

CALAND Model Development and Next Steps

Introduction

The following is a technical description of the California Natural and Working Lands Carbon and Greenhouse Gas Model (CALAND), which is being developed by Lawrence Berkeley National Laboratory (LBNL) under contract to the California Natural Resources Agency (CNRA). Model development has and will continue to be informed by formal input and guidance from multiple state agencies and departments via a Steering Committee and a Technical Committee (described below); from the general public via written and other comments; and from experts across various fields as needed by LBNL researchers and as suggested by public and Committee input.

This [technical description](#) is of CALAND Version 2, which follows on Version 1, which was presented by the lead LBNL researchers at a Scoping Plan public workshop in December 2016. Changes between Version 1 and Version 2 are noted throughout and include the addition of greenhouse gas (GHG) and black carbon outputs; improved land type delineation across land ownerships and regions; and additional data and methodological refinements. Future iterations will include additional land management practices; correct known errors to land type delineation; further refine data and methods; and, ultimately, incorporate expected climate change impacts.

The model will be used to quantitatively assess the activities set forth in the Natural and Working Lands Implementation Plan identified in the January 2017 draft of the 2017 Climate Change Scoping Plan Update. CALAND will quantify the expected net GHG and black carbon emissions outcomes of a suite of land management and conservation activities relative to a statewide, business-as-usual (BAU) emissions scenario through 2030, 2050, and 2100 for Natural and Working Lands (NWL) using historical data and recent trends, including climate change. It will model the expected impacts of land conservation, restoration, and management activities the State expects to undertake and promote to meet the climate change mitigation reduction targets identified in the Scoping Plan, over those same time periods.

This quantitative analysis of net GHG emissions over time, tied to a suite of activities, will be a valuable evaluative tool to guide expenditures across multiple programs within CNRA and its boards, departments, and conservancies. Clarity on expected net GHG reduction outcomes will improve tracking of expected GHG outcomes across relevant programs, regardless of whether the primary purpose of those programs is to reduce GHG emissions. CNRA expects that the version of CALAND used in the NWL Implementation Plan will continue to evolve after 2018 to support programmatic assessments, and in a manner that complements related projections currently under development at the California Air Resources Board (CARB), as well as the CARB Inventory for Natural and Working Lands.

All agencies involved in CALAND development and the NWL Implementation Plan - CNRA, CARB, California Department of Food and Agriculture (CDFA), California Environmental Protection

Agency (CalEPA), and the Governor's Office of Planning and Research - invite engagement from the public to assist in producing a robust model that can be used for policy planning purposes by summer 2018. Formal public engagement is expected to take the form of:

- workshops and topical webinars (broad and specific to key land types and actions);
- written communications and comments; and
- convening of a Technical Advisory Committee, which provides technical input to LBNL regarding data and methods to be considered for use in CALAND. The CALAND Steering Committee seeks members of the public to sit on this committee. The procedure for application is described in the [notice](#) posted to CNRA's website.

State agencies expect that technical capabilities to model both the BAU and alternative scenarios for net GHG and black carbon emissions associated with land conservation and management activities will improve over time as new data and methods emerge. It is expected that the projections modeled in CALAND will be updated over time, and that the mix of land management and restoration activities will change as well as science advances. The NWL Implementation Plan will identify the multi-agency collaboration(s) needed to ensure ongoing coordination of research and timely conversion of the best available science to policymaking.

CALAND Versions

CALAND model development began in August 2016. The first iteration of the model, Version 1, was developed to inform the 2017 Scoping Plan Update. It served to inform goal-setting for the Natural and Working Lands sector in the Scoping Plan, establish the scope of work for building projections of GHG and carbon sequestration, and identify issues for further investigation. Version 1 was presented at a public workshop in December 2016. Version 2, which is underway now, builds on Version 1.

CALAND is a data-driven, empirical model of the California landscape carbon budget and associated GHG emissions. It follows an Intergovernmental Panel on Climate Change (IPCC) Tier 3 approach that tracks carbon stocks and fluxes annually using California-specific data. Its primary function is to estimate the changes in California landscape carbon and GHG emissions due to various management targets with respect to a historical business-as-usual scenario. Model dynamics include ecosystem carbon exchange, wildfire, land use/cover change, and a suite of management practices (see Table 1). Annual emissions of CO₂, CH₄, and black carbon are calculated based on the respective carbon pathways within the overall carbon budget. The utilization of Forest biomass for wood products and bioenergy is also included, and their respective emissions are also quantified. Research process and distinguishing features of the model versions are listed below.

Version 1 of CALAND:

- CALAND Steering and Technical committees and researchers established scope of work
- Researchers began gathering data, establish structure for model function

- CALAND Steering and Technical committees and researchers began identifying land conservation, management, and restoration activities to model
- Contained delineation of 45 land categories based on 15 land types and 3 ownership classes (plus seagrass)
- Presented at public workshop in December 2016

Version 2 of CALAND:

- Incorporates CALAND Steering and Technical committees and public suggestions for improvement and other oral and written public comments received at December 2016 CALAND workshop and relevant written comments from 2016 and 2017 Scoping Plan workshops
- Contains improved spatial structure, resulting in 940 land categories based on 9 geographic regions, 15 land types, and 9 ownership classes (plus seagrass)
- Adds functionality to partition process-specific carbon emissions to specific GHG species (CO₂, CH₄, and black carbon) and produce new GHG and global warming potential (GWP) outputs
- Includes additional forest understory/debris biomass utilization capability
- Incorporates new data and refined methods for the conservation, management, and restoration activities identified in Version 1
- Includes a new R script for CALAND users to regenerate input files, making it possible to easily change input parameters (e.g. management factors, or fractions of slash utilized for bioenergy or wood products)
- To be presented in October 2017

Version 3 of CALAND will:

- Include identification and resolution of data gaps
- Incorporate recent natural resource trends or observations expected to significantly impact modeled outcomes (e.g., bark beetle outbreak and drought- and beetle-related tree mortality)
- Include final data and methods to model BAU scenario
- Implement land-use-driven land cover change for BAU scenario, including incorporation of California Department of Conservation Farmland Mapping and Monitoring Program (FMMP) data
- Include expected climate change impacts to BAU and alternative scenarios, using data and initial project outputs from California's Fourth Climate Change Assessment
- Extend BAU and alternative scenario projections to 2100
- Expand wildfire process to incorporate spatially explicit data for burn area and severity
- Model expected GHG outcomes associated with pathways for woody biomass utilization and that are identified in existing and emerging statewide policies and plans
- Model additional land management and restoration practices and further refine data and methods as needed
- Be run through sensitivity analyses
- Be finalized for use in the NWL Implementation Plan

In addition, researchers will identify key unknowns to address in future iterations of scenario modeling upon completion of Version 3.

Version 2 will be improved upon through 2017 and into 2018. A draft Version 3 is expected to be complete in Spring of 2018, and will be used to run preliminary analysis of proposed GHG mitigation activities and the associated programmatic planning for a draft version of the NWL Implementation Plan. A final Version 3 will be utilized in the NWL Implementation Plan. This final version will use the best available science, demographic data, and other inputs to model projected BAU emissions. LBNL will identify known uncertainty across the model as a whole and for specific inputs and outputs. This final version will also be used to compare projected emissions from a suite of alternative land use and management scenarios with those from the BAU reference. The land conservation, restoration, and management activities modeled in CALAND will be used as the building blocks for these scenarios. Therefore, finalizing the list of management activities to be included and clearly parameterizing those activities – or, defining them such that they can be modeled using empirical data consistent with CALAND’s structure – is a critical next step at this juncture. Table 1 contains a listing of management practices currently implemented in CALAND Version 2; the parameters currently used for modeling; and management practices that the Steering Committee has directed LBNL to review for potential inclusion in Version 3. References for the derivation of parameters and modeled outcomes are contained in *CALAND Technical Documentation (Sept. 2017)*. CNRA also expects to use CALAND Version 3, and future versions as developed, to track expected progress towards statewide net GHG reduction goals, as conservation, restoration and management activities are undertaken through programs at Agency and at boards, departments and conservancies. Monitoring of actual, as opposed to expected, outcomes of individual projects or suites of activities will take place through existing regulatory structures or program-specific monitoring procedures. The GHG Inventory for Natural and Working Lands, scheduled for completion by CARB in 2018, will track statewide GHG emissions from this sector on a periodic basis.

Table 1

Management Practices Currently Implemented in CALAND and Planned for Potential Inclusion

Italics indicate activities that they have not been implemented in the current Version 2 and are undergoing review for potential inclusion going forward.

Activity	Description/ Parameters
Practices that (may) change ecosystem carbon exchange rate	
Cultivated land soil conservation	Cover-crops, conservation tillage practices
Rangeland compost amendment	10-year or 30-year repeat compost amendment for Grassland, Savanna, or Woodland
Urban forest expansion	Increase forest fraction of Developed area
<i>Rotational grazing</i>	<i>Reviewing COMET-Planner and other sources for supplemental data and methods</i>
<i>Conservation crop rotation on Cultivated lands</i>	

<i>Mulching of Cultivated lands</i>	
Practices that explicitly transfer carbon among pools and can contribute to emissions, and that may also change ecosystem carbon exchange rate	
Forest clearcut	Harvest of 66% of live and dead standing trees for wood products and bioenergy
Forest partial cut	Thinning of 20% of live and dead standing trees for wood products and bioenergy
Forest fire fuel reduction	Clearing of ladder fuels and debris through thinning – includes removal of 20% of live and dead standing trees for wood products and bioenergy
Forest understory treatment	Understory clearing and removal
Forest prescribed burn	Collecting and burning of understory and debris
Extra Forest biomass utilization	Diversion of burned and decayed understory and debris to energy and wood products
<i>Improved Forest Management</i>	<i>Need input parameters to define practices</i>
<i>Restoration of natural fire regimes</i>	<i>Need input parameters, e.g., annual burned areas at different severities if available</i>
Practices that involve land cover change (plus seagrass)	
Forest area expansion	Increase forest area
Meadow restoration	Creation of meadows
Delta wetlands restoration	Creation of managed wetlands in Sacramento-San Joaquin Delta (from Cultivated land)
Coastal marsh restoration	Creation of saline tidal wetlands (from Cultivated land)
Land Protection	Reduction of baseline urban area growth rate
Seagrass restoration	Creation of offshore seagrass beds
<i>Oak woodland restoration</i>	<i>Afforestation/restoration of oaks trees on suitable land types</i>
<i>Conversion of Cultivated land and other agricultural lands to other land cover types, undertaken for whole-farm carbon, habitat, productivity, and other improvements (e.g., installation of hedgerows, riparian area restoration)</i>	<i>Reviewing COMET-Planner and other sources for supplemental data and methods</i>

Process for Ongoing Model Development

CNRA received significant, constructive input on CALAND from members of the public throughout its development thus far. This input includes a number of questions about CALAND and suggestions for land restoration or management activities to include in modeling alternative scenarios, as well as observations on issues that should be considered in model

development. In addition, the inter-agency Technical and Steering committees have reviewed both Version 1 and Version 2 and provided similar input. Both agencies and members of the public also provided literature references, suggested carbon accumulation modeling methods, referenced datasets, and otherwise provided valuable technical input that LBNL has reviewed and, in many cases, incorporated into Version 2 of CALAND. Some of these technical resources are still undergoing review at this time, and it is expected that ongoing model development will yield additional resources.

Appendix A summarizes the public and agency input that has been received to date, with an emphasis on model elements that were altered between Version 1 and Version 2 and those issues that remain outstanding. This “issues matrix” organizes input and questions by land type across four topic areas: considerations that would affect the BAU projection; suggested management practices to include in the model; data needs; and other “big issues” that exist for a given land type. Going forward, CNRA will track these and other issues raised and convey progress to the public on a quarterly basis as Version 2.0 develops into the final version to be used in the NWL Implementation Plan. CNRA expects to hold three public workshops on CALAND through summer 2018: one in October 2017, and then approximately quarterly. In addition to these public workshops, CNRA plans to convene issue-specific webinars or other smaller, more focused workshops on specific topics that would benefit from a more in-depth discussion and sharing of information.

CALAND also benefits from the engagement of two inter-agency committees – Steering and Technical – convened to guide and inform development. Current agency membership is listed in Table 2. Participation has grown as the model’s scope expands and new issues are raised. The Steering Committee consists of executive leadership across agencies and serves to guide decision-making on CALAND’s quantification and accounting of the carbon sequestration and GHG emissions flux associated with land use and management, as well as their relationship to the goals and implementation recommendations to be included in the 2017 Scoping Plan Update. The purpose and scope of responsibilities of the Steering Committee will be revisited after the Scoping Plan Update is complete. The Technical Committee, at this stage, serves to represent the collective knowledge of carbon sequestration and GHG emissions flux on natural and working lands across state agencies to inform modeling of land use and management impacts for the 2030 Target Scoping Plan Update. The Technical Committee also serves to provide ongoing technical input to the members of the Steering Committee. The purpose and scope of responsibilities of the Technical Committee will be revisited after the Scoping Plan Update is complete.

Table 2: CALAND Steering and Technical Committee Membership

Steering Committee	Technical Committee
California Natural Resources Agency	California Natural Resources Agency
Governor's Office of Planning and Research	Governor's Office of Planning and Research
California Environmental Protection Agency	California Environmental Protection Agency
California Department of Food and Agriculture	California Department of Food and Agriculture
California Strategic Growth Council	California Strategic Growth Council
California Air Resources Board	California Air Resources Board
	California Department of Forestry and Fire Protection
	Department of Conservation
	Department of Fish and Wildlife
	Ocean Protection Council
	Department of Water Resources
	California Energy Commission
	State Coastal Conservancy
	Wildlife Conservation Board

CALAND also benefits from the willing participation of federal partners, the academic research community, and professional experts. The LBNL research team has and expects to continue to have significant engagement with experts at the U.S. Geological Service (USGS), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), and the U.S. Department of Agriculture Forest Service (USFS). These experts have been extremely valuable in providing knowledge of and access to critical data and input on modeling methods.

The Steering Committee now seeks additional public engagement to inform the work of the Technical Committee. Public participation in the Technical Committee is not meant to replace ongoing public participation as described above. Rather, it is intended to provide the Technical and Steering Committees committed, ongoing (through 2018) access to scientific and policy experts in the fields of land use and management across the multiple land types modeled in CALAND, to expedite review of information that may be used in CALAND development and finalization for use in the NWL Implementation Plan. The [application is available online](#), and all applications are due by close of business on October 23, 2017. Please submit applications to NWL@resources.ca.gov.