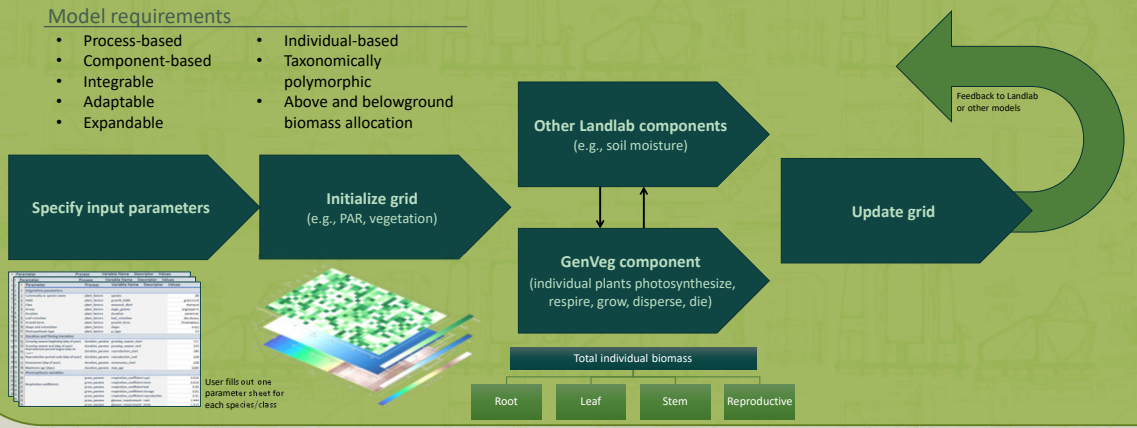
GenVeg: development of an individual-based plant population dynamics model for Landlab

Candice D. Piercy[1], Emily R. Russ[1], Carra C. Carrillo[1], and Todd M. Swannack[1,2]
[1]U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS
[2]Texas State University, San Marcos, TX

GenVeg is designed for use in ecosystems where vegetation dynamics affect other physical and/or ecological processes

Model requirements

- Process-based
- Component-based
- Integrable
- Adaptable
- Expandable
- Individual-based
- Taxonomically polymorphic
- Above and belowground biomass allocation



GenVeg will inform planning and management of ecosystems shaped by plants

Numerous vegetation models exist from global primary productivity models to detailed plant morphology models, but many existing models are narrowly constrained by the system, species, and/or processes of interest and lack the ability to simulate the effect of specific management actions. GenVeg is designed to be applied at a scale on the order of 10s to 1000s of meters over years to decades to inform ecosystem management and engineering planning. The Landlab (Barnhart *et al*., 2020; Hobley *et al*., 2017) framework allows users to flexibly apply relevant physical process feedbacks as well allowing the integration with other models as necessary.

GenVeg uses three main classes

GenVeg
Component class that integrates plant data across the model grid and controls interspecies interactions
Child of PlantGrowth

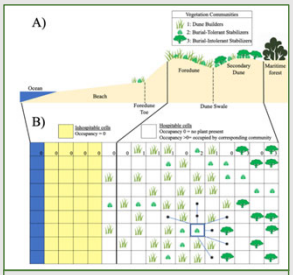
PlantGrowth
Controls growth and development of individual plants
Child of Species

Species
Class that stores species-specific properties and methods

While GenVeg is individual-based, plants are stored in an array for computational efficiency.

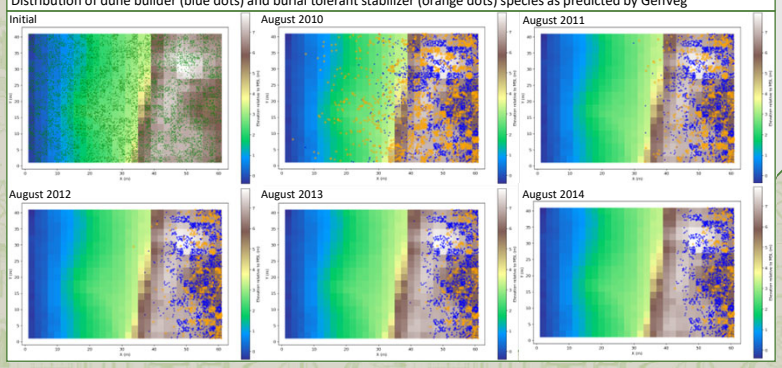
Modeling dune vegetation: from grid-based to individual-based

The DOONIES model (Charbonneau *et al*., 2022) uses a grid-based approach to simulate dune vegetation community dynamics. DOONIES model functionality was incorporated into GenVeg and applied to Island Beach State Park. GenVeg was run for 5 years (2010-2014). Vegetation was randomly initialized across the entire domain and two mortality factors shaped the species distribution: elevation relative to water level and distance to the shoreline. Initial results show skill in predicting the expected species distribution, but the initial assignment of cells is still detectable.



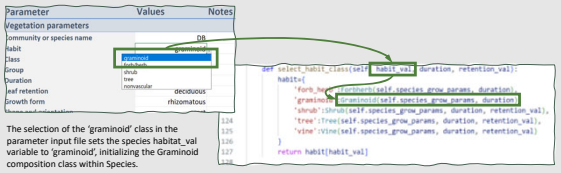
DOONIES model conceptualization from Charbonneau *et al*., 2022

Distribution of dune builder (blue dots) and burial tolerant stabilizer (orange dots) species as predicted by GenVeg



GenVeg's Species class is polymorphic

GenVeg utilizes plant taxonomic principles to select appropriate class properties and methods. This allows GenVeg to simulate a variety of species across many types of ecological systems. The process-based approach also allows the developers to set default parameter values at the plant class level. In the future, default parameterizations for common plant orders and families will be developed, facilitating easy application with minimal species-specific data required.



The selection of the 'graminoid' class in the parameter input file sets the species habitat_val variable to 'graminoid', initializing the Graminoid composition class within Species.

Future directions

We are incorporating plant morphology and biomass turnover, both of which directly affect primary production. The dune vegetation application will be refined for Oregon coastal species and coupled with Landlab soil moisture components and the aeolian transport model, AEOLIS, using the Basic Model Interface.

Final steps for this phase of development will be unit testing, Landlab standard and style compliance, and tutorial development.

Contact
3909 Halls Ferry Road,
Vicksburg, MS 39180
ecomodteam@usace.army.mil
goteamecomod
www.ecomod.erdc.dren.mil

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"Research supported by the U.S. Army Corps of Engineers, Engineer Research and Development Center. The views expressed are those of the authors and do not reflect the official policy or position of the Department of Army, Department of Defense, or the U.S. Government."
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