Weed Markup Language (WeedML) Requirements

The outline of this document copies the *XML Query (XQuery) Requirements* document (www.w3.org/TR/xquery-requirements/).

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Abstract

The Weed Markup Language (WeedML) is an open, XML-based format for representing models of the population dynamics of agricultural weeds. WeedML is a software-independent language freely available on Internet. WeedML makes it easy to employ parameters defined in the Weed Traits Database (WTDB). WeedML is managed by the ENDURE RA4.5 Working Group but is open for research purposes for the whole scientific community.

1. Goals

The goal of the ENDURE RA4.5 Working Group is to develop the WeedML specification and to publish it to the scientific community. To enhance the usefulness of WeedML, it is developed in tandem with the Weed Traits Database (WTDB). With WeedML we aim to support a community ecology perspective in weed research and to enhance collaboration between weed and plant ecologists.

Users of WeedML will not write WeedML files by hand. Software tools must be developed to edit WeedML files. A WeedML file is just a specification of a model. To work withWeedML, software tools (e.g. WeedML Editor, WeedML Simulator) must be developed but their specification is not part of this document.

2. Usage Scenarios

The following usage scenarios describe how WeedML may be used in various environments, and represent a wide range of activities and needs that are representative of the problem space to be addressed. They are intended to be used as design cases during the development of WeedML, and should be reviewed when critical decisions are made.

2.1 General Scenarios

2.1.1 Improved Understanding

Use WeedML-based model to identify key parameters in weed population dynamics.

2.1.2 Idea generation

Use WeedML-based model to inspire to new scientific perspectives on weed ecology.

2.1.3 Model Complexity

Use WeedML-based model to explore different levels of model complexity.

2.1.4 Distributed databases

Use WeedML-based model to draw upon a mixture of data from both local and remote computers.

2.1.5 Weed Community Succession

Use WeedML-based model to predict the succession of weed communities.

2.1.6 Environmental Impact

Use WeedML-based model to assess the impact of weeds on the environment, e.g. biodiversity.

2.1.7 Climate Change

Use WeedML-based model to assess the effect of climate change on weed communities.

2.1.8 Management Strategies

Use WeedML-based model to assess the value of new weed management strategies.

2.1.9 Herbicide Resistance

Use WeedML-based model to develop herbicide resistance management strategies.

2.1.10 Decision Support

Use WeedML-based model as part of a decision support system.

2.1.11 Public usage

WeedML used by researchers outside the ENDURE RA4.5 Working Group.

2.1.12 Scientific publications

Use WeedML-based model as a basis for scientific publications.

2.1.13. Teaching

Possible student exercises:

Explore effects of weather, crop rotation and control in the short term (weed density, seed production, crop yield) and long term (seed bank).

Which parts of the weed life cycle would be affected by crop choice? E.g. maize *vs.* winter wheat would that cause a trend up or don in seed bank?

What are the effects of different weed traits on weed dynamics? Identify functional groups.

What is the optimum time for control? Control methods: herbicides (dose-response curves; can be simplified), mechanical control, stale seedbed.

Explore the dynamics (not evolution) of herbicide resistance for weeds with different traits.

What is the consequence of the chosen level of control?

Which factors are important? Sensitivity analysis.

2.2 Spatial Modelling Scenarios

The modelling of spatial weed dynamics can take many forms. The usage scenarios below are listed in order of priority. If WeedML is extended to accomodate the specification of spatial models (*cf.* 3.3 'WeedML may support spatially-explicit models'), design cases should be picked beginning from the top of the list.

2.2.1 Spatial field management

Use WeedML-based model to evaluate the consequences of spatially arranged field management, e.g., non-cropped or unsprayed margins, and site-specific weed management. How precise must precision agriculture be?

2.2.2 Landscape biodiversity

Use WeedML-based model to explore the effects of landscape management on weeds and biodiversity.

2.2.3 Dispersal biology

Use WeedML-based model to explore how different weed characteristics influence weed spatial dynamics. E.g. sexual *vs*. vegetative reproduction, annual *vs*. perennial life form, different seed dispersal mechanisms.

2.2.4 Environmental heterogeneity

Use WeedML-based model to assess to what degree environmental heterogeneity can explain the relative abundance of species.

2.2.5 Landscape structure

Use WeedML-based model to assess the effect of landscape and infrastructure on weed dispersal, e.g. dispersal by trucks and tools in and between fields.

2.2.6 Weed patchiness

Use WeedML-based model to identify the factors determining weed patchiness and to investigate how stable patches are.

2.2.7 Invasive weeds

Use WeedML-based model to identify regions susceptible to weed invasion.

2.2.8 Individual-based modelling

Extend WeedML with the option of representing every individual of the weed population, include maybe a 3D soil sub-model. Use this WeedML-based model to to study emergent population dynamics.

2.2.9 Weeds outside fields

Use WeedML-based model to assess the role played by weeds outside fields.

3. Requirements

3.1 Terminology

The following key words are used throughout the document to specify the extent to which an item is a requirement for WeedML:

- ‘must’ means that the item is an absolute requirement;
- ‘should means that there may exist valid reasons not to treat this item as a requirement, but the full implications should be understood and the case carefully weighed before discarding this item;
- ‘may’ means that an item deserves attention, but further study is needed to determine whether the item should be treated as a requirement; the item may be deferred to later versions of WeedML.

3.2 General Requirements

WeedML must conform to the XML 2.0 specification.

3.3 WeedML Components

WeedML must support models of multiple weed species.

WeedML must support models of annual weed species.

WeedML may support models of perennial weed species.

WeedML may support models of parasitic weed species.

WeedML must support a layered seed bank.

WeedML may support models that include soil conditions.

WeedML must support the inclusion of both crop and weed phenology.

WeedML must support models with different crop rotations.

WeedML must support models with different management practices.

WeedML may support models that include economy.

WeedML must support weather-driven models.

WeedML may support genetically-explicit models.

WeedML may support spatially-explicit models.

WeedML may support models that include herbivores and weed patogens.

WeedML may support models that include allelopathy.

3.4 WeedML Functionality

WeedML must facilitate metadata for model documentation.

WeedML must support sensitivity analysis.

WeedML should facilitate stochastic models.

WeedML may facilitate formatting of model output (e.g. graphics).

WeedML must be component-based, making different versions of a component interchangeable.

WeedML must support versioning to facilitate continuous improvement of WeedML, while not breaking existing WeedML-based models.

WeedML must support the definition of default values for model parameters.

WeedML must be freely accessible on Internet.

WeedML should be accessible through ENDURE's Virtual Lab.