ECOLOGY

Adding Biofuels to the Invasive Species Fire?

Biofuel crops, particularly using non-native species, must be introduced with an understanding of possible risks to the environment.

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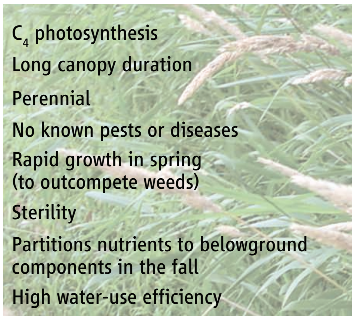
The U.S. renewable energy initiative (*1*) announced in the 2006 presidential State of the Union address (*2*) has given new impetus to the identification of biofuel crops as sources of energy. However, an earlier presidential directive, Executive Order 13112 (*3*), attempts to protect the United States from invasive species, unless benefits clearly outweigh potential harms. The policies may conflict because traits deemed ideal in a bioenergy crop are also commonly found among invasive species (see figure).



Ideal ecological traits of biomass energy crops (*4*). All traits shown other than perennial growth and sterile seeds are known to contribute to invasiveness. See (*25*).

Biofuel crops may have economic benefits, but studies of concomitant environmental risks of movement into novel habitats are seldom conducted. Although anecdotal claims of "low risk" for some species (*4*) may be valid, many purportedly beneficial introduced species have had long-term economic and environmental costs owing to their invasiveness (*5*, *6*). For example, *Sorghum halepense* is an introduced forage grass that became an invasive weed in 16 of the 48 U.S. states in which it occurs. Even the most conservative estimate of competitive losses for cotton and soybean crops in three states is in excess of $30 million annually (*7*).

Several grasses and woody species have been evaluated for biofuel production, with perennial rhizomatous grasses showing the most economic promise (*4*, *8*). *Arundo donax* (giant reed; native to Asia) and *Phalaris arundinacea* (reed canary grass; native to temperate Europe, Asia, and North America) are two C_3 grasses being considered as biofuel species (*8*) that are invasive in some U.S. ecosystems. The former threatens riparian areas and alters fire cycles (*9*); the latter invade wetlands (*10*) and affect wildlife habitat.

The hybrid grass *Miscanthus* × *giganteus* (native to Asia) and *Panicum virgatum* (switchgrass; native to central and eastern United States) are C_4 grasses being considered in Europe and the United States (*4*, *11*). Several *Miscanthus* species are invasive or have invasive potential (*12*); in particular, the parent species of *M.* × *giganteus* (*13*, *14*). *Miscanthus* × *giganteus* is an allopolyploid that does not produce viable seed and reproduces vegetatively. However, allopolyploidy does not guarantee continued sterility (*15*) and vegetative propagation is often associated with invasiveness (*16*, *17*) or directly contributes to it (*18*). Several other traits that make *Miscanthus* potentially valuable as a crop could enhance invasiveness (ability to resprout from below ground, efficient photosynthetic mechanisms, and rapid growth rates) (*16*, *19*).

The U.S. native, *P. virgatum*, shares many traits with *Miscanthus* and can also produce seeds, which may give *P. virgatum* even greater invasive potential. Furthermore, plants native in one region can become invasive when established elsewhere (*20*). Escape from competitors and natural enemies may help explain the weedy nature of *P. virgatum* outside its endemic range (*21*).

Internationally, there has been little success in eradicating or even controlling an invading grass. Herbicides are used to control invasive grasses on croplands, but they are too expensive to use on rangelands, national parks, and reserves. Development of the most economical tool, biological control with a specific natural enemy, has been avoided because of the perceived risk of its expanding its host range to include commercial grasses, such as wheat, corn, barley, or rice (*22*).

Balancing costs and benefits of species introductions is a key contemporary challenge. Introducing some plant species as biofuel sources may be safe, but safety must be established by agronomic and ecological analyses. Such analyses are already mandatory for biological control agents (*23*) and transgenic plants (*24*). Experts must assess ecological risks before introducing biofuel crops, to ensure that we do not add biofuels to the already raging invasive species fire.

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