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Managing invasive plants on public conservation forestlands: Application of a bio-economic model ☆

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ABSTRACT

Public conservation forestlands protect natural resources, provide wildlife habitat, and service a multi-billion dollar recreation industry. Invasive upland plants (IPs) threaten to dramatically reduce the flow of goods and services from these lands. In the late 1990s, a Florida (USA) state program began combating IPs on public conservation lands. By 2007, the program had controlled roughly 1/3 of the 1.5 million IP-infested acres, primarily due to a surge in expenditures that began in 2001 and peaked in 2005. This study evaluates the effectiveness and efficiency of the program by simulating the costs and benefits of IP control through 2016 under five feasible policy alternatives: (I) *Do nothing*, (II) *Maintenance control*, (III) *2001–2004 level* (of program spending), (IV) *2005 level*, and (V) *Maximum net present value*. To evaluate the policies, we construct a bio-economic model that is parameterized using observations of IP coverage and data from 11 state regions. Given the uncertain nature of IP spread, we simulate the policies' economic impacts under two plausible spread rates. Simulation results indicate that the program's recent efforts are highly effective – generating up to $865.1 million in present value net benefits through 2016 – but less efficient than more costly, front-loaded spending that can generate up to 4.37 times more net benefits.

1. Introduction

Florida's forests provide critical life-support functions for people and wildlife and generate other valuable goods and services, such as wildlife recreation worth $7.8 bn/year (FDEP, 2001) and forest products worth $16.63 bn/year (Hodges et al., 2003). In 1995, destructive non-native, "invasive" plants (IPs) infested 1.5 mn acres of Florida's public conservation lands and threatened to irreversibly reduce the flow of forestland benefits. In response, the Florida Department of Environmental Protection's Bureau of Invasive Plant Management (FDEP) began a program to achieve "maintenance control" of IPs (keeping populations at very low levels for the foreseeable future) on public lands (Simberloff et al., 1997). The program provides direct support to public land managers and coordinates the efforts of over 500 public entities involved in IP control. Although the program boasts success – by 2006 an estimated 500,000 acres had been reclaimed – public funding has been inconsistent and may be insufficient given the high values associated with public conservation lands.

Economic studies that can support IP policy decisions are lacking (U.S. General Accounting Office, 2002), which is a concern particularly for sustainable forest management (Siry et al., 2005). We present an empirical study that applies a bio-economic model to examine the costs and benefits of the FDEP program compared to feasible alternatives. We (1) describe a conceptual bio-economic model of the FDEP program, (2) discuss the economics of a coordinated IP management program, (3) present an empirical bio-economic model of IP control, and (4) report the results of five simulated policy scenarios that we used to evaluate the effectiveness and relative efficiency of the FDEP program.

1.1. Florida conservation forestlands

Conservation lands (mostly state and federal) make up 27.4% of Florida's landmass, and 23% of these conservation lands are forested (FNAI, 2006). Historically, public forests were managed for long-term timber production; but since the 1960s other goods and services – watershed protection, carbon storage, wildlife habitat & biodiversity, recreation, and other amenity values – have also been considered (Pearce, 2001; Glück 2000). Conservation forestlands play an increasingly vital role in sustaining environmental goods and services, particularly given Florida's rapid population growth and rate of conversion of non-public land. IPs threaten to significantly erode the value of these lands to the public.

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1.2. Invasive plant threats

IPs are non-native species whose introduction "causes or is likely to cause economic or environmental harm or harm to human health" (Executive Order 13112, 1999). Florida has a high rate of non-native species introduction, with the Port of Miami receiving about 85% of the non-native plant shipments into the United States each year (OTA, 1993). Although many non-native species have slight impacts on natural areas, a small percentage are tremendously harmful. According to the "tens rule," about one in 10 non-native species that establish in natural areas will become invasive (Williamson and Fitter, 1996). Over 1300 non-native plant species are established in Florida: 124 are classified as invasive, and 92 of these are upland plants that typically infest forests (FLEPPC, 2007).

Invasive plants are a critical issue that needs to be resolved to protect biodiversity and maintain sustainable forest cover. They are a particular problem for Florida, where physiographic characteristics make it relatively easy for non-native species to invade and form widespread, dense monocultures (Simberloff et al., 1997). They can have devastating ecological impacts and may be the primary cause of biodiversity loss (Mack et al., 2000). They also reduce the quantity and quality of outdoor recreation and hamper ecotourism opportunities (Adams and Lee, 2007).

An estimated 10.3% (1.0 mn acres) of Florida's public conservation land is infested with IPs (FDEP, 2006). Given the fast growth/spread rates of IPs, infestation is likely to increase without significant management efforts. Among the worst IPs in Florida are Old World climbing fern, Brazilian pepper, and Melaleuca (see Box 1). With increases in trade and immigration, the arrival rate of non-native species may be rising.

1.3. The upland invasive exotic plant management program

The FDEP works with public land managers to control IPs in Florida. Efforts are coordinated through the Upland Plant Management Program, whose goals include: "Achieve eradication or maintenance control of invasive exotic plants on public lands" that are detrimental to "the state's natural environment… [or] agricultural productivity…." (28 Fla. Stat. 369.252(1) (2008)). From 1997 to 2006, the program spent an average of $5.03 mn/year to combat IPs on public conservation lands (FDEP, 2006). In 2001, there was a notable spending increase, averaging $6.16 mn/year from 2001 to 2004 and peaking in 2005 at $8.69 mn. Also in 2001, federal and state agencies began pooling financial and informational resources to help coordinate IP research, educational and control efforts. Through its 11 working group regions, the program coordinates the efforts of 67 counties, and over 500 federal, state, local, non-governmental, and private entities (see Box 2). Currently, the FDEP estimates that the program has controlled roughly 500,000 acres of IPs on public lands (FDEP, 2006). Continued funding for the program is uncertain given recent state budgetary shortfalls.

Box 1
Ecosystem and Wildlife Impacts from Invasive Upland Plants (Adapted from National Park Service, 2007).

Old World Climbing Fern (*Lygodium microphylum*) from Australia was introduced to Florida to help reclaim wetlands. Instead, this vine smothered trees, covered canopies, and changed the fire regime by providing a bridge by which fires could traverse water breaks. Notable problem areas are in Central and South Florida.
Brazillian Pepper (*Schinus terebinthifolius*), a hearty shrub with bright red berries, was shipped from South America as an ornamental. It grows in dense monocultures in aquatic and terrestrial habitats displacing native plants, habitats, and bird food sources. The chemicals from the plant are irritating to human skin and toxic when consumed by animals and birds.
Melaleuca (*Melaleuca quinquenervia*), native to Australia, was introduced to the Everglades to help reclaim wetlands. Lacking natural competitors, it spread across 359,000 acres, displaced native habitat, interfered with utility lines and drainage canals, reduced biodiversity in prairie and marshlands, and fueled wildfires that are hotter and more frequent than normal.

Box 2
Florida's Upland Invasive Exotic Plant Management Program.

The FDEP program provides public land managers with information and financial assistance, plus access to an herbicide "bank," where managers apply for assistance for plant control projects through 11 regional working groups (FDEP, 2003). The herbicide bank aids budget-constrained public agencies by reducing the cost of treatment. It also provides a detailed source of record keeping, such as the quantity of chemical used and application times and locations. A recent cost-cutting innovation by the program was the use of premixed herbicides and refillable containers. Typical handling of herbicides requires transportation to the field, accurately using in-field mixing equipment, rinsing containers three times, and removing and disposing of containers. The innovation reduces waste, disposal costs, spoilage, and mixing errors.

2. The conceptual economic problem of invasive species control

The economic dimensions of invasive plant impacts include: (1) IP management generates a public good, and welfare gains are possible through public subsidization (Perrings et al., 2002; Burnett, 2006); (2) management of IPs entails scale economies due to the multi-region dimension of the problem (bio-pollution can drift onto neighboring lands); and (3) scope economies are available because multiple invasive species managed simultaneously enables sharing of scarce financial resources, control strategies, and inputs.

IP control has been called a "weakest link" public good (Vicary and Sandler, 2002; Burnett, 2006), where the party least willing to invest becomes the host for consistent bio-pollution drift onto neighboring lands. Underinvestment in IP control is likely to occur when public lands are managed independently without regard to overarching impacts on habitat or recreation, or to the spillover of IPs to nearby lands.

Consider a quantity of land L comprising multiple parcels held publicly and managed by separate entities (Fig. 1). Control of IPs within each parcel may seem efficient depending on land uses, budget constraints, and local priorities. Since each entity does not consider the total benefits to society of invasive plant management, they manage IPs at level S_p such that Z_p is the amount of public land free of IPs. The marginal benefit curve, MB_p is a horizontal summation of individual marginal benefit curves faced by each entity. At IP acres S_p and equilibrium point A, marginal benefit and marginal cost of IP management is equal.

With coordinated efforts, ideally, each entity considers the total public benefits of IP management. This situation might occur by tying funding support to targeted IP results, increasing awareness of economic interdependence, and fostering a cooperative culture. As a result, social welfare can be maximized when the *total* marginal benefit (MB_{tot}) equals the marginal cost of management (MC). The