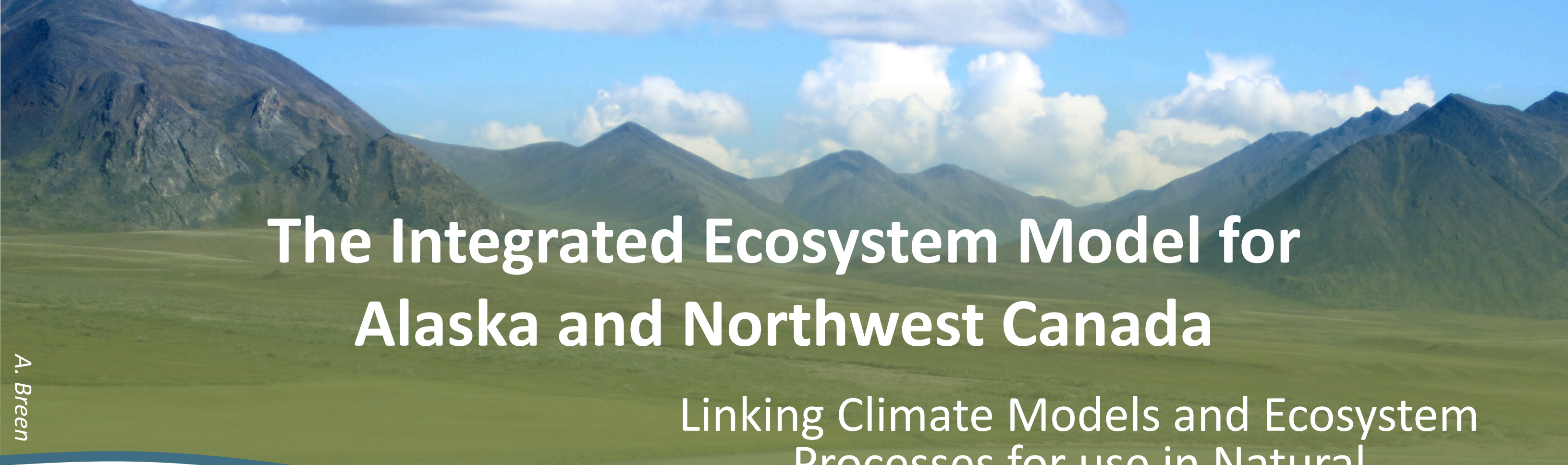


The Integrated Ecosystem Model for Alaska and Northwest Canada

Linking Climate Models and Ecosystem Processes for use in Natural Resource Management

The Integrated Ecosystem Model is designed to help resource managers understand the nature and expected rate of landscape change. Maps and other products generated by the IEM will illustrate how arctic and boreal landscapes are expected to alter due to climate-driven changes to vegetation, disturbance, hydrology, and permafrost. The products will also provide resource managers with an understanding of the uncertainty in the expected outcomes.

Fire, vegetation, and permafrost are a few of the many factors that will be considered in the IEM.

The Integrated Ecosystem Model also known as the IEM uses three ecosystem models that link changing climate scenarios to different ecological processes:

The Alaska Frame-Based Ecosystem Code (ALFRESCO)

ALFRESCO simulates wildland fire, vegetation establishment, and succession. These are the dominant landscape-scale ecological processes in boreal ecosystems, and potentially of increasing importance in tundra ecosystems as well.

The Terrestrial Ecosystem Model (TEM)

TEM simulates characteristics of organic and mineral soils, hydrology, vegetation succession, plant community composition, biomass, and carbon balance in soil. These characteristics have important influences on ungulate populations and other resources important for subsistence by people in Alaska and northwest Canada. Resource managers want to better understand how these dynamics may change due to climate change.

The Geophysical Institute Permafrost Lab model (GIPL)

GIPL simulates permafrost dynamics in arctic and sub-arctic ecosystems—such as active layer thickness (the depth of summer seasonal thaw in perennially frozen ground), changes in soil temperature and changes in permafrost extent. Changes in permafrost can trigger substantive changes in hydrology, carbon cycling, and landscape structure, impacting both the ecosystems and the built environment (infrastructure).

The individual models simulate key processes influencing how the landscapes of Alaska and northwest Canada may respond to climate change. However, these processes do not act in isolation—each influences processes in the other component models. Thus linking ALFRESCO, GIPL, and TEM together should produce a more realistic picture of potential future landscape conditions by more accurately simulating known interactions of ecosystem components and physical processes.

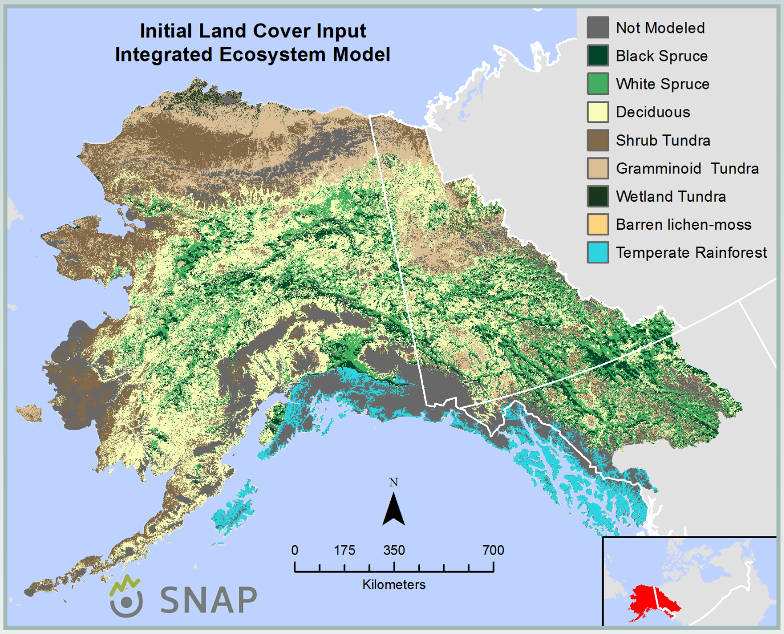
The IEM is also developing new functionality so it can better simulate additional ecosystem dynamics:

Tundra fire and treeline dynamics: Representing tundra succession and disturbance dynamics will allow the IEM to better forecast landscape changes in western Alaska.

Landscape-level thermokarst dynamics: Thermokarst, the characteristic landscapes formed by thawing of ice-rich permafrost, are the dominant feature of much of the arctic and subarctic and are increasing in those areas and the boreal. The dynamics of these landscapes are associated with subsidence and can result in substantial shifts in vegetation and habitat.

Wetland dynamics: Wetland dynamics are important to represent because of their prevalence and importance in northern landscapes.

Forecasting changes in vegetation structure and composition can help resource managers understand ecosystem connections and make decisions about subsistence species, such as caribou.



What type of data products will the IEM generate?

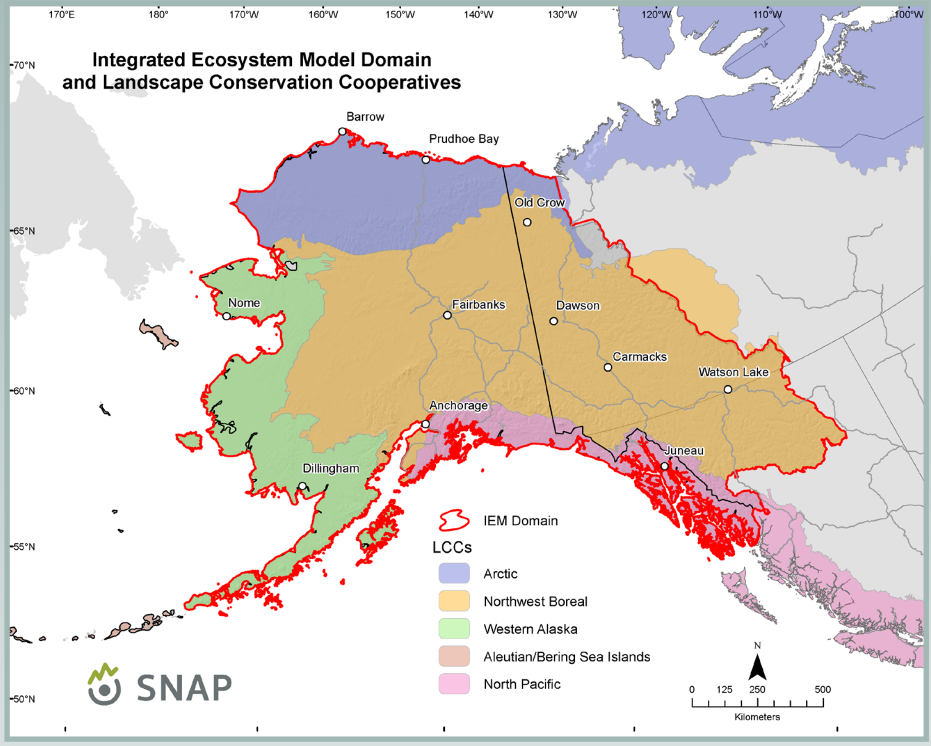
The IEM will generate a broad variety of datasets for use by land and resource managers as well as researchers. The geographic domain of the IEM is based on ecological rather than political boundaries, so its products will be a valuable resource for entities focusing on landscape issues that do not necessarily stop at the Alaska-Canada border. Different categories of data products include: climate, disturbance, landcover and landscape, ecosystem dynamics, soil properties, and model code and documentation. A detailed description of the IEM data products is available in the supplemental insert that accompanies this fact sheet (see back page for more information).

Figure 1. *(Left) The initial land cover input to the IEM. This input is modified from the North American Land Change Monitoring System (NACLMS) and was created by SNAP for use in landscape scale modeling studies. Graphic created by SNAP.*

What climate models and scenarios are used by the IEM? Why were they selected?

All three models within the IEM require information about air temperature, precipitation, and other climate-related variables (e.g. vapor pressure deficit and cloudiness). The source of this information can either be historical data or future climate scenarios generated by Global Climate Models (GCMs). Two GCMs, operating under the moderate A1B (i.e., mid-range) emissions scenario, were chosen to represent the range of warming and precipitation expected to occur across Alaska. The Canadian Centre for Climate Modeling and Analysis General Circulation Model 3.1 - t47 (CCCMA) and the Max Planck Institute for Meteorology European Centre Hamburg Model 5 (ECHAM5) were chosen among a suite of 15 IPCC Fourth Assessment Report (AR4) GCMs ranked among the top five for performance across Alaska and the Arctic (Walsh et al., 2008). These two climate models were selected specifically because they bound the uncertainty associated with ALFRESCO simulations for future fire regime. ECHAM5 climate produces the greatest burned area, while the CCCMA climate produces the lowest estimates of burned area.

Starting in 2014, the IEM will transition from using climate projections based on the AR4 models and the A1B scenario to a new generation of IPCC Fifth Assessment Report (AR5) GCMs and projections that use representative concentration pathways, or RCPs. RCPs (i.e. RCP4.5, RCP6.0, and RCP8.5) are defined by varying degrees of "radiative forcing," or the balance between incoming and outgoing radiation. A positive forcing (more incoming radiation) tends to warm the system, while a negative forcing (more outgoing energy) tends to cool the system. Increasing concentrations of greenhouse gases, such as carbon dioxide, cause a positive forcing. The RCP 8.5 scenario is the most extreme case, where radiative forcing reaches 8.5 Wm-2 by 2100 and continues to rise (Moss et al. 2010). RCP's 4.5 and 6.0 are mid-range scenarios where radiative forcing reaches 4.5 Wm-2 or 6.0 Wm-2 by 2100, but subsequently stabilizes at that level.



What is the area covered by the IEM products?

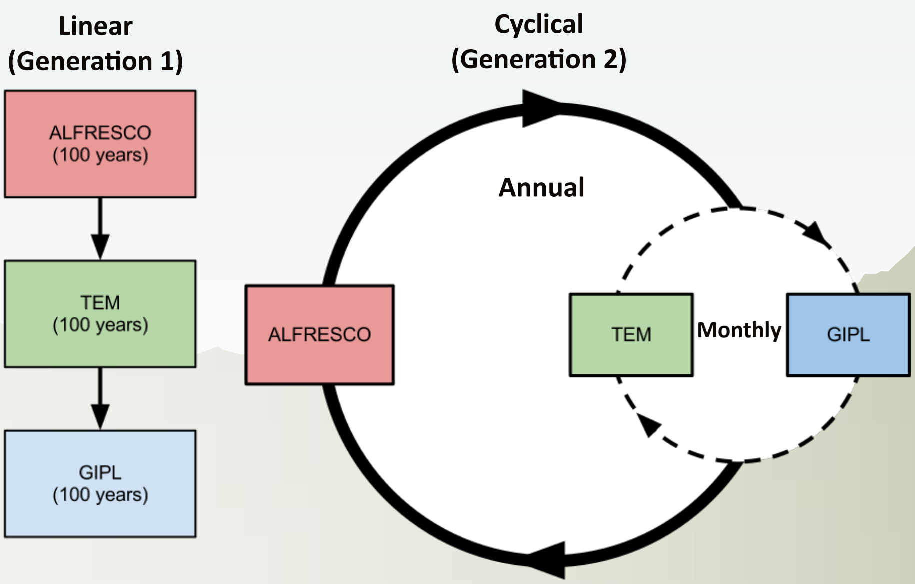
The IEM domain covers most of Alaska, the Yukon Territory, and portions of northern British Columbia (Figure 2), coinciding with the western portion of the Arctic, Northwest Boreal, northern portion of the North Pacific, and Western Alaska LCCs.

Figure 2. *(Left) The Alaska and Northwest Canada geographic domain for the IEM and location of Landscape Conservation Cooperatives (LCCs). Note that a portion of the Northwest Boreal LCC (Mackenzie and Selwyn Mountains) is not included in the IEM domain due to the lack of PRISM data used for downscaling GCM projections. The Aleutian and Bering Sea Islands are also not included because the dominant ecosystem processes at work in this maritime environment are not well represented by the IEM. Graphic created by SNAP.*

How are the models linked together?

There are two different methods used to link the components of the IEM together. One method, referred to as linear coupling, allows for the exchange of information between models to occur in series. For example, data generated by the first model in the series is used as input for a second model, and output from the second model is subsequently used as input for the next model. The second method, referred to as cyclical coupling, allows data outputs to be exchanged among all models and incorporates the output for the next time step. The IEM output generated by linear coupling mode is identified as Generation 1 and data generated by cyclical coupling is called Generation 2 (Figure 3).

Figure 3. *Diagram showing the linear and cyclical coupling methods used to link the three models that comprise the IEM. Graphic created by SNAP.*



How will the accuracy of the IEM be evaluated?

The outputs from the IEM will be compared to historical observations from Alaska and Northwest Canada. Comparisons will assess the accuracy of modeled vegetation distribution, historical burned area, fire size distribution, forest age class distribution, vegetation biomass, thickness of soil organic horizons, soil carbon stocks, leaf area index, soil temperature, soil moisture, snow water content, and distribution. Other accuracy assessments will be added as new data sets become available.

What has been accomplished?

The project's pilot phase (2010-2011) focused on the Alaska Yukon River Basin. A proof-of-concept model run linking ALFRESCO, TEM, and GIPL was completed during this pilot phase and researchers evaluated the degree to which feedbacks between forest type and fire regime may alter organic soils and permafrost under a scenario of warming climate (Rupp et al., 2012).

The significant progress made during 2012 is summarized below by research activity:

Input Data: Prepared downscaled data sets of climate drivers and various other model inputs for the entire project domain and developed a new modeled vegetation input based on the North America Land Change Monitoring System's 2005 North American Land Cover at 250 m spatial resolution (CEC 2010).

Model Coupling: Cyclically coupled the ALFRESCO, TEM, and GIPL models by assembling all of the models on a common computer platform and set up communication among the models so they exchange data at appropriate time steps.

Tundra Fire & Treeline Dynamics: Developed a conceptual framework and new algorithm and incorporated these processes into ALFRESCO.

Thermokarst Dynamics: Developed a conceptual approach to representing permafrost dynamics appropriate to the landscape scale of IEM.

Wetland Dynamics: Conducted field studies that provide insight into carbon and vegetation dynamics for boreal fens and collapse-scar bogs.

Scientists collect data in the field to determine how tundra vegetation and soils respond to fire and accumulate fuel over time. A better understanding of post-fire vegetation processes will improve forecasts of future tundra habitats and is important to inform land managers of the implications of a potentially changing fire regime.

What can we expect from the IEM team in the future?

Long-term objectives for the IEM team are to develop datasets for Alaska and northwest Canada and phase in refinements to the model that are necessary to better understand the potential effects of climate change. A more detailed table of long term objectives is available in the supplemental insert that accompanies this document (described below).

Where can I learn more about the IEM?

This fact sheet has a supplemental insert with more detailed information about the research plan and the project objectives for each project year (2013-2016).

Visit **http://csc.alaska.edu/projects/integrated-ecosystem-model** or scan the QR code (left) with your mobile phone or tablet to view and download the supplementary information.

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