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The characterization of willow (*Salix* L.) varieties for use in ecological engineering applications: Co-ordination of structure, function and autecology

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ABSTRACT

The rapid development of innovative and highly specialized ecotechnologies targeting site-specific problems and pollutants requires precisely tailored designs. The proper selection of remedial plant genotypes that possess the correct structure and function to effectively address a specific problem is a vital step in the design of ecological engineering applications because numerous essential traits must be evaluated to maximize the effectiveness of each installation. Knowledge about the biology of willow species from decades of research as a perennial biomass crop has recently been applied to resolving an array of environmental and ecological problems. Here, essential characteristics of *Salix* varieties that are pertinent to ecological engineering are described and related to particular ecotechnologies. We identified thirty-six agronomical, physiological, and ecological attributes of willow that provide a framework for species selection and assist in the identification of site-specific functional types of willows for land reclamation, phytoremediation, bioengineering, and agroforestry.

1. Introduction

Over the last three decades ecological design has been applied to a diverse range of technologies including waste conversion, environmental protection, ecological restoration, brownfield remediation, food production, landscape design and architecture (Todd et al., 2003) opening a new frontier in ecological engineering. New ecotechnologies hold considerable promise for creating more sustainable systems as the additional potential of green plants to accelerate ecological and biochemical transformations of damaged land is being understood and applied. The proper selection of plant genotypes for particular applications at specific geographic locations is a vital step in successful ecosystem design (Licht and Isebrands, 2003).

The objective of the present paper is to identify the range of agronomical, physiological and ecological characteristics of the genus *Salix* that are pertinent to ecological engineering, and to examine how these characteristics are relevant to particular ecotechnologies. A case study focusing on the genotype selection of shrub willow for the development of an alternative vegetative cap in the state of New York is presented to illustrate the outlined specifics.

2. *Salix* diversity

There are about 330–500 species of *Salix* worldwide (Argus, 1997), predominantly in temperate and arctic zones, but also in subtropical and tropical zones. Willows are distributed throughout the Northern Hemisphere with only a few species native to the Southern Hemisphere. Any native flora in temperate parts of the world includes numerous *Salix* species, thus a range of indigenous willows is suitable for a design in most locations (Kuzovkina and Quigley, 2005).

The representatives of the genus *Salix* are divided into five subgenera: *Salix*, *Protitea*, *Longifoliae*, *Chamaetia* and *Vetrix* (Argus, 2007), and each subgenus except *Longifoliae* consists of many sections. The subgenus *Salix* is comprised of mostly tree-type species sharing many common characteristics with *Populus*, such as arborescent growth, large size, and rather loose catkins that appear with the leaves on leafy stalks. The most common representatives of subgenus *Salix* include *S. alba* (white willow), *S. babylonica* (weeping willow) and *S. lucida* (shining willow). Subgenus *Protitea* encompasses a dozen species distributed in temperate as well as tropical and subtropical regions with distinctive free overlapping bud scale margins. Common North American species – *S. nigra*

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