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Short communication

An open access database of plant species useful for controlling soil erosion and substrate mass movement

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ABSTRACT

Due largely to anthropogenic activities and extreme climate events, the risk of shallow landslides and erosion has increased enormously over the last decade. Although the planting of vegetation is widely acknowledged as improving soil conservation on slopes, how to plant and manage a vegetated slope over time can be problematic. Correct identification of the mass-wasting process and site characterization is necessary before choosing the plant species best suited to a site. To aid the site manager choose the most appropriate species, we have developed a database containing species sorted by their utility for retaining soil on slopes subject to shallow landslides, wind and water erosion. The list of species was compiled from the literature and suitability is based on ecological attributes, shoot and root traits. The database is open to experts who can add new information via a website, whereas the general public can access the data freely: http://publish.plantnet-project.org/project/stability_en.

1. Introduction

Managing soil conservation on vegetated hillslopes incurs the use of specialized planting techniques and farming practices, some of which have been used for thousands of years (Stokes et al., 2010). Over the last century however, deforestation and the cultivation of crops on sloping marginal lands has increased enormously, often with little thought for the impacts on soil loss (Stokes et al., 2014). Rapid development of infrastructure and road-building (Sidle and Ziegler, 2012) has also led to the creation of artificial slopes, as well as destabilizing the hillslope into which they are integrated. Although many countries are now performing mitigating actions for stabilizing slopes and reducing soil erosion, easy-to-use web-based tools providing practical information for site managers, engineers and stakeholders are sorely lacking.

Vegetation alters soil erodibility and slope stability in several ways (Stokes et al., 2009). If vegetation is used to conserve soil on a hillslope, or mitigate against slope failure, the target process to be remediated needs to be correctly identified. Surface erosion is defined as the detachment, transport and deposition of soil particles by an erosive process e.g. wind or water (Gray and Sotir, 1996; Boardman and Poesen, 2006), and is often managed using ground-cover, clumping grasses or plant species with shallow, fibrous root systems (de Baets et al., 2009). Landslides are defined as processes that result in the downward and outward movement of slope-forming materials composed of natural rocks, soil, artificial fill, or combinations of these materials (Sidle and Ochiai, 2006) with gravity and water as the primary triggers of landslides. Soil reinforcement to prevent shallow landslides occurs deeper in the soil, often at 1–2 m below the soil surface (Norris et al., 2008), therefore, deep-rooting species are more suitable for increasing resistance to failure (Stokes et al., 2009). Mass-wasting phenomena such as rock fall can be mitigated using protection forests. However, the density and size of trees, as well as their mechanical properties influence the efficacy of the forest (Dorren and Berger, 2005). Further situations where the choice of vegetation influences soil conservation and slope stability include e.g. river banks and vegetated dikes (levees), where complex hydrological processes such as scouring and piping exist (Abernethy and Rutherfurd, 1999). Choosing the right species for a given environment and as a solution to a particular problem is challenging, and if errors are incurred in the choice, can result in plantations with undesirable consequences. Therefore, species databases and decision support tools would help a site manager choose an appropriate species, or mixture of species to plant

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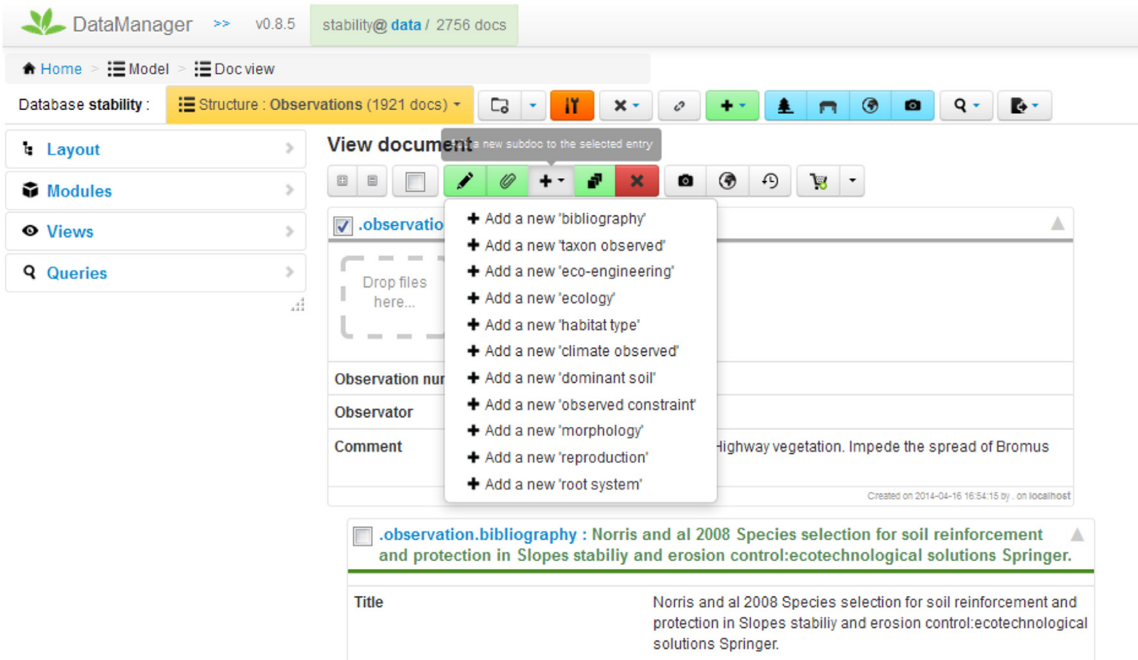

Fig. 1. Stability database OBSERVATIONS page which allows end-users to add data either manually or as a csv file.

on a site, once the slope degradation process has been identified (Mickovski and van Beek, 2007).

Choosing a mixture of species should be considered in terms of spatial position along a slope and also over time, depending on the final goal of the site manager. Optimal planting patterns and species mixtures on large-scale slopes are starting to appear, although most studies on soil fixation by plants have focused on the use of one or two species only. To aid site managers and engineers choose suitable species or species mixtures for a given site, we created a web based database, which is also accessible to specialists wishing to add data. The database, named '*Stability*' can be accessed freely by the public after registering online. We compiled existing knowledge on species identified as 'useful' for preventing substrate mass movement and soil, water and wind erosion. We included these species into the *Stability* database, along with their ecological requirements. End-users can interrogate the database to find species suitable for their needs, as well as share their own data on potentially useful species for ecological engineering.

2. Specifications for administration and use of the *Stability* database

The *Stability* Database and available data are managed by the administrator using the freely available management tool Pl@ntNet DataManager which employs the Apache CouchDB software. This software allows the administrator or end-user to work with the same interface on a local or a remote database. Data conflict is prevented and continuous or one-shot synchronization is possible. Three default roles are available: reader, writer and administrator. Only the writer and administrator can add data. To obtain the statute of writer, a user must contact the administrator and request permission. No development for the interface is needed and batch data can be readily imported. Using the online Pl@ntNet DataManager tool also permits text, image and video files to be attached to each record.

End-users can search or add information to the *Stability* database by contacting the corresponding author. The database runs on the web browsers Google Chrome or Mozilla Firefox and end-users can make simple searches for data (see Section 'Searching the Database' for simple and advanced types of searches) at:

http://publish.plantnet-project.org/project/stability_en

2.1. Structure of the stability database

To facilitate simultaneous management of information, the database is organized into three main parts (Supplementary material online**):**

1. The data repositories: TAXA, BIOLOGICAL TYPES, LOCATIONS CLIMATES, TYPOLOGIES, CONSTRAINTS, SOILS and RISKS group together regularly used data in the database.
2. A central table called OBSERVATIONS, which is the term used when a user adds a new species and associated data into the database (Fig. 1).
3. A set of sub-modules including information that enriches the content of observations when a writer adds a new species to the database: BIBLIOGRAPHY, TAXON OBSERVED, ECO-ENGINEERING, ECOLOGY, HABITAT TYPE, MORPHOLOGY, REPRODUCTION and ROOT SYSTEM, CLIMATE OBSERVED, DOMINANT SOIL and OBSERVED CONSTRAINT.

Certain data are obligatory when added to the database and include the taxonomical description of species (TAXA), e.g. family, genus, species and common name. The life form (BIOLOGICAL TYPES) of each species is described as herb, shrub, tree, small tree or liana. When including the native range or location of a species (locations), a mandatory area specifies the site name and continent, country, district (state, region or other), city and GPS coordinates where the species is found. In CLIMATES, data concerning the preferred climate of a species is found, as well as species hardiness to certain weather events, e.g. Mediterranean, frost hardiness and exposure to sunlight. As root system architecture and traits are important factors governing slope stability and erosion control, we have included a collection of 22 root system architectural