

# Incorporating Computational Sustainability into AI Education through a Freely-Available, Collectively-Composed Supplementary Lab Text



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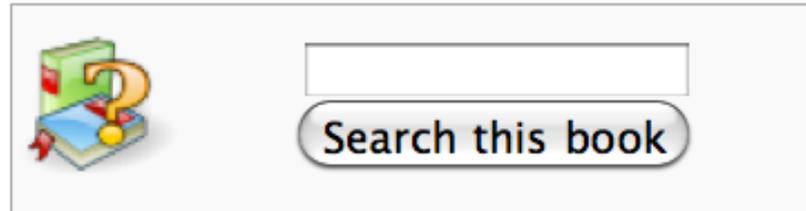
Presentation to the  
3<sup>rd</sup> International Conference on Computational Sustainability  
July 6, 2012  
University of Copenhagen, Denmark



## Preamble

[\[edit\]](#)

This laboratory companion is designed to introduce students of artificial intelligence (AI) to problems of environmental and societal sustainability, together with projects and problem sets at the intersection of AI and sustainability. The lab text can accompany any primary AI textbook, or can be used independently, though the material in it will typically assume selected knowledge of AI at an undergraduate level. The material in the text is organized primarily around AI topics, and includes explanatory and illustrative material concerning specific sustainability problems, together with *projects* (of several weeks duration), *assignments* (of duration on the order of a week) and *exercises* . . .



# Examples of Artificial Intelligence for Computational Sustainability



# Artificial Intelligence for Computational Sustainability: A Lab Companion

Please see how you can contribute: [Guide for Contributors](#)



0. Preface for educators and learners

1. Introduction to Computational Sustainability

## AI Chapters

2. State Space Search

3. Constraint-Based Reasoning and Optimization

4. Knowledge Representation

5. Reasoning Under Uncertainty

6. Machine Learning for Prediction

7. Deterministic Planning and Problem Solving

8. Planning Under Uncertainty

9. Machine Learning for Planning and Problem Solving

10. Multi-Agent Systems

## Sustainability Chapters

11. Agriculture

12. Behavior and Consumerism

13. Biodiversity and Conservation

14. Climate and Ocean modeling and observation

15. Design, Life-Cycle, and Materials

16. Energy, including Smart Grids

17. Fresh Water Ecosystems and Resources

18. Transportation and Urban Design

# Motivations for (AI, Wikibook) Lab Companion(s)

## Educational support for

- *Deep infusion of sustainability into non-sustainability focused courses*
- Sustainability-focused AI courses

## More generally, support for

- Integration of research and education (research suggests educational exercises, and students have ideas for extensions)
- Communication of science to public, encouraging contributions elsewhere (e.g., Wikipedia)
- a survey of the field, associated data sets, opportunities for broader impact plans (e.g., of federal agency proposals)
- the growing community of Computational Sustainability

# Motivations for (AI, Wikibook) Lab Companion(s)

## Why AI (as a start)?

- Sustainability depends on rational, timely, strategic, long-term thinking and decision making under uncertainty – AI is the most relevant area of computing to this sustainability necessity

## Why a Wikibook?

- existing infrastructure for open, transparent, and community contributions, another best fit to sustainability desiderata

## Desirable Characteristics of (AI, Wikibook) Lab Companion(s)

*portable*, a supplement to any primary textbook and other resources;

*online and freely available*, for use in courses world-wide, as well as for use in broader impact plans by research teams/projects ;

*compartmentalized* into self-contained sections/exercises, so instructors can easily “snip out” portions of the textbook for use in their courses;

*interlinked* with other resources (e.g., Wikipedia articles, textbooks, online courses and lectures, online research papers);

*community-developed*, evolving as projects, assignments, and explanatory material at the intersection of computing and sustainability evolve;

*multi-perspective*, indexing by both computing and sustainability themes.

# Sample Lab Assignment: Species Distribution Modeling Using Maxent\*

## Lab Summary:

1. Students examine the effect of climate and climate change on the distribution of several species of tree
2. Using species-range data, students model species distributions using maximum entropy (Maxent)

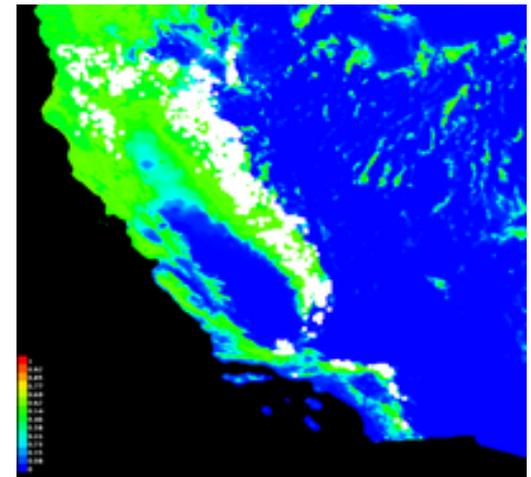
## AI Concepts:

distribution modeling, Maxent, ROC analysis

## Sustainability Concepts:

species distribution modeling, climate change

Cross-referenced in *Machine Learning for Prediction and Biodiversity*

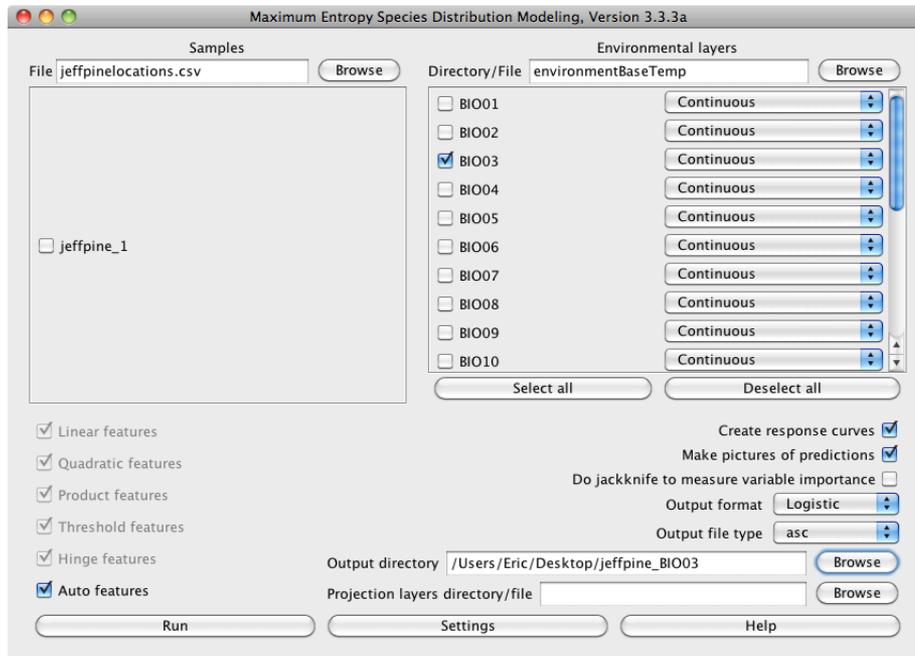


\* This lab is based on an assignment by Park Williams (UCSB Geography), and was extended for an AI audience and posted to the Wikibook with his permission.

# Sample Assignment: Species Distribution Modeling Using Maxent

## Design philosophy:

- Each section contains background material and exercises
- Lab walks students step-by-step through each exercise
- Lab is easily adapted to different course levels, from Intro CS through an advanced AI/ML course
- Maxent software is freely available in Java



**Response curves**

These curves show how each environmental variable affects the Maxent prediction. The curves show how the logistic probability changes as each environmental variable is varied, holding all other environmental variables at their average (mean) value. This is a projection onto a single response curve. The mean of the curves can be used as a measure of the overall response to the variable. The curves are plotted against the standardized environmental variable, which ranges from -1 to 1. The curves are plotted against the standardized environmental variable, which ranges from -1 to 1. The curves are plotted against the standardized environmental variable, which ranges from -1 to 1.

**Analysis of variable contributions**

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To illustrate the five values in each bracket of the following table, the response curve is added to the contribution of the corresponding variable, or combination of variables, to the relative value of variable importance. The response curve is then compared to the response curve of the other variables, or combination of variables, to determine the relative importance of each variable. The response curve is then compared to the response curve of the other variables, or combination of variables, to determine the relative importance of each variable.

Variable	Relative contribution	Permutation importance
BIO03	0.45	0.45
BIO01	0.35	0.35
BIO02	0.20	0.20
BIO04	0.15	0.15
BIO05	0.10	0.10
BIO06	0.05	0.05
BIO07	0.05	0.05
BIO08	0.05	0.05
BIO09	0.05	0.05
BIO10	0.05	0.05

**Raw data outputs and control parameters**

The data used in the above analysis is summarized in the raw data. Please see the help button for more information on these. The data used in the above analysis is summarized in the raw data. Please see the help button for more information on these.

Species: jeffpine\_1  
 Output directory: /Users/Eric/Desktop/jeffpine\_BIO03  
 Projection layers directory/file: /Users/Eric/Desktop/jeffpine\_BIO03  
 Output format: Logistic  
 Output file type: asc

Maxent software by  
R. Schapire et al.  
(2004, 2006, 2011)



# Sample Assignment: Species Distribution Modeling Using Maxent

Introduction

Getting started

Examining species range maps

Modeling species distributions using Maxent

Improving the model using multiple climate parameters

Examining the effects of climate change

## Lab: Species Distribution Modeling Using Maximum Entropy

The distribution of most species is determined by a combination of physical, historical, and dispersal factors. The species distribution model (SDM) is a tool that uses the distribution of a species to predict the distribution of other species. This lab will focus on the use of Maxent to model the distribution of a species. Maxent is a machine learning algorithm that uses the distribution of a species to predict the distribution of other species. It is a powerful tool for modeling the distribution of a species, and it is widely used in conservation biology. In this lab, you will learn how to use Maxent to model the distribution of a species. You will learn how to download the Maxent software, how to prepare the data, how to run the model, and how to interpret the results. You will also learn how to use the Maxent software to model the distribution of a species under different climate scenarios. This lab is designed to help you understand the basics of species distribution modeling. It can be used as a reference for students who are interested in learning more about species distribution modeling.

### Getting Started

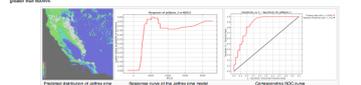
1. Get the Maxent software. Maxent is a Java-based software package that runs on Windows, Mac OS, and Linux. You can download the Maxent software from the Maxent website. The Maxent software is available for free. You can also find the Maxent software on the Maxent website. The Maxent software is available for free. You can also find the Maxent software on the Maxent website. The Maxent software is available for free. You can also find the Maxent software on the Maxent website.

### Examining Species Distributions

1. Examine the species distribution map. The species distribution map shows the distribution of a species across a geographic area. The species distribution map is a map that shows the distribution of a species across a geographic area. The species distribution map is a map that shows the distribution of a species across a geographic area. The species distribution map is a map that shows the distribution of a species across a geographic area.

### Learning a Computational Model of Species Distributions Using Maxent

1. Prepare the data. The Maxent software requires the following data: a species distribution map, a set of climate variables, and a set of background points. The Maxent software requires the following data: a species distribution map, a set of climate variables, and a set of background points. The Maxent software requires the following data: a species distribution map, a set of climate variables, and a set of background points.



### Improving the Model by Using Multiple Climate Parameters

1. Evaluate the model. The Maxent software provides a variety of metrics to evaluate the performance of a model. The Maxent software provides a variety of metrics to evaluate the performance of a model. The Maxent software provides a variety of metrics to evaluate the performance of a model.

### Examining the Effects of Climate Change on Species Distributions

1. Simulate climate change. The Maxent software can be used to simulate the effects of climate change on species distributions. The Maxent software can be used to simulate the effects of climate change on species distributions. The Maxent software can be used to simulate the effects of climate change on species distributions.

1. Examine the results. The Maxent software provides a variety of metrics to evaluate the performance of a model. The Maxent software provides a variety of metrics to evaluate the performance of a model. The Maxent software provides a variety of metrics to evaluate the performance of a model.

Species Distribution Modeling Maxent

Maxent & Distribution Modeling

ROC Analysis

Climate Change

Background Questions

# You can contribute!

- the Wikibook is open to contributions by anyone, from small edits to creating new sections;
- with organization and scope still evolving;
- with monthly video getting-over-the-contribution-hump sessions for new contributors (of exercises or simply editing);

Book **Discussion** [Read](#) [Edit](#) [View history](#)

## Revision history of "Artificial Intelligence for Computational Sustainability: A Lab Companion/Machine Learning for Prediction"

- [\(cur | prev\)](#)  17:39, 25 June 2012 **Eaton** ([discuss](#) | [contribs](#)) . . (27,104 bytes) **(+18,110)** . . *(Added lab on species distribution modeling)* ([undo](#))
- [\(cur | prev\)](#)  16:01, 25 June 2012 **Eaton** ([discuss](#) | [contribs](#)) **m** . . (8,994 bytes) **(+6)** . . *(Revised structure to promote classification and regression from 3rd to 2nd level)* **Credit assignment**
- [\(cur | prev\)](#)  15:04, 17 May 2012 **AIProf** ([discuss](#) | [contribs](#)) **m** . . (8,988 bytes) **(+17)** . . *(→Regression)* ([undo](#)) [checked by QuiteUnusual]
- [\(cur | prev\)](#)  14:56, 17 May 2012 **AIProf** ([discuss](#) | [contribs](#)) **m** . . (8,971 bytes) **(+5)** . . *(→Overview)* ([undo](#))
- [\(cur | prev\)](#)  14:55, 17 May 2012 **129.59.115.2** ([discuss](#)) . . (8,966 bytes) **(+432)** . . *(→Overview)* ([undo](#))

Rollback possible

having an account is not required

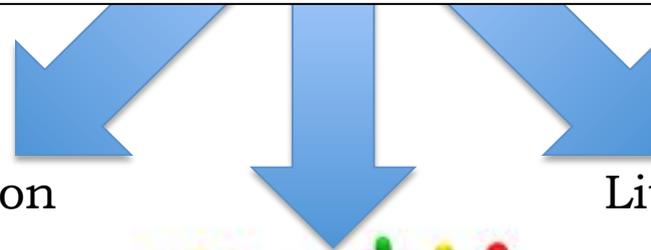
# Summary

## AI for Computational Sustainability Lab Companion

- intended to infuse sustainability into AI coursework through class exercises and projects
- is open, free, community-driven and guided, continually evolving
- is currently very incomplete
- needs contributors of exercises, data, and challenges!
- can be a basis for other community-composed texts,
  - ◆ in other areas of computing for computational sustainability,
  - ◆ of computational sustainability generally (beyond “lab companions”)
  - ◆ and a seed for computational sustainability growth generally

# Conclusions

## AI for Computational Sustainability Lab Companion



Education



Literature



Building the Community