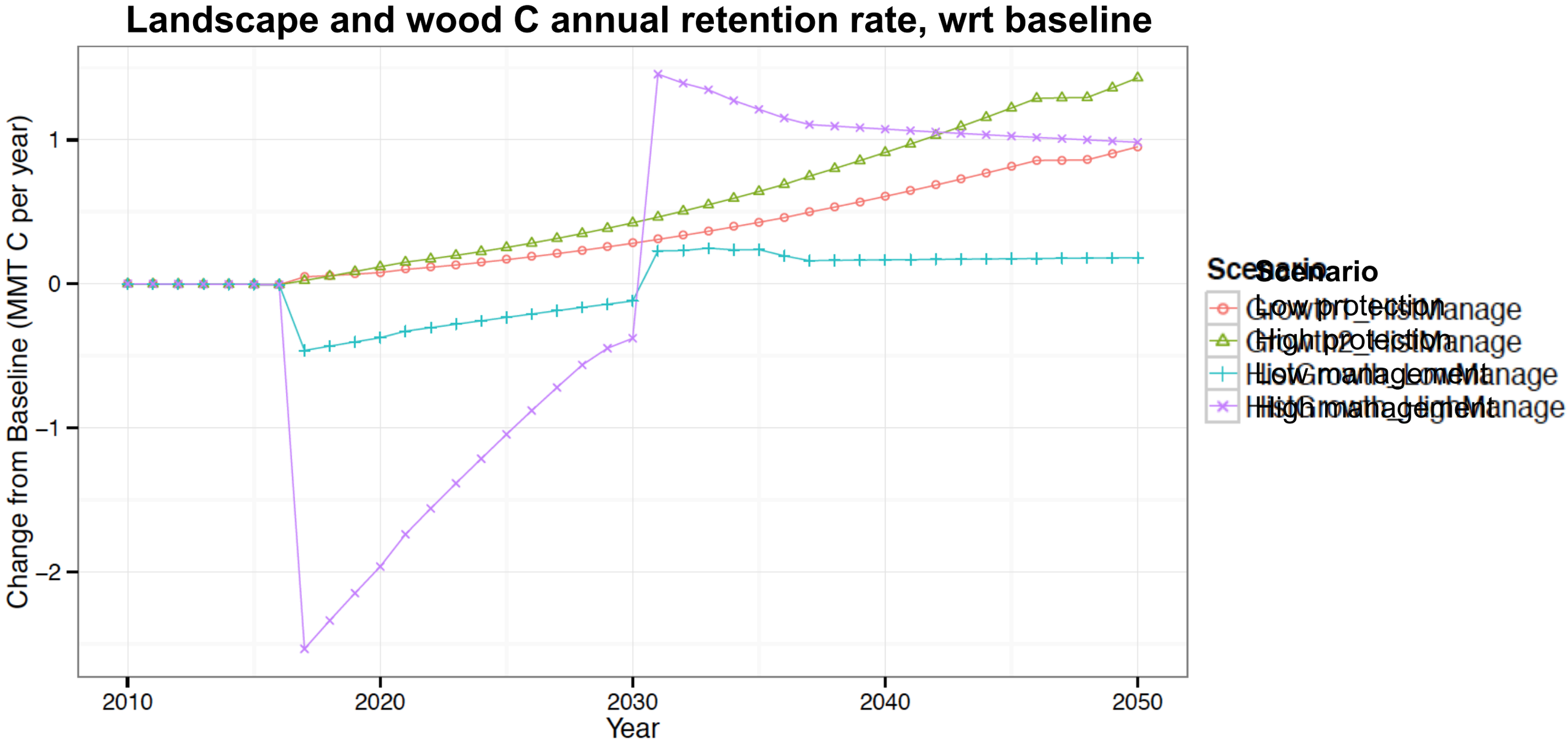


Management and reduced urban area growth affect annual carbon balance



Carbon benefits of scenarios on annual landscape and wood carbon retention in 2050

Land Type	Low management	High managment	Low protection	High protection
All land	0.18 MMTC/yr	0.98 MMTC/yr	0.95 MMTC/yr	1.42 MMTC/yr
Forest	43%	44%	21%	21%
Developed	6.7%	38%	-16%	-16%
Fresh marsh	17%	7.4%	0%	0%
Coastal marsh	19%	7.1%	0.1%	0.1%
Meadow	8.5%	3.1%	0%	0%
Grassland	10%	2.9%	-5.2%	-5.2%
Seagrass	0.13%	0.05%	0%	0%

Main points 1

- **Comprehensive landscape carbon accounting tool!**
- **These results depend on the land type area and the managed area**
- **Land protection reduces land change emissions**
  - Land protection also limits urban forest expansion
- **Land protection plus management benefits are mostly additive**
- **Under management, total landscape carbon recovers by 2050**
  - Less Forest biomass carbon, more soil carbon
- **Forest management can provide long-term benefits:**
  - Reductions in annual wildfire emissions
  - Increased annual C accumulation
  - C storage in durable wood products
  - Biomass use for energy and fuels and other products

Main points 2

- **Fresh marsh restoration** contributes to carbon retention
  - Methane emissions may diminish GHG benefits

- **Coastal marsh** and **Meadow restoration** gain about half as much carbon per acre (less for meadow) as fresh marsh
  - Coastal marsh has negligible methane emissions

- **Management scenarios shift Cropland carbon** to marsh
  - Substantially larger Cropland management area may have potential for carbon benefits

- **Grassland management** has little effect at 10,000 acres/yr
  - 10X this area gives 3.4X the annual grassland C retention
  - Limited info on grassland/rangeland carbon stocks/dynamics

- **Seagrass restoration** has negligible effects on total area basis

Next steps

March

- Model improvement
  - Further spatial delineation
  - Methane and black carbon
- Sensitivity analysis
  - initial carbon state
  - C accumulation rates

Ongoing

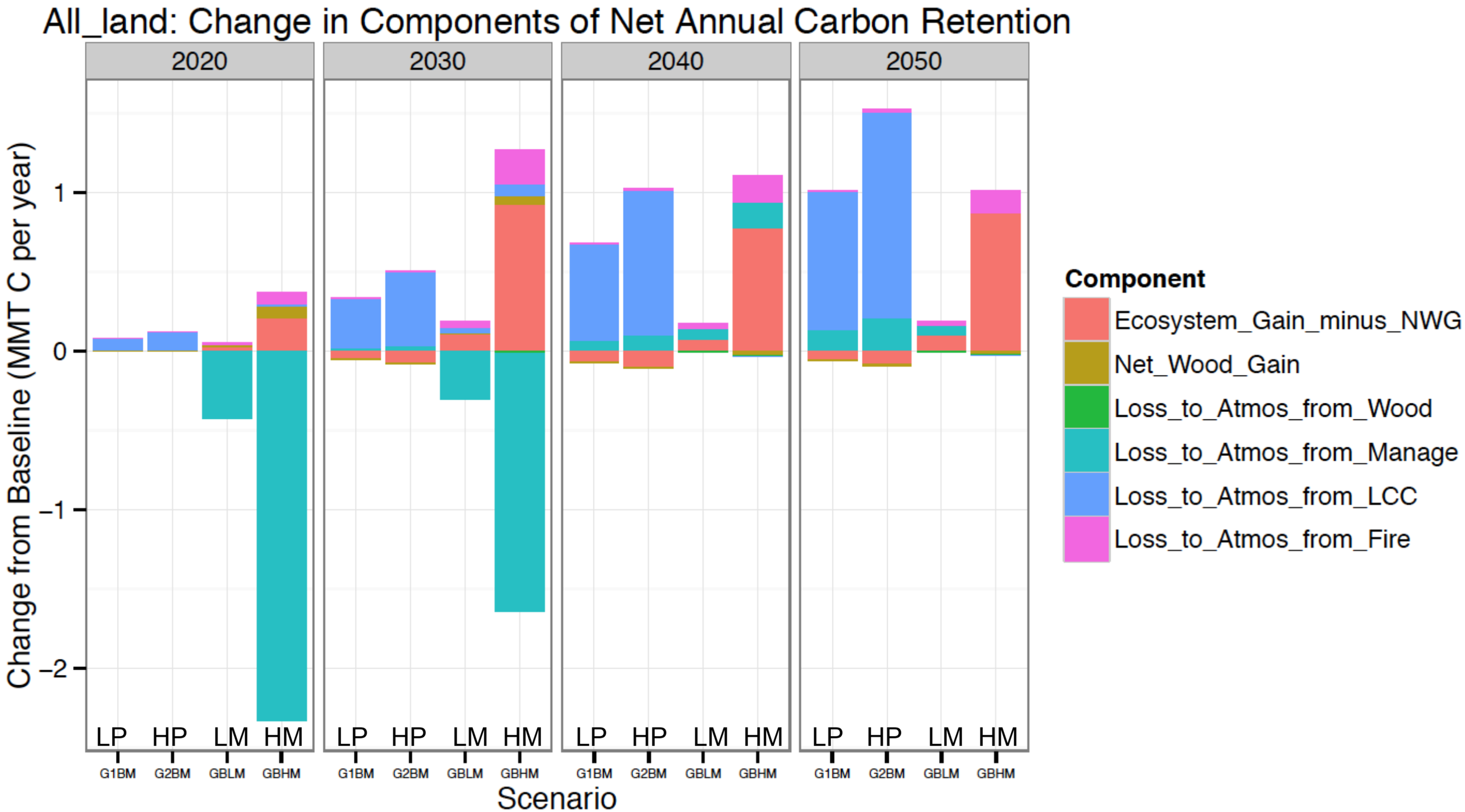
- Engage with ongoing research to improve model processes
  - rangeland carbon
  - mortality
  - land cover responses to growth and restoration targets

Potential?

- Alternate scenarios?
- User friendly interface?

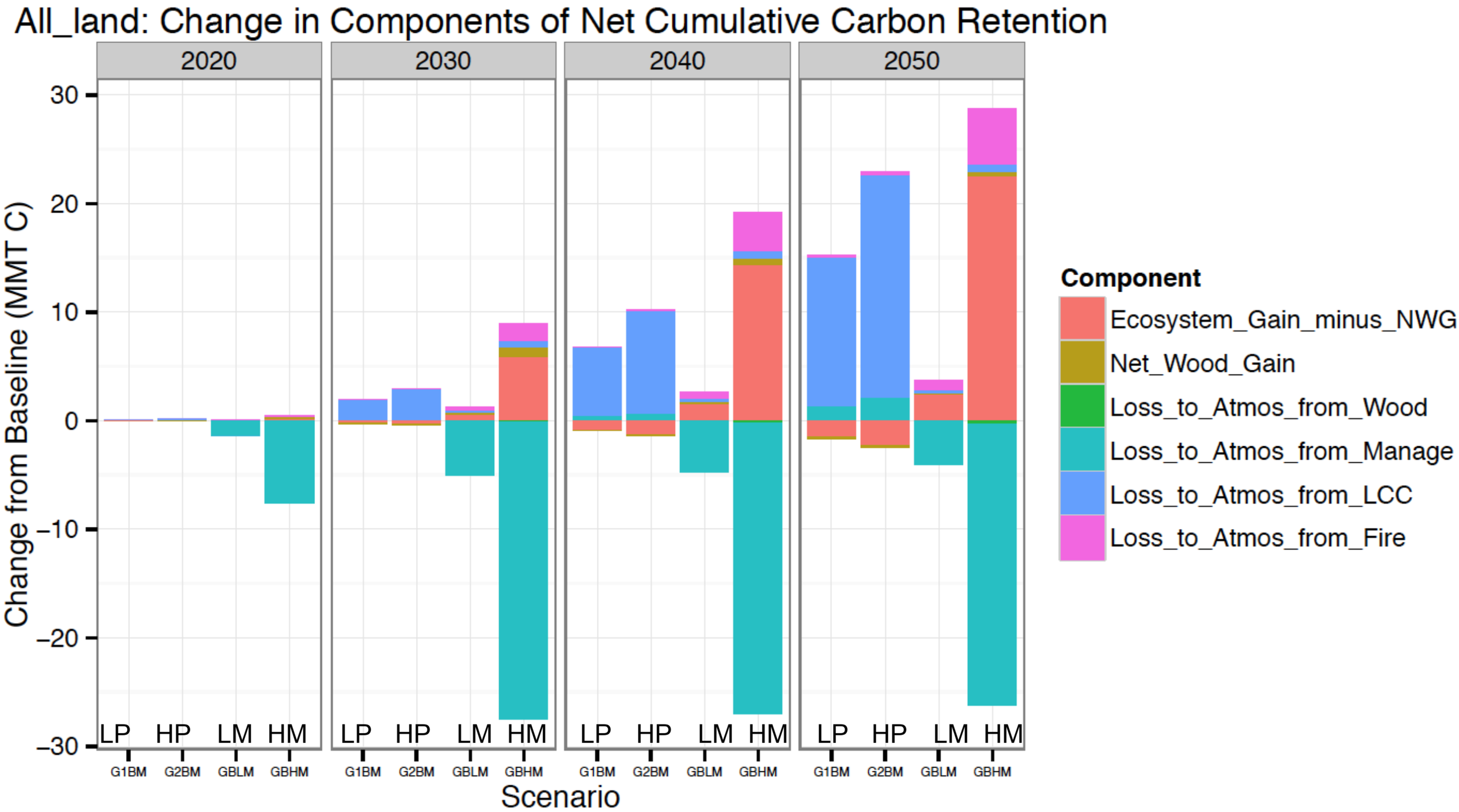
E1

Annual carbon budget: change from baseline



E2

Cumulative carbon budget: change from baseline



E3

Carbon benefits of scenarios on the annual ecosystem carbon exchange in 2050

Land Type	Low management	High managment	Low protection	High protection
All land	0.10 MMTC/yr	0.85 MMTC/yr	-0.06 MMTC/yr	-0.09 MMTC/yr
Developed	0%	73%	438%	438%
Fresh marsh	32%	8.5%	0%	0%
Coastal marsh	36%	8.2%	-249%	-248%
Forest	9.3%	6.7%	-2.5%	-2.5%
Meadow	16%	3.6%	0%	0%
Grassland	19%	3.3%	79%	79%
Seagrass	0.23%	0.05%	0%	0%