The Biofuel Ecophysiological Traits and Yields Database: Developer's Guide Version 0.001

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Foreward

Objectives

The objective of this document is to provide a roadmap for the development and maintenance of the Biofuel Ecophysiological Traits and Yields database (BETYdb).

0.1 Design

The design of this database will enable these usage scenarios to be supported:

1. Carry out statistical analyses to explore the relationships between traits
2. Identify differences among species and functional groups
3. Access BETY-db from simulation models to look up values for traits and parameter
4. Identify gaps in knowledge about biofuel crop traits and model parameters to aid rational planning of research activities

Raw data After data is submitted and reviewed by a database admistrator, it is made available for analysis. These data are suitable for basic scientific research and modeling. All previously published, reviewed data are made publicly available to users of BETY-db who are conducting primary research. Access to these raw data is provided to users based on affiliation and contribution of data.

The BETY-db can be reached through its web interface `http://ebi-forecast.igb.uiuc.edu/ebi-forecast.igb.uiuc.edu`.

Acknowlegments

BETY-db is a product of the Energy Biosciences Institute at the University of Illinois at Urbana-Champaign. Funding for this research was provided by British Petroleum through a grant to the Energy Biosciences institute.

Data: We gratefully acknowledge the great effort of other researchers who generously made their own data available for further study.

Chapter 1

Methods

1.1 Data

1.1.1 Data Sources

where do we find it?

Methods of Data Collection

Literature search How did we do the literature search? how do we extract data from literature

Other databases What other databases did we query? how do we extract data from these databases?

EBI energy farm How did we get data from the EBI energy farm, how is it referenced?

raw data from other investigators

1.1.2 Types of Data

For all plants, the database contains trait data that can be used to generate informative prior distributions.

For plant species that with potential utility as biofuel crops

published materials and unpublished sources on plant traits (Table 3.17)

We include data on plant traits as well as yield, management, and environmental variables for a range of species grown in both polycultures and monocultures.

Data comes from many sources: previously published data

Two types: multiple species for generating prior trait information

keep biofuel and non-biofuel data separate so that we don't duplicate prev. work.

Plant Traits

define plant traits, Conceptially, what do we mean by plant traits?

The database includes data on the physiological and ecological traits of plants with potential use as biofuel crops.

all photosynthesis traits must have Temperature as a covariate, ideally will also have PAR.

Crop Yield

We have also included data on the yield of various biofuel crops

Management

encapsulate different kinds of data

Yield data will include both peak and harvest biomass. Information on cultivars and experimental design, such as plot size, replication, and arrangement, will be collected for each trial. The database will provide information on management types, including planting time and methods, stand age, fertilization, irrigation, herbicides, pesticides, harvest method, time and frequency, and etc. Together with yield data, we will collect local information on soil, climate, and topography data for each trial.

Ecosystem Function

Where available, we have included data from the surface energy budget, net primary productivity (NPP), gross primary productivity (GPP), net ecosystem exchange (NEE), respiration, soil moisture, runoff, soil temperature, soil carbon, soil nitrogen, and trace gas fluxes.

1.2 Data Transformation

Most data were entered directly as found, with the following exceptions: Linear transformations were made following the ASA-CSSA-SSSA conversion recommendations

http://www.scijournals.org/misc/conversion.shtml

1) when some data were presented as ppt and others as percent, (e.g. leaf %N, %P were reported as mg P per g leaf **?**)

2)For Wulleschleger 1993 **?**, calculated effective n for both Vcmax and Jmax as

$$SD = \frac{range(95\%CI)}{2 * 1.96}$$

$$n_{eff} = (\frac{SD}{SE})^2$$

and conservatively used the minimum of the two values.

3) Vc_{max} to V_{m0}:

When Vcmax is entered into the TraitData table in raw form, it is associated with temperature at which the observation was made.

$$V_{m0} = Vc_{max,T_{ref}}/arr(T_{ref})$$

Where T_{ref} is the temperature (in Kelvin) at which Vc_{max} was measured.

For use with the ED2 model, we want to convert the Vcmax to Vm0 with a reference temperature of 288.15K (15°C). Note that many applications use a reference temperature of 298.15K (25°C), in which case the equation below can be modified accordingly.

$$arr(T) = e^{3000*(1/288.15-1/T_{ref})}$$

4) How to convert among different statistics, with examples

1.3 QA/QC protocols

spot rechecking on some percent of data

outliers

units

reviewing mgmt/treatment recording

Comparison of database with other sources.

1. ORNL Switchgrass database **?**
2. Manually compared plant species names in large DB (like Reich et al with USDA acronyms)

Find citations with no associated trait or yield data `select c.id, y.id,t.id from citations as c left join`

Find sites with no associated trait or yield data `select s.id,y.id,t.id from sites as s left join yields as`

Find covariates with no variable_id `select trait_id from covariates where variable_id is null;`

Delete covariates with no associated traits `delete from covariates where trait_id not in (select distinct`

Replace records from backup table, ex: covariate records `replace missing records in ebi_production from e`

1.4 Software

The BETY-db has beeen developed by MySQL on a RedHat Linux Server (ebi-forecast.igb.uiuc.edu). BETY-db is a relational database designed in a generic way to facilitate easy implementation of additional traits and parameters. The web interface of the database will be accessible soon after the database is developed. It will allow detailed browsing and searching of data, user feedback and data export.

1.4.1 Example database queries

Find USDA Accepted Symbol for Switchgrass:

```
select plants.AcceptedSymbol from plants
where plants.ScientificName like ('Panicum_virgatum');
```

Find species id for Switchgrass:

```
select species.id from species
where species.plant_id
in (select plants.id from plants where AcceptedSymbol = 'PAVI2');
```


Find available trait data for Switchgrass:

```
select variables.name, variables.description
from variables where id
in (select distinct traits.variable_id from traits
where traits.specie_id = 938);
```

Find citations associated with data for Switchgrass:

```
select distinct variables.name, citations.author
from citations join traits on (citations.id = traits.citation_id)
join variables on (variables.id = traits.variable_id)
where variables.name in ('SLA', 'leaf_width', 'root2shoot')
and traits.specie_id = 938;
```

1.4.2 Find yield data with associated management

1.4.3 Find trait data for a specific species

1.4.4 Find data for different traits with same site, trtID, time

1.4.5 Find managements associated with citation

```
select * from managements
where id in (select management_id from managements_treatments where treatment_id in
(select treatment_id from citations_treatments
where citation_id = (select id from citations where author like 'neukirchen'));
```

1.4.6 Find priors assigned to a plant functional type (PFT) for each trait, in this case for the temperate deciduous tree PFT 'tempdecid'.

```
select priors.id, variable_id, priors.pft_id from priors, pft_priors
where pft_priors.prior_id = priors.id and priors.pft_id = 'tempdecid';
```

1.4.7 Example database queries used to update from MySQL

These changes should only be made by an administrator (David L. or Patrick M.), but examples are provided so that users can send example queries when making change requests. Use `select` statements to test your query and make sure that it finds the expected entries.

Required Documentation

When changing database entries at the command line, it is necessary to document the time and user id with each change using:

```
update traits set updated_at =NOW() user_id = 2 where id = 'xxxx';
```

Remove Populus trait and yield data and associated treatments

```
delete from `ebi_analysis`.`treatments`
where id in (select distinct treatment_id from traits where specie_id in
(select id from species where genus = 'Populus'));

delete from `ebi_analysis`.`traits`
where specie_id in (select id from species where genus = 'Populus');

delete from `ebi_analysis`.`treatments`
where id in (select distinct treatment_id from yields where specie_id in
(select id from species where genus = 'Populus'));

delete from `ebi_analysis`.`yields`
where specie_id in
(select id from species where genus = 'Populus');

delete from `ebi_analysis`.`yields`
where citation_id in
(select id from citations where title like '%Populus%' or title like '%poplar%' or title
```

Remove records with ambiguous ids

```
delete from `ebi_production`.`traits`
where citation_id is NULL and specie_id is NULL and id < 10000;
```

Transform variable by 1000

Note that range statistics (e.g. CI, LSD, etc) need to be transformed as well; error statistics (MSE, SD, SE) do not.

```
update traits set mean = mean / 1000 where variable_id = 9 and mean > 1;
```

Edit definitions for allometry variables

```
delete from `ebi_analysis`.`variables` where `id`='196';

update `ebi_analysis`.`variables`
set `description`='Stem biomass allometry slope coefficient ',
`units`='kg stem biomass / plant (cm^b1Bs)'
where `id`='198';
```

1.4.8 How to access database from R

1.5 Web Interface

1.5.1 How it was constructed

The web interface was written in Ruby by Patrick Mulrooney of the department in the University of Illinois School of Life Sciences (email:pat@life.illinois.edu).

1.5.2 How to access database

1.5.3 How to enter data

Users must have a login to enter data. The web interface has been developed to facilitate accurate and efficient data entry. Provides a logical workflow (figure?) to guide the user through comprehensively documenting data along with species, site information, and experimental methods.

1.

2.

Chapter 2

Database Structure

2.1 Overview

This chapter gives an overview of each table within the biofuel database and the relationships among the tables.

The database is designed as a relationship database management system (RDBMS), following the normalization .

The foreign keys are identified by `FK: table.column` in the comment fields of the database tables where `table` is either a) for 1:many relationships the name of the master table in which `column` is the primary key or b) for many to many (m:n) relationships, to the auxillary table with `column` adjacent to another column with which the m:n relationship is simplified into 1:m and 1:n relationships.

2.2 Database contents

2.3 Dimensional Model

2.3.1 Schema

Figure 2.1 provides an overview of the database structure and relationships among tables.

2.4 Trait Data

put TraitData table here and explain

change trait names match database

Table is the trait data, and table 3.20 includes the definitions of traits included in the traits table

TraitDate **TraitDateLOC** is the level of confidence with which the trait date is known: 1=min, 2=hr, 3=3hr, 4=6hr, 5=day, 6=month, 7=season, 8=year, 9=no information; can be a decimal on the pseudo-log scale. **TraitTImeLOC** Precision with which time / date is known: 1=min, 2=hr, 3=3hr, 4=6hr, 5=day, 6=month, 7=season, 8=year, 9=no information

2.5 Yield Data

put YieldData table here and explain

Table 3.21 is the yield data

Table	use	Description
citations	Information about citations	
citations_sites	lookup	
citations_treatments	lookup	
covariates		covariates are required for some traits (see
cultivars		cultivars associated with species
error_logs		
managements		quantifies managements, including treatment levels; provides dat associated with treatments
managements_treatments	lookup	
pfts		defines plant functional types (PFTs), users may choose existi pfts can be used, or user can enter pfts
pfts_priors		
pfts_species		
plants		
priors		
schema_migrations		
sites		
species		
traits		
treatments		identifies experimental treatment name
users		controls data access levels, provides name and contact
variables		provides description and units associated with variables used define traits, trait covariates, and priors
yields		

Table 2.1: Comprehensive list, overview, and brief description of tables in BETY

2.6 Priors

Table 3.13 is the prior data

distributions

make table of distributions, headers = distribution, r-name, paramA paramB

'beta', 'binom', 'cauchy', 'chisq', 'exp', 'f', 'gamma', 'geom', 'hyper', 'lnorm', 'logis', 'nbinom', 'norm', 'pois', 't', 'unif', 'weibull', 'wilcox'

2.7 Context Tables: managements, treatments, and sites

We have divided the *managements* and *treatments* into two different tables.

2.7.1 Managements

The managements table includes managements that were conducted at a specific time... (Table 3.7)

The `treatments` table (Table 3.18) is linked to specific management operations through the managements_treatments lookup table (Table 3.8).

2.7.2 Site

Each site is described in the `sites` table (Table 3.15). A site can have multiple studies and multiple treatments. Sites are identified and should be used as the unit of spatial replication; treatments are used identify independent units within a site, and these can be compared to other studies at the same site with shared management. "Studies" are not identified explicitly but independent studies can be identified via shared management entries at the same site.

Soil This includes the soil types recognized by ED2, based on twelve USDA soil classes (Cite USDA)

make table of soil types

'sand', 'loamy sand', 'sandy loam', 'silt loam', 'loam', 'sandy clay loam', 'silty clay loam', 'clay loam', 'sandy clay', 'silty clay', 'clay', 'peat'

2.8 Definition Lookup Tables

3.20 3.16 3.5 3.1

2.9 Auxillary (m:n lookup) Tables

2.9.1 managements_treatments

3.8

2.9.2 Citation_has_Site

Because a single study can use multiple sites and multiple studies can use the same site, these relationships are tracked in the Citation_has_Site table (Table **??**).

To record one or more covariates associated with each data point, there is a `covariates` (Table 3.4). For example, photosynthesis measurements are often recorded along with irradiance, temperature, and relative humidity. Covariates are frequently recorded for multiple data points, so an m:n lookup table was required. The definition of specific covariates can be found in the `variables` 3.20 table.

move admin tables to separate document / appendix

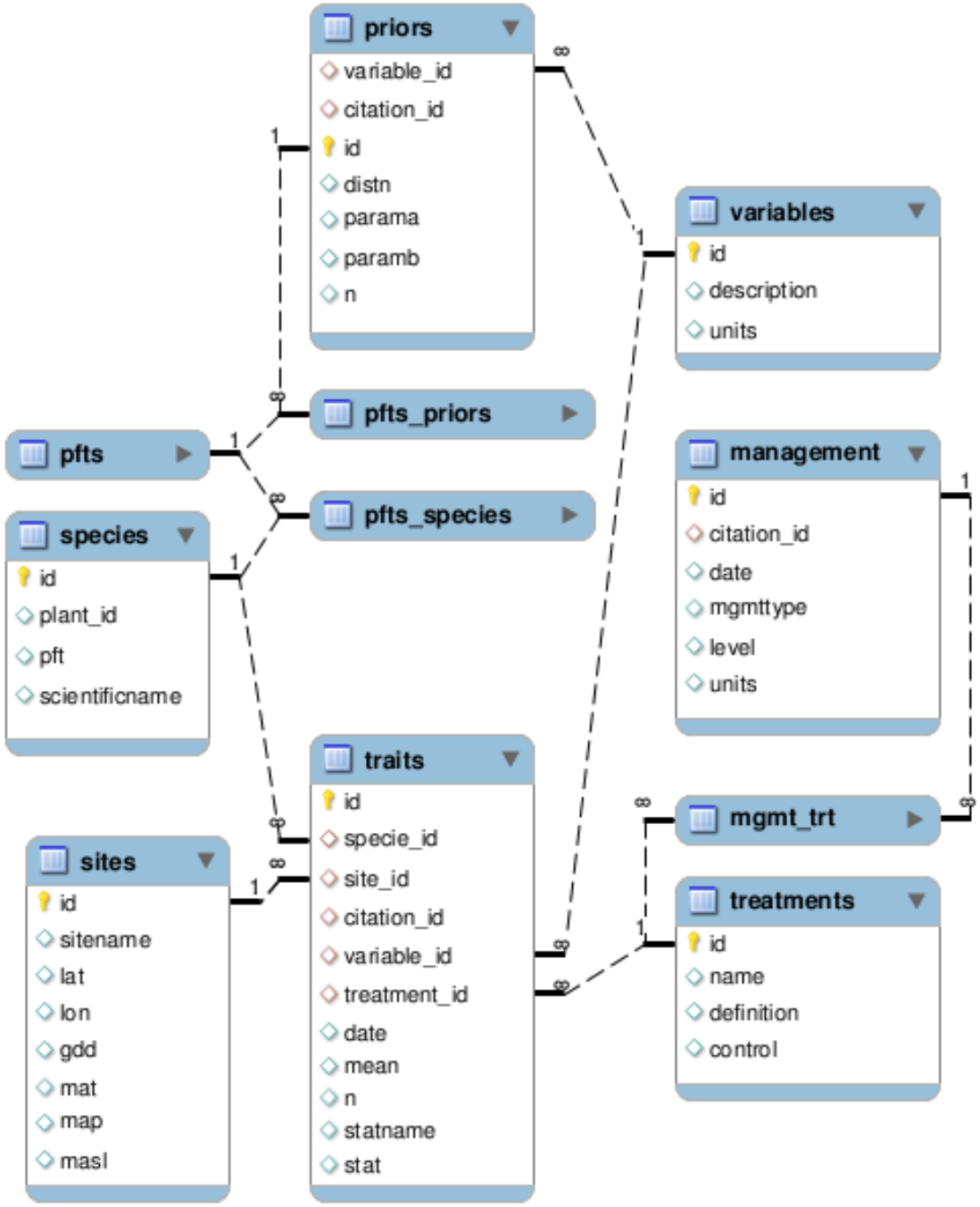

Figure 2.1: Database tables and relationships

Chapter 3

Appendices

Todo list

keep biofuel and non-biofuel data separate so that we don't duplicate prev. work. 5
put TraitData table here and explain 10
change trait names match database 10
put YieldData table here and explain 10
make table of distributions, headers = distribution, r-name, paramA paramB 12
make table of soil types 12
move admin tables to separate document / appendix 12

3.1 Administration

Data is entered into ebi_production; all mysql queries and changes should be made on ebi_analysis. The database ebi_analysis is a copy of ebi_production intended for regular use. To update ebi_analysis from ebi_production, execute from the command line:

/home/dlebauer/db_copy.sh

the contents of the db_copy.sh file are:

```
#!/bin/bash

DB_USER="ebi_user"
DB_PASSWORD="mScGKxhPhdq"
DB="ebi_analysis"

echo "Backing up \$DB to \$DB-backup.sql"
mysqldump \$DB -u \$DB_USER -p\$DB_PASSWORD >> \$DB-backup.sql

echo "Dropping tables from \$DB"
mysqldump \$DB -u \$DB_USER -p\$DB_PASSWORD --add-drop-table --no-data | grep ^DROP
| mysql -u \$DB_USER -p\$DB_PASSWORD \$DB

echo "Transfering tables from ebi_production to \$DB"
mysqldump -u \$DB_USER -p\$DB_PASSWORD ebi_production | mysql -u \$DB_USER -p\$DB_PA
SSWORD \$DB

echo "Done!"
```

3.2 Appendix X: The USDA Plants Database Table

Details of fields in the USDA plants database `http://plants.usda.gov/about_adv_search.html`core data and `http://plants.usda.gov/charinfo.html`characteristics data can be found at the `http://plants.usda.gov`plants.usda.gov website. 3.12

Table 3.1: Structure of citations table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
author	varchar(255)	Yes	NULL		
year	int(11)	Yes	NULL		
title	varchar(255)	Yes	NULL		
journal	varchar(255)	Yes	NULL		
vol	int(11)	Yes	NULL		
pg	varchar(255)	Yes	NULL		
url	varchar(512)	Yes	NULL		
pdf	varchar(255)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
doi	varchar(255)	Yes	NULL		

Table 3.2: Structure of citations_sites table

Field	Type	Null	Default	Comments	MIME
citation_id	int(11)	Yes	NULL		
site_id	int(11)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.3: Structure of citations_treatments table

Field	Type	Null	Default	Comments	MIME
citation_id	int(11)	Yes	NULL		
treatment_id	int(11)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.4: Structure of covariates table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
trait_id	int(11)	Yes	NULL		
variable_id	int(11)	Yes	NULL		
level	decimal(16,4)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.5: Structure of cultivars table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
specie_id	int(11)	Yes	NULL		
name	varchar(255)	Yes	NULL		
ecotype	varchar(255)	Yes	NULL		
notes	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
previous_id	varchar(255)	Yes	NULL		

Table 3.6: Structure of error_logs table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
record_id	int(11)	Yes	NULL		
description	varchar(255)	Yes	NULL		
relationship	varchar(255)	Yes	NULL		
user_id	int(11)	Yes	NULL		
fixed	int(11)	Yes	0		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.7: Structure of managements table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
citation_id	int(11)	Yes	NULL		
date	date	Yes	NULL		
dateloc	decimal(4,2)	Yes	NULL		
mgmttype	varchar(255)	Yes	NULL		
level	decimal(16,4)	Yes	NULL		
units	varchar(255)	Yes	NULL		
notes	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.8: Structure of managements_treatments table

Field	Type	Null	Default	Comments	MIME
treatment_id	int(11)	Yes	NULL		
management_id	int(11)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.9: Structure of pfts table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
definition	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
name	varchar(255)	Yes	NULL		

Table 3.10: Structure of pfts_priors table

Field	Type	Null	Default	Comments	MIME
pft_id	int(11)	Yes	NULL		
prior_id	int(11)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.11: Structure of pfts_species table

Field	Type	Null	Default	Comments	MIME
pft_id	int(11)	Yes	NULL		
specie_id	int(11)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.12: Structure of plants table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
AcceptedSymbol	varchar(255)	Yes	NULL		
SynonymSymbol	varchar(255)	Yes	NULL		
ScientificName	varchar(255)	Yes	NULL		
Symbol	varchar(255)	Yes	NULL		
CommonName	varchar(255)	Yes	NULL		
PLANTS_Floristic_Area	text	Yes	NULL		
State	text	Yes	NULL		
Category	varchar(255)	Yes	NULL		
Genus	varchar(255)	Yes	NULL		
Family	varchar(255)	Yes	NULL		
FamilySymbol	varchar(255)	Yes	NULL		
FamilyCommonName	varchar(255)	Yes	NULL		
xOrder	varchar(255)	Yes	NULL		
SubClass	varchar(255)	Yes	NULL		
Class	varchar(255)	Yes	NULL		
SubDivision	varchar(255)	Yes	NULL		
Division	varchar(255)	Yes	NULL		
SuperDivision	varchar(255)	Yes	NULL		

Table 3.12: Structure of plants table (continued)

Field	Type	Null	Default	Comments	MIME
SubKingdom	varchar(255)	Yes	NULL		
Kingdom	varchar(255)	Yes	NULL		
ITIS_TSN	int(11)	Yes	NULL		
Duration	varchar(255)	Yes	NULL		
GrowthHabit	varchar(255)	Yes	NULL		
NativeStatus	varchar(255)	Yes	NULL		
FederalNoxiousStatus	varchar(255)	Yes	NULL		
FederalNoxiousCommonName	varchar(255)	Yes	NULL		
StateNoxiousStatus	text	Yes	NULL		
StateNoxiousCommonName	text	Yes	NULL		
Invasive	varchar(255)	Yes	NULL		
Federal_TE_Status	varchar(255)	Yes	NULL		
State_TE_Status	varchar(255)	Yes	NULL		
State_TE_Common_Name	text	Yes	NULL		
NationalWetlandIndicatorStatus	varchar(255)	Yes	NULL		
RegionalWetlandIndicatorStatus	varchar(255)	Yes	NULL		
ActiveGrowthPeriod	varchar(255)	Yes	NULL		
AfterHarvestRegrowthRate	varchar(255)	Yes	NULL		
Bloat	varchar(255)	Yes	NULL		
C2N_Ratio	varchar(255)	Yes	NULL		
CoppicePotential	varchar(255)	Yes	NULL		
FallConspicuous	varchar(255)	Yes	NULL		
FireResistance	varchar(255)	Yes	NULL		
FlowerColor	varchar(255)	Yes	NULL		
FlowerConspicuous	varchar(255)	Yes	NULL		
FoliageColor	varchar(255)	Yes	NULL		
FoliagePorositySummer	varchar(255)	Yes	NULL		
FoliagePorosityWinter	varchar(255)	Yes	NULL		
FoliageTexture	varchar(255)	Yes	NULL		
FruitColor	varchar(255)	Yes	NULL		
FruitConspicuous	varchar(255)	Yes	NULL		
GrowthForm	varchar(255)	Yes	NULL		
GrowthRate	varchar(255)	Yes	NULL		
MaxHeight20Yrs	int(11)	Yes	NULL		
MatureHeight	int(11)	Yes	NULL		
KnownAllelopath	varchar(255)	Yes	NULL		
LeafRetention	varchar(255)	Yes	NULL		
Lifespan	varchar(255)	Yes	NULL		
LowGrowingGrass	varchar(255)	Yes	NULL		
NitrogenFixation	varchar(255)	Yes	NULL		
ResproutAbility	varchar(255)	Yes	NULL		
Shape_and_Orientation	varchar(255)	Yes	NULL		
Toxicity	varchar(255)	Yes	NULL		
AdaptedCoarseSoils	varchar(255)	Yes	NULL		
AdaptedMediumSoils	varchar(255)	Yes	NULL		
AdaptedFineSoils	varchar(255)	Yes	NULL		

Table 3.12: Structure of plants table (continued)

Field	Type	Null	Default	Comments	MIME
AnaerobicTolerance	varchar(255)	Yes	NULL		
CaCO3Tolerance	varchar(255)	Yes	NULL		
ColdStratification	varchar(255)	Yes	NULL		
DroughtTolerance	varchar(255)	Yes	NULL		
FertilityRequirement	varchar(255)	Yes	NULL		
FireTolerance	varchar(255)	Yes	NULL		
MinFrostFreeDays	int(11)	Yes	NULL		
HedgeTolerance	varchar(255)	Yes	NULL		
MoistureUse	varchar(255)	Yes	NULL		
pH_Minimum	decimal(5,2)	Yes	NULL		
pH_Maximum	decimal(5,2)	Yes	NULL		
Min_PlantingDensity	int(11)	Yes	NULL		
Max_PlantingDensity	int(11)	Yes	NULL		
Precipitation_Minimum	int(11)	Yes	NULL		
Precipitation_Maximum	int(11)	Yes	NULL		
RootDepthMinimum	int(11)	Yes	NULL		
SalinityTolerance	varchar(255)	Yes	NULL		
ShadeTolerance	varchar(255)	Yes	NULL		
TemperatureMinimum	int(11)	Yes	NULL		
BloomPeriod	varchar(255)	Yes	NULL		
CommercialAvailability	varchar(255)	Yes	NULL		
FruitSeedAbundance	varchar(255)	Yes	NULL		
FruitSeedPeriodBegin	varchar(255)	Yes	NULL		
FruitSeedPeriodEnd	varchar(255)	Yes	NULL		
FruitSeedPersistence	varchar(255)	Yes	NULL		
Propogated_by_BareRoot	varchar(255)	Yes	NULL		
Propogated_by_Bulbs	varchar(255)	Yes	NULL		
Propogated_by_Container	varchar(255)	Yes	NULL		
Propogated_by_Corms	varchar(255)	Yes	NULL		
Propogated_by_Cuttings	varchar(255)	Yes	NULL		
Propogated_by_Seed	varchar(255)	Yes	NULL		
Propogated_by_Sod	varchar(255)	Yes	NULL		
Propogated_by_Sprigs	varchar(255)	Yes	NULL		
Propogated_by_Tubers	varchar(255)	Yes	NULL		
Seeds_per_Pound	int(11)	Yes	NULL		
SeedSpreadRate	varchar(255)	Yes	NULL		
SeedlingVigor	varchar(255)	Yes	NULL		
SmallGrain	varchar(255)	Yes	NULL		
VegetativeSpreadRate	varchar(255)	Yes	NULL		
Berry_Nut_Seed_Product	varchar(255)	Yes	NULL		
ChristmasTreeProduct	varchar(255)	Yes	NULL		
FodderProduct	varchar(255)	Yes	NULL		
FuelwoodProduct	varchar(255)	Yes	NULL		
LumberProduct	varchar(255)	Yes	NULL		
NavalStoreProduct	varchar(255)	Yes	NULL		
NurseryStockProduct	varchar(255)	Yes	NULL		

Table 3.12: Structure of plants table (continued)

Field	Type	Null	Default	Comments	MIME
PalatableBrowseAnimal	varchar(255)	Yes	NULL		
PalatableGrazeAnimal	varchar(255)	Yes	NULL		
PalatableHuman	varchar(255)	Yes	NULL		
PostProduct	varchar(255)	Yes	NULL		
ProteinPotential	varchar(255)	Yes	NULL		
PulpwoodProduct	varchar(255)	Yes	NULL		
VeneerProduct	varchar(255)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.13: Structure of priors table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
citation_id	int(11)	Yes	NULL		
variable_id	varchar(255)	Yes	NULL		
phylogeny	varchar(255)	Yes	NULL		
distn	varchar(255)	Yes	NULL		
parama	decimal(16,4)	Yes	NULL		
paramb	decimal(16,4)	Yes	NULL		
paramc	decimal(16,4)	Yes	NULL		
n	int(11)	Yes	NULL		
notes	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.14: Structure of schema_migrations table

Field	Type	Null	Default	Comments	MIME
version	varchar(255)	No			

Table 3.15: Structure of sites table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
usgsmuid	varchar(255)	Yes	NULL		
city	varchar(255)	Yes	NULL		
state	varchar(255)	Yes	NULL		
country	varchar(255)	Yes	NULL		
lat	decimal(9,6)	Yes	NULL		
lon	decimal(9,6)	Yes	NULL		
gdd	int(11)	Yes	NULL		
firstkillingfrost	date	Yes	NULL		
mat	int(11)	Yes	NULL		

Table 3.15: Structure of sites table (continued)

Field	Type	Null	Default	Comments	MIME
map	int(11)	Yes	NULL		
masl	int(11)	Yes	NULL		
soil	varchar(255)	Yes	NULL		
zrt	decimal(4,2)	Yes	NULL		
zh2o	decimal(4,1)	Yes	NULL		
som	decimal(4,2)	Yes	NULL		
notes	text	Yes	NULL		
soilnotes	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
sitename	varchar(255)	Yes	NULL		
greenhouse	tinyint(1)	Yes	NULL		

Table 3.16: Structure of species table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
plant_id	int(11)	Yes	NULL		
spcd	int(11)	Yes	NULL		
pft	int(11)	Yes	NULL		
genus	varchar(255)	Yes	NULL		
species	varchar(255)	Yes	NULL		
scientificname	varchar(255)	Yes	NULL		
commonname	varchar(255)	Yes	NULL		
notes	varchar(255)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		

Table 3.17: Structure of traits table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
site_id	int(11)	Yes	NULL		
specie_id	int(11)	Yes	NULL		
citation_id	int(11)	Yes	NULL		
cultivar_id	int(11)	Yes	NULL		
treatment_id	int(11)	Yes	NULL		
date	datetime	Yes	NULL		
dateloc	decimal(4,2)	Yes	NULL		
time	time	Yes	NULL		
timeloc	decimal(4,2)	Yes	NULL		
mean	decimal(16,4)	Yes	NULL		
n	int(11)	Yes	NULL		
statname	varchar(255)	Yes	NULL		
stat	decimal(16,4)	Yes	NULL		

Table 3.17: Structure of traits table (continued)

Field	Type	Null	Default	Comments	MIME
notes	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
variable_id	int(11)	Yes	NULL		
user_id	int(11)	Yes	NULL		
checked	tinyint(1)	Yes	0		
access_level	int(11)	Yes	NULL		

Table 3.18: Structure of treatments table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
name	varchar(255)	Yes	NULL		
definition	varchar(255)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
control	tinyint(1)	Yes	NULL		

Table 3.19: Structure of users table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
login	varchar(40)	Yes	NULL		
name	varchar(100)	Yes			
email	varchar(100)	Yes	NULL		
city	varchar(255)	Yes	NULL		
country	varchar(255)	Yes	NULL		
field	varchar(255)	Yes	NULL		
crypted_password	varchar(40)	Yes	NULL		
salt	varchar(40)	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
remember_token	varchar(40)	Yes	NULL		
remember_token_expires_at	datetime	Yes	NULL		
access_level	int(11)	Yes	NULL		
page_access_level	int(11)	Yes	NULL		

Table 3.20: Structure of variables table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
description	varchar(255)	Yes	NULL		
units	varchar(255)	Yes	NULL		
notes	text	Yes	NULL		
created_at	datetime	Yes	NULL		

Table 3.20: Structure of variables table (continued)

Field	Type	Null	Default	Comments	MIME
updated_at	datetime	Yes	NULL		
name	varchar(255)	Yes	NULL		

Table 3.21: Structure of yields table

Field	Type	Null	Default	Comments	MIME
id	int(11)	No			
citation_id	int(11)	Yes	NULL		
site_id	int(11)	Yes	NULL		
specie_id	int(11)	Yes	NULL		
treatment_id	int(11)	Yes	NULL		
cultivar_id	int(11)	Yes	NULL		
date	date	Yes	NULL		
dateloc	decimal(4,2)	Yes	NULL		
statname	varchar(255)	Yes	NULL		
stat	decimal(16,4)	Yes	NULL		
mean	decimal(16,4)	Yes	NULL		
n	int(11)	Yes	NULL		
notes	text	Yes	NULL		
created_at	datetime	Yes	NULL		
updated_at	datetime	Yes	NULL		
user_id	int(11)	Yes	NULL		
checked	tinyint(1)	Yes	0		
access_level	int(11)	Yes	NULL		