DCERP MODEL FACTSHEET

LANDIS-II Landscape Change Model

Data Name:	LANDIS-II Model Outputs
Attributes/outputs:	Biomass (g C m^{-2}) Forest carbon storage (g C m^{-2})
Temporal Resolution:	Annual
Spatial Resolution:	Results are provided by MCBCL Forest Management Compartments
Data Years	*Baseline: 1960-2010* *Forecast:* 2015-2100

Description of the Model

The LANDIS-II model shows different annual estimates of forest C storage (g/m^2) across the MCBCL landscape, based on the user selecting different forest management scenarios typically used in the southeastern US. LANDIS-II is a model with several extensions capable of simulating different landscape and ecosystem-level dynamics. We used the LANDIS-II Century extension (Scheller et al., 2011) to account for above- and below-ground biogeochemical processes and their response to the different management strategies and different climatic change parameters. Ecosystem processes in this extension are driven by average monthly weather data. Data used to drive the model include maximum and minimum temperatures, and standard deviations of monthly temperature and monthly precipitation. Thus, the model responds to inter-annual differences in both temperature and precipitation. LANDIS-II also automatically calculates the relative humidity from the temperature and precipitation parameters used. More information on the LANDIS-II model is available at http://www.landis-ii.org/.

Model Inputs

- **MCBCL Vegetation Data –** Species composition, tree density, size class distribution, and seedling abundance from DCERP1 Monitoring Data on 89 plots at MCBCL. Data can be found in MARDIS.
- **MCBCL Soil Data** – Soil organic matter content from DCERP1 monitoring data on 89 plots at MCBCL. Data found in MARDIS.
- **Forest Height** – Estimated from 2010 LiDAR data collected by MCBCL. Data is available in the DCERP Document Database.
- **Forest stand age and management history** – Data provided by the MCBCL Environmental Management Division.
- **Root Decomposition Rate** – Rates were determined by species from the literature: Loblolly pine (Cybulski et al., 2000; King, 1997; Sanchez, 2001) and Longleaf pine (Samuelson et al., 2014).
- **Fuel Consumption Rate –** Measured in forest management plot associated with DCERP1 Research Project T-1. Data is available in MARDIS.

Forest Management Scenarios: We ran the LANDIS-II model with six different management scenarios and mean fire return intervals (MFRIs) for 3 and 6 years.

Forest Management Scenarios

Management Treatment	Description of LANDIS-II procedures
No Management (Control)	Ran model without the Base Fire module and without the Leaf Biomass Harvest module. Century Succession module was used for modeling forest succession and ecosystem processes.
Prescribed Fire Only: No thinning or cutting	Ran model without the Leaf Biomass Harvest module, but with the Base Fire module. Century Succession module was used for modeling forest succession and ecosystem processes.
Commercial Harvest Cycle I: Loblolly pine clear-cut at 25 years for pulpwood	Ran module with the Leaf Biomass Harvest module and the Prescribed Fire module. Century Succession module was used for modeling forest succession and ecosystem processes.
Commercial Harvest Cycle II: Loblolly pine clear-cut at 60 years for timber production	Ran module with the Leaf Biomass Harvest module and the Prescribed Fire module. Century Succession module was used for modeling forest succession and ecosystem processes.
Longleaf Savanna Restoration I: Loblolly pine understory/midstory thinned, followed by longleaf pine plantings	Ran module with the Leaf Biomass Harvest module and the Prescribed Fire module. Century Succession module was used for modeling forest succession and ecosystem processes.
Longleaf Savanna Restoration II: Loblolly pine clear-cut, followed by longleaf pine restoration	Ran module with the Leaf Biomass Harvest module and the Prescribed Fire module. Century Succession module was used for modeling forest succession and ecosystem processes.

Climate Data: DCERP2 Research Project CC-1 provided baselin (1960-2010) and future (2015-2100) climate data. More information is available in the *DCERP2 Final Report* (2018).

- **Baseline Climate Data -** University of Idaho's Gridded Surface Meteorological Data (METDATA; Abatzoglou, 2011) was used to generate daily maximum temperature, minimum temperature, and precipitation from 1960 through 2010.
- **Future Climate Data** – Four climate projections were used that represent a range of uncertainty in 24 climate projections identified from hiearachal clustering techniques by DCERP2 Research Project CC-1. The four models selected included the ECHAM5, ECHO-G, GFDL-CM2.1 and MIROC-ESM-CHEM.

Global Climate Models Used for Climate Change Projections

Projection	Model	Model Origin	Atmospheric Resolution	Ocean Resolution	Hydrology	Physiology
ECHAM5	MACA	Max Plank Institute for Meteorology, Hamburg, Germany	1.9×1.9	1.5×1.5	Bucket	Canopy
ECHO-G	SERAP	Meteorological Institute of the University of Bonn, Bonn, Germany	3.9×3.9	0.5 to 2.8×2.8	Bucket	Canopy
GFDL-CM2.1	SERAP	NOAA + the U.S. Department of Commerce	2.0×2.5	0.3 to 1×1	Bucket	Canopy
MIROC-ESM-CHEN	SERAP	Meteorological Research Institute, Tsukuba, Japan	2.8×2.8	0.5 to 2.0–2.5	Layers	Canopy

Note: MACA = Multivariate Adaptive Constructed Analogs; NOAA = National Oceanic and Atmospheric Administration; SERAP = Southeast Regional Assessment Project.

From each model, daily data for maximum temperature, minimum temperature, and precipitation was provided for 2011–2099. We only ran climate scenarios once for each climate model.

Model Outputs

Outputs from LANDIS-II were generated in GeoTIFF format with pixel values representing total carbon, one file per annual timestep. High and low values of 20,774 to 115 kg carbon/meter^2 were generated. Data were arranged temporally and symbolized in ArcGIS to create an ArcGIS Image Service. This image service can be accessed with data values through an ArcGIS Desktop server connection. Outputs are available in the Document Database.

Outputs can be used to visualize projected patterns of carbon storage across MCBCL. Such a visualization can enable both an understanding of how forest management can impact long term carbon storage as well as a visualization of how potential carbon storage varies across the MCBCL landscape. The latter may be particularly important, as potential carbon storage varies considerably.

Limitations of the Model

This model was used to determine the effects of various management practices on carbon storage in longleaf and loblolly pine. The model did not determine the carbon storage of managed hardwood forests on MCBCL so that the total carbon storage capacity of MCBCL included only projections for the managed longleaf and loblolly areas and therefore would underestimate the total carbon storage since hardwood values are excluded. It should also be noted that under the No Management scenario (i.e., no fire) longleaf and loblolly pines would both revert to hardwoods over time.

Research Project CC-1 identified 24 climate models that would need to be run with each management scenario to get the full range of uncertainty in future climates. Due to time constraints, we used only four models that the CC-1 team identified as the least number of models to run but still be representative of the range of uncertainty in the climate data. Furthermore, we were only able to run each climate scenario once for each management scenario. Therefore, the results from the climate scenarios should be used to represent a range of responses to possible climate futures.

Model Performance and Uncertainty

Modeled data approximate long-term forest ecosystem dynamics for longleaf and loblolly pines. Uncertainty for each scenario was determined by running multiple replicates runs of the LANDIS-II model to determine the variability in results for each management scenario. Uncertainty for future climate scenarios could not be determined. Based on Multi-Response Permutation Procedure analyses, the LANDIS-II model results displayed a high degree of statistical significance among the various combinations of forest management and fire frequency scenarios (A=0.24, p<0.0001).

Average Carbon Stored (kg C m^{-2} ± SD) in the Year 2100 Across MCBCL's Landscape in Each Management and MFRI Scenario for Current Climate Conditions.

Each estimate and SD is based on three independent model runs. Superscript letters denote statistically homogeneous (p>0.05) subsets based on MRPP analysis.

Treatments	Prescribed Fire Frequency (MFRI=3 years)	Prescribed Fire Frequency (MFRI=6 years)
No Management	8,378±106^{a}	
Prescribed Fire Only	8,377±108^{a}	11,018±242^{b}
Commercial Harvest Cycle I	2,663±30^{c}	3,627±42^{c}
Commercial Harvest Cycle II	9,127±170^{c}	9,473±509^{c}
Longleaf Restoration I	11,986±279^{b}	13,339±116^{b}
Longleaf Restoration II	10,274±334^{b}	11,598±239^{b}

Model Owner

Name	Stephen Mitchell
Affiliation	IBM (Formerly Duke University)
E-mail	ecomitch@gmail.com

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Selected Publications

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