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Original Article

Integrated Damage Management Reduces Grazing of Wild Rice by Resident Canada Geese in New Jersey

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ABSTRACT Tidal freshwater marshes of the Maurice River, New Jersey, USA, have been long renowned for robust stands of wild rice (*Zizania aquatica*). During the 1990s, these marshes experienced an apparent decline in wild rice. During 2000–2002, I used paired fenced exclosures and open control plots to measure herbivory by the Atlantic Flyway Resident Population of Canada geese (*Branta canadensis*) on wild rice and response of rice to an integrated damage management program (IDMP). The IDMP consisted of rendering goose nests unhatchable, shooting, and culling molting geese. The IDMP reduced the number of goslings by 60% during the first year and essentially eliminated recruitment during the second year. Prior to the IDMP, grazing by geese reduced the density of rice by 78% and the height of plants surviving grazing by 17%. With implementation of an IDMP, rice density between exclosures and control plots did not differ. Wetland managers should consider the grazing impacts that resident population Canada geese can incur on native plant communities and develop a plan for mitigating that damage.

KEY WORDS *Branta canadensis*, Canada geese, herbivory, integrated damage management program, New Jersey, wild rice, *Zizania aquatica*.

Historically, wild rice (*Zizania aquatica*) was an abundant, emergent annual plant in tidal freshwater marshes of the Maurice River, New Jersey, USA (Ferren 1976) and elsewhere along the mid-Atlantic coast (Cowardin et al. 1979). Wild rice (rice) seed is a selected food by many dabbling ducks (Martin and Uhler 1939, Moyle and Hotchkiss 1945, Martin et al. 1951) and red-winged blackbirds (*Agelaius phoeniceus*; Meanley 1961). Rice is also selected by soras (*Porzana carolina*; Webster 1964, Meanley 1965), and plays a critical role in sora fitness during autumn migration (Haramis and Kearns 2007*a*). Stands of rice are also important habitats for many birds, particularly soras (Melvin and Gibbs 1994), with resulting detritus from the decomposition of wetland plants being an important food source for invertebrates (Odum et al. 1984).

The Maurice River estuary is an important site for wintering and spring-staging waterfowl (Sutton et al. 1998), particularly northern pintails (*Anas acuta*; Malecki et al. 2006), as well as migrating and wintering raptors (Sutton and Kerlinger 1997). During the 1870s, soras were so abundant in Maurice River marshes that ≥100,000 rails were harvested annually (Bowen 1885). Although soras are not nearly as numerous today, these marshes still provide critical habitat for migrating rails and the area has a culturally unique rail hunting tradition (Dunne 1997). Sneddon et al. (1995) recognized the Wild Rice Herbaceous Alliance as an important native plant community in tidal freshwater marshes of the Delaware Estuary. Ferren (1976) noted the importance of study area marshes for sensitive joint-vetch (*Aeschynomene virginica*), which is a rare obligate wetland annual plant. More recently, marshes of the Manumuskin River, a major tributary of the Maurice River, contained the largest global population (>10,000 stems) of sensitive joint-vetch now classified (G2) as globally threatened (U.S. Fish and Wildlife Service 1995).

A widespread and readily apparent decline in rice abundance in the Maurice River estuary during the 1990s caused concern because of the critical importance of these marshes to wildlife and plant communities. Studies of a similar and concurrent decline in rice in marshes of the Patuxent River, Maryland, USA (Haramis and Kearns 2007*b*), found that excessive grazing by Atlantic Flyway Resident Population (AFRP) Canada geese (*Branta canadensis*) caused the decline in rice. During the 1990s, the number of AFRP Canada geese in New Jersey nearly tripled from 28,000 birds in 1990 to 82,300 in 1999 (Atlantic Flyway Council 1999). Given the study by Haramis and Kearns (2007*b*) and the growth of AFRP geese in New Jersey, I hypothesized that AFRP Canada geese were also causing the decline of rice in Maurice River marshes. The objectives of my study were to 1) measure the impact of AFRP Canada goose herbivory on wild rice in Maurice River marshes, and 2) determine whether goose herbivory could be abated through an integrated damage management program.

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STUDY AREA

The tidal freshwater marshes of the Maurice River were located between Millville and Port Elizabeth in Cumberland County, New Jersey, USA (Fig. 1). This section of river was about 9 km in length and included 2 major eastern tributaries, Menantico Creek (3 km) and Manumuskin River (5 km). Maurice River marshes were bounded upstream by the Union Lake dam in Millville and downstream, the marshes exhibited oligohaline characteristics before ultimately draining into Delaware Bay. The location at which Maurice River marshes exhibited oligohaline characteristics varied somewhat from year to year depending on precipitation and temperature during the growing season in a given year (Ferren 1976). The area consisted of about 420 ha of freshwater tidal marsh dominated by the coastal form of southern wild rice (*Z. a.* var. *aquatica*; Oelke et al. 2000). Other common emergent plants included arrow arum (*Peltandra virginica*), bur marigold (*Bidens laevis*), spatterdock (*Nuphar lutea*), smartweeds (*Polygonum* spp. and *Persicaria* spp.; especially *Persicaria punctata*), and rice cutgrass (*Leersia oryzoides*). Ferren (1976) described the vegetation characteristics of the study area, and other plant associates of similar tidal freshwater marshes can be found in Tiner (1985). Typical tidal amplitudes ranged from 1.3 m to 1.8 m. The highest marshes were inundated with 20–50 cm of water at high tide. Rice and other wetland plants were generally exposed on

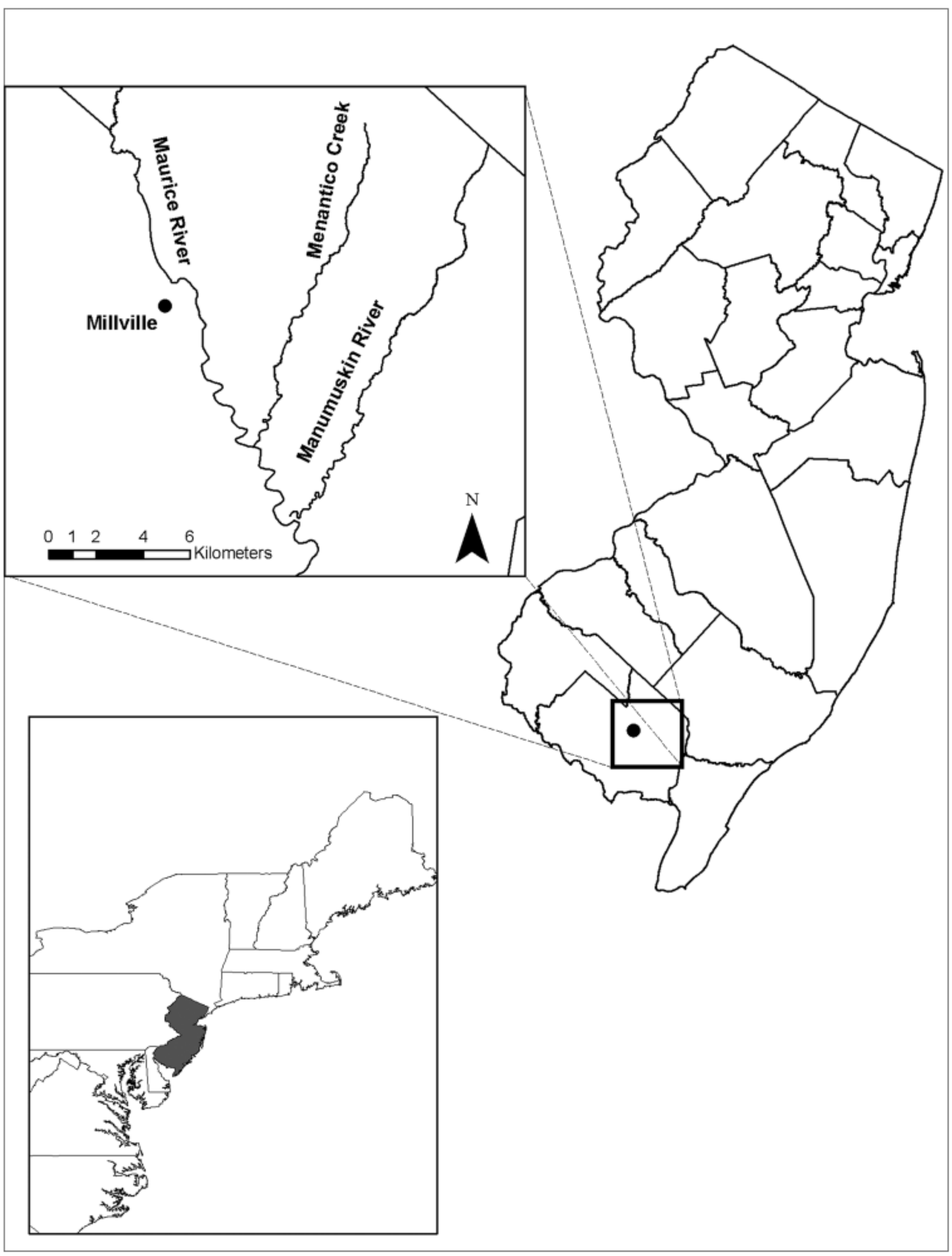

Figure 1. Location of Maurice River study area, showing major tributaries, New Jersey, USA, where herbivory by the Atlantic Flyway Resident Population Canada geese (*Branta canadensis*) on wild rice and response of rice to an integrated damage management program was measured during 2000–2002.

mudflats for 1–3 hours during each low-tide cycle. During the early 1800s, many of the marshes were diked, drained, and farmed for vegetable and hay crops (Sebold 1992). All but one of these diked marshes fell into disrepair or was otherwise reclaimed by tides between the 1870s and 1940s (Vanaman 1976, Sebold 1992). As a result of these previous agricultural practices, the study area contained about 7.3 km of linear dike remnants of various lengths, many of which occurred as islands. Most dike remnants were 3–5 m wide. Dike remnants were dominated by upland vegetation, including red maple (*Acer rubrum*), eastern red cedar (*Juniperus virginiana*), various oaks (*Quercus* spp.), sweet gum (*Liquidambar styraciflua*), green briar (*Smilax rotundifolia*), poison ivy (*Toxicodendron radicans*), arrow wood (*Viburnum dentatum*), and various huckleberries (*Vaccinium* spp.). Mean annual temperature and precipitation were 12.4°C and 106.9 cm, respectively (NCDC 2011). The riverbanks were predominantly forested with much of the marsh and adjacent uplands in public or non-government conservation organization ownership; however, several sections of low-density housing were present on the study area. The Maurice River was designated as a National Scenic and Recreational River in 1993 because of its rich biological diversity and cultural history.

METHODS

Integrated Damage Management Program

During 2000, no goose control activities occurred on the study area. During 2001 and 2002, an integrated damage management program (IDMP) was implemented. Geese were shot from early April through mid-May with 12-gauge shotguns loaded with nontoxic, fine-shot ammunition. All geese that presented safe targets and were within effective shotgun range ($\leq$40 m) were removed. Eggs in nests of incubating females that could not be shot were rendered unhatchable by puncturing with a strong, thin wire (Smith et al. 1999). Geese that could not be approached within shotgun range, usually due to shallow water that would not allow access by boat, were harassed with various pyrotechnics fired from a 15-mm pistol-launcher or 12-gauge shotgun (Smith et al. 1999). Geese molting in nearby (approx. 1 km) lakes were captured using panel nets (Costanzo et al. 1995) and euthanized with CO_2 gas during late June 2002.

Canada Goose Use of Study Area

Aerial surveys were conducted at periodic intervals (approx. 20 day) from about 5 April to 20 June each year (2000–2002). The survey period occurred after migrant population (i.e., Atlantic Population) Canada geese had departed on spring migration and encompassed the nesting, brood rearing, and remige molting period for AFRP Canada geese. The survey period coincided with rice germination continuing until about mid-growing season. Aerial surveys were conducted from a fixed-wing airplane (Cessna 182) at an altitude of 50–70 m and a speed of 160 km/hour. I served as the only observer. Because geese used the marshes most readily when rice was exposed for grazing during the low-tide cycle, I conducted surveys within a 4-hour window from 2 hours prior to (ebbing) low tide to 2 hours after (rising) low tide. All wetlands and grassy uplands within 200 m of the marsh were systematically flown and I assumed that all geese present were observed. During the nesting season (survey onset to 10 May), single geese were presumed to represent a nesting pair (Malecki et al. 1981) and therefore, accounted for 2 birds. Observed goslings were also included in totals of goose use.

Quantifying Canada Goose Grazing

To measure the impact of goose grazing, I utilized study units that consisted of a staked circular 1-m^2, 1.5-m-high, wire mesh (5.1 cm × 10.2 cm) exclosure paired with a 1-m^2, circular, unfenced control plot. Control plots were located in a random compass direction 3 m from the exclosure and marked on the perimeter with 2 wooden stakes. Study units were placed at random locations on mudflats from 1 to 7 April during 2000–2002. I established 17 units during 2000 and 22 units during both 2001 and 2002. Because rice seed generally sinks in the mud substrate near the parent plant (Dore 1969), units were located >100 m from any unit from the previous year to avoid the potential confounding effects of abundant seed from plants in exclosures from previous years.

During 2000 and 2001, I counted rice plants in study units shortly after germination (20–27 Apr 2000; 1–7 May 2001) and then again about 40 days after germination (7–9 Jun 2000; 12–15 Jun 2001). During 2002, rice plant counts were not done after germination or during June because of logistical constraints. During June observations within control plots each year, I categorized young rice plants into 2 groups as either grazed or ungrazed by geese. The number of rice plants was also counted in study units at the end of the growing season (22 Sep–4 Oct) during each of the 3 study years. Because rice sometimes sprouts secondary flowering stems (tillers) from nodes of the parent plant (Moyle 1944, Meeker 2000), I also counted the total number of panicles in study units. As an index of rice plant size, I measured the height (nearest cm) of a methodical sample (10 plants nearest center of each exclosure and control plot) of plants in each study unit.

To test the effect of goose grazing damage on rice density during each observation period each year, as well as panicle density at the end of the growing season, I compared data from exclosures and control plots within each unit using paired *t*-tests. I used the Student's *t*-test to test the effect of goose grazing damage on plant height at the end of the growing season each year between exclosures and control plots. To test the effect of the IDMP on the proportion of grazed and ungrazed rice plants in control plots during June 2000 and 2001, I used a chi-square test of proportions. All tests were done using SigmaStat 3.11 (Systat Software, Inc., Chicago, IL).

RESULTS

During 2001, 65 nests were destroyed or rendered unhatchable and 182 geese were shot. During 2002, 49 nests were treated and 79 geese were shot. A total of 150 geese was captured during molt and euthanized during 2002. The number of geese that were hazed from the study area was not quantified because of uncertainty as to whether hazed birds left or simply moved to a different section of marsh within the study area. In addition, nearby geese (e.g., $\leq$400 m) were frequently hazed by the sound of gunshots when geese were shot.

Six aerial surveys were conducted during 2000 and 2001 with 5 during 2002. During 2000, when no IDMP was implemented, the number of geese ($n = 250$) increased during the survey period as nests hatched and peaked in late June when geese moved into the largely denuded marshes to molt (Fig. 2). During the IDMP, the number of geese initially declined from early April to early May. However, during both years of the IDMP, the number of geese declined to its lowest point in late June during the Canada goose remige molt (Fig. 2). The mean number of molting geese during the IDMP ($\bar{x} = 61$) declined 76% from 2000 ($n = 250$). During 2000, with no IDMP, a maximum of 43 goslings were observed. During 2001, the number of goslings was reduced 60% from the previous year with a maximum of 17 goslings observed. Gosling production was virtually eliminated during 2002 with no goslings observed during aerial surveys.

Shortly after rice germination in 2000, there was no difference ($t_{11} = 1.15$, $P = 0.270$) in young rice plant densities between exclosures and control plots; however, by June, rice density in exclosures was more than twice ($t_{16} = -2.80$, $P = 0.010$) that in control plots (Fig. 3A). During the IDMP in 2001, there was no difference in young rice plant density between exclosures and control plots (Fig. 3B) following germination ($t_{21} = -0.47$, $P = 0.640$) or during June ($t_{21} = -0.42$, $P = 0.680$). Nearly 4 times the percentage of rice plants in control plots exhibited grazing damage during June in 2000 than 2001 ($\chi^2_1 = 116.8$, $P < 0.001$; Fig. 4). Further, during June 2000, all rice plants in control plots were grazed in 35% ($n = 6$) of control plots but only 9% ($n = 2$) of control plots in 2001 had all plants grazed (Fig. 5A–D).

By the end of the growing season during 2000, the growth of rice within exclosures was greater ($P < 0.001$) for all plant

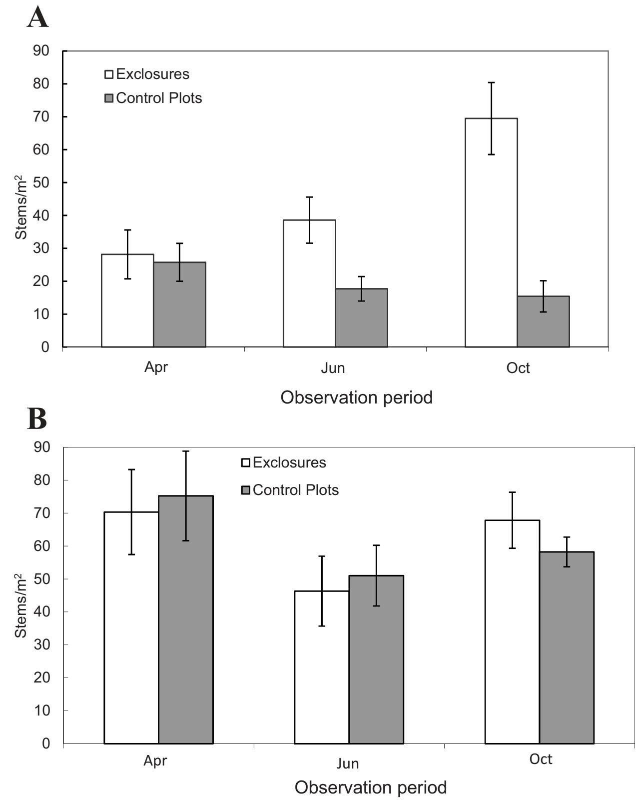

Figure 3. Mean (SE) number of wild rice plants during the early (Apr–May), middle (Jun), and late (Oct) portion of the growing season within paired 1-m^2 exclosures and un-exclosed control plots during 2000 (A: no Integrated Damage Management Program [IDMP] to abate Canada goose herbivory) and 2001(B: active IDMP), in Maurice River marshes, New Jersey, USA.

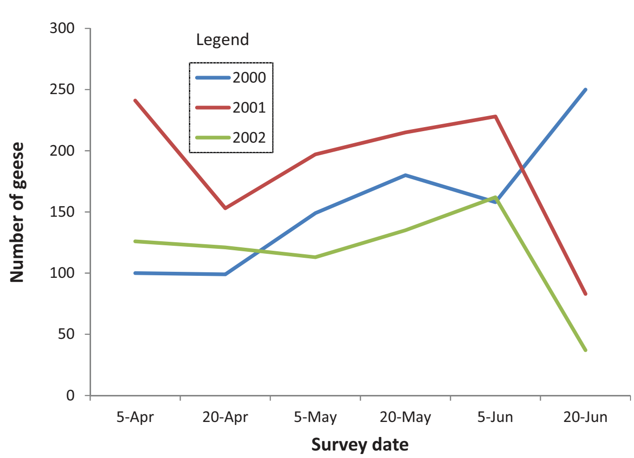

Figure 2. Number of Canada geese observed during periodic aerial surveys in Maurice River marshes, New Jersey, USA, from early April to mid-June, 2000–2002. An Integrated Damage Management Program to abate Canada goose herbivory of wild rice was implemented during 2001–2002 but not during 2000.

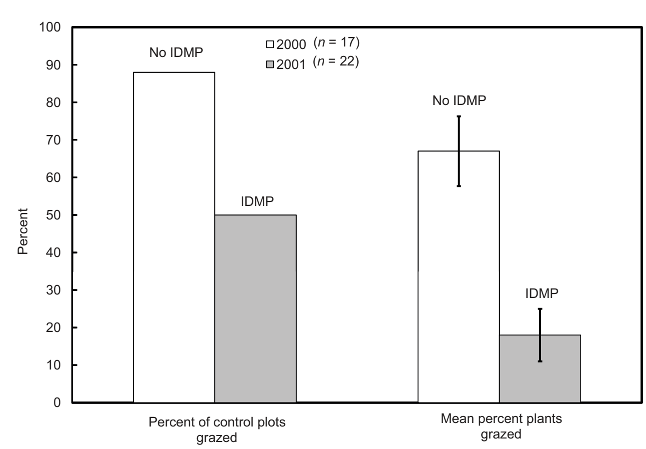

Figure 4. Percent of un-exclosed 1-m^2 control plots exhibiting wild rice grazing damage by Canada geese and the mean (SE) percent of wild rice plants grazed within control plots during June 2000 (no Integrated Damage Management Program [IDMP]) and 2001 (active IDMP), in Maurice River marshes, New Jersey, USA.

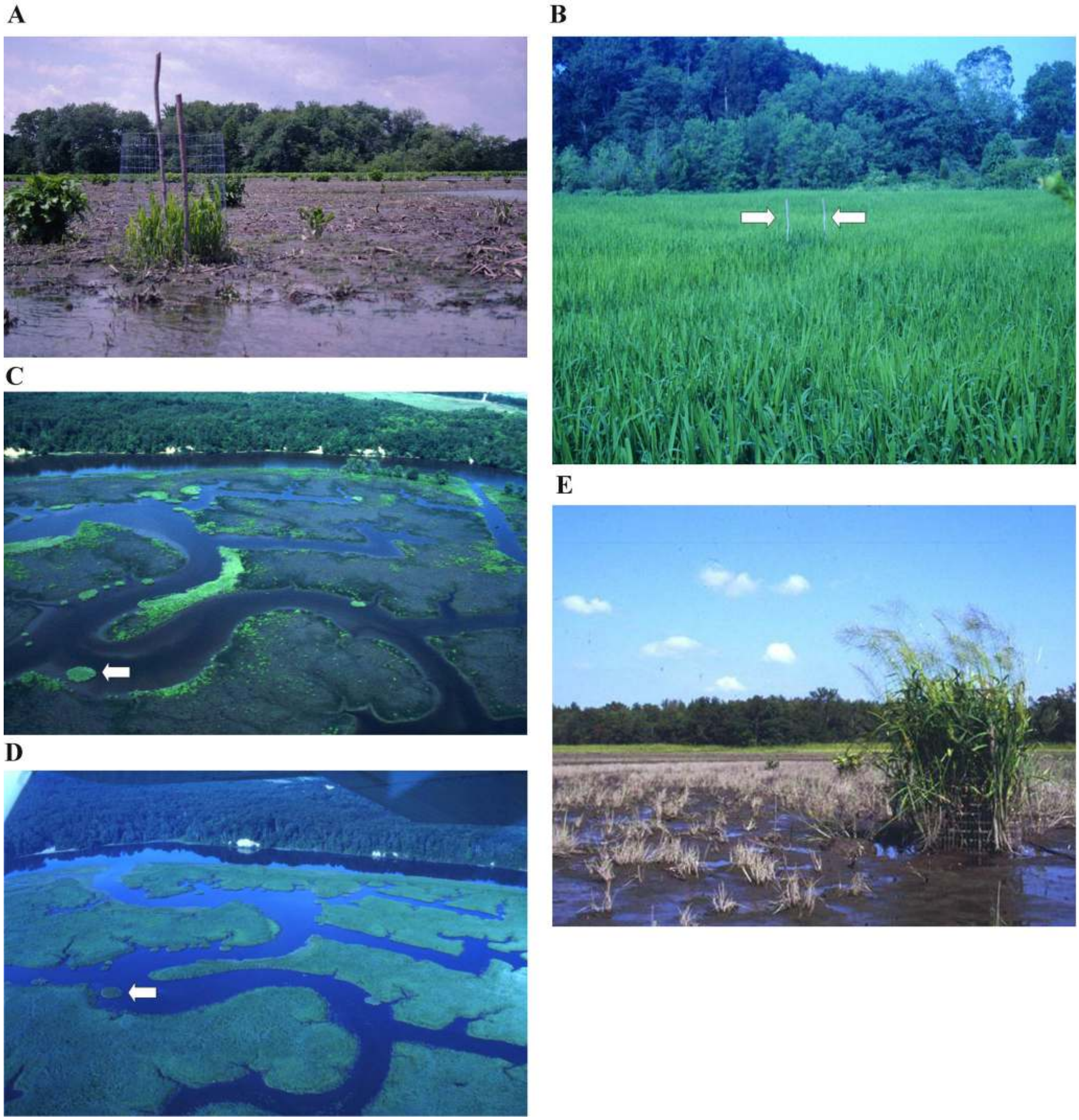

Figure 5. A: June 2000 (no Integrated Damage Management Program [IDMP] to abate Canada goose herbivory) photo taken in Maurice River marshes, New Jersey, USA, shows mid-growing-season rice plants (approx. 60 cm tall) within an exclosure contrasting with heavily grazed (<5 cm), low-density rice plants outside exclosure, which appear as small green wisps at the mud interface. Note 2 clumps of vegetation, one to the left of and the other slightly behind and to the right of, the exclosure are arrow arum and appeared to be little preferred as forage for Canada geese. B: June 2001 shows the recovery of rice with an active IDMP; the density and height of rice inside exclosures (exclosure support poles marked with arrows) was similar to rice outside of exclosures. Note that exclosures depicted in photos (A: 2000) and (B: 2001) are located approximately 120 m apart. C, D: Aerial views at low tide during June of 2000 (C) and 2001 (D) of the same marsh (Peek Preserve) depict the response of rice to the IDMP. For reference, note the arrow in both photos depicting the same circular island within the tributary oxbow. Nearly naked mudflats resulting from goose grazing excepting spatterdock (light green adjacent to tributary channels) and algae (dark green) during 2000 (C) are a stark contrast to vibrant green stands of wild rice in 2001 (D). E: September 2000 (no IDMP) shows the difference of mature wild rice plants within an exclosure versus an almost complete absence of rice plants outside the exclosure. Gray, stunted plants surrounding exclosure are primarily grazed smartweeds, but also note survival of rice (vivid green) in the background within 10 m of forested river banks.

attributes when compared with control plots (Table 1; Fig. 5E). Rice plant ($t_{16} = 5.19$, $P < 0.001$) and panicle ($t_{16} = 5.16$, $P < 0.001$) densities were about 5 times greater in exclosures than control plots, while height of the few plants surviving goose grazing in control plots was reduced 17% ($t_{338} = -4.74$, $P < 0.001$) when compared with rice in exclosures. With implementation of the IDMP in 2001 and 2002, rice plant density was similar between exclosures

Table 1. September–October measurements of mature wild rice plants within paired 1-m^2 exclosures and 1-m^2 unfenced control plots in Maurice River marshes, New Jersey, USA, prior to (2000) and during (2001–2002) implementation of an Integrated Damage Management Program (IDMP) to abate Canada goose herbivory.

		Year					
		No IDMP		IDMP implemented			
		2000		2001		2002	
		($n = 17$)[a]		($n = 22$)[a]		($n = 22$)[a]	
Attribute	**Study unit**	$\bar{x}$[b]	SE	$\bar{x}$[b]	SE	$\bar{x}$[b]	SE
No. plants/m^2	Exclosure	69.5	11.0	67.8	8.5	60.2	7.1
	Control plot	15.4**	4.7	58.2	4.5	55.3	6.4
No panicles/m^2	Exclosure	76.1	11.8	77.5	8.9	65.3	7.4
	Control plot	15.0**	4.6	61.0*	4.1	57.8	6.5
Plant height[c] (cm)	Exclosure	240.9	4.8	298.0	4.0	212.1	3.4
	Control plot	200.3**	9.5	280.9**	3.4	208.3	3.3

[a] No. of paired exclosures and control plots.
[b] Within years, differences in means significant at *($P < 0.050$) and **($P < 0.001$) using paired t-test for plant and panicle density and Student's t-test for plant ht.
[c] Plant ht measured from a random sample of 10 plants within each exclosure and control plot.

and control plots at the end of the growing season (Table 1). During 2001, panicle density was reduced by 21% ($t_{21} = -2.19$, $P = 0.040$) and rice plant height was reduced by 6% ($t_{438} = -3.39$, $P < 0.001$) in control plots. All rice plant attributes were similar between exclosures and control plots in 2002 (Table 1).

DISCUSSION

Canada goose grazing affected wild rice in Maurice River marshes by the end of the growing season, which is similar to findings in Patuxent River marshes (Haramis and Kearns 2007*b*). In this study, I determined that geese reduced rice density by June. However, implementing an IDMP during spring reduced grazing damage for the duration of the growing season. Although rice plant density was similar between exclosure and control plots during June and October during 2001, panicle density and plant height were somewhat reduced in control plots, suggesting that grazing by geese still had some impact on plant development during the first year of the IDMP. However, all rice plant attributes were similar at the end of the growing season between exclosure and control plots by the second year of the IDMP (2002).

Goslings must obtain enough nutrients for rapid growth within a short fledging period and rely predominantly on protein from plants for that growth (Owen 1980). Compared with animal foods, plant foliage is generally lower in protein; the high fiber content of plants results in a less digestible diet (Demment and Van Soest 1985). Given these diet deficiencies, goslings must compensate with high food intake to obtain needed nutrients (Buchsbaum et al. 1986, Sedinger and Raveling 1988). Although resident geese are renowned for feeding on upland grasses such as lawns and golf courses (Conover and Kania 1991, Smith et al. 1999), the study area had few upland grass areas adjacent to the river banks, so wetland plants, such as rice, presented the primary forage available to sustain gosling growth. Therefore, limiting goose recruitment by treating nests on the study area was important to abate grazing damage on rice.

Although goose recruitment was reduced through the IDMP, adult geese were also observed grazing rice. During the goose nesting season (early Apr–mid-May) about half of the geese observed in aerial surveys were adults in loose flocks, while the remainder occurred as single birds or pairs. During the IDMP years from April through early June, there were similar numbers of geese ($\bar{x} = 168$), despite that geese were being shot, compared with the same period in 2000 ($\bar{x} = 147$) when no IDMP was implemented. By the early part of the rice-growing season (1 May) during the IDMP years, most (2001: $n = 122$ [68%]; 2002: $n = 68$ [86%]) of the geese taken during the IDMP had already been removed. Given the similar number of adult geese among years, it was somewhat unexpected that rice density was similar between exclosures and control plots during June 2001 and that rice plants in control plots exhibited less grazing damage in 2001 when compared with 2000. Given the similar number of adult geese among all years, but with the reduced number of goslings observed during IDMP years, I conclude that goslings played a major role in rice herbivory measured during 2000.

Human conflicts concerning resident population Canada geese are well-recognized (Conover and Chasko 1985, Hindman and Ferrigno 1990, Ankney 1996) and managers have generally only conducted population-control efforts in response to agricultural damage or other human landscapes (i.e., parks) or for human health and safety. The grazing impact of geese on wetland vegetation has generally gone overlooked until recently (Haramis and Kearns 2007*b*, Dawe et al. 2011). Atlantic Flyway Resident Population Canada geese may present a serious constraint to the abundance or long-term persistence of rice in the mid-Atlantic region. Further, because tidal freshwater marshes in the eastern United States usually occur near the head-of-tide of major rivers, and these same areas are also sites of major human development, the situation is further exacerbated because resident geese frequently occur at their highest densities within urban and suburban areas (U.S. Fish and Wildlife Service 2005).

MANAGEMENT IMPLICATIONS

Leck and Simpson (1995) indicated that community dynamics of annual plants in freshwater marshes were dependent on seedling recruitment. Leck and Simpson (1987) concluded that most annuals in tidal freshwater marshes did not appear to have long-lived seeds and accordingly, seeds cannot accumulate over time. Although the precise longevity of rice in the seed bank is not known, rice seed can apparently remain viable for about 5 years in the wild (Natural Resources Conservation Service 2004; J. E. Meeker, Northland College, personal communication). Given a management objective to retain marshes dominated by annual plants and the relatively short longevity of wetland annual seeds, managers may have a limited time to act if intensive herbivory caused by resident Canada geese is observed. Wetland managers need to consider the grazing impacts that resident population Canada geese can incur on plant communities and develop a plan for mitigating that damage when it occurs. In this study, an IDMP to abate goose damage significantly reduced goose damage to rice. In addition, rice was able to make a full recovery without the added effort and expense of fencing and reseeding that was done in Patuxent River marshes (Haramis and Kearns 2007*b*). Experience at this study site has shown that the intensity of an IDMP can be reduced over time while maintaining the integrity of wild rice in these marshes (Nichols 2014).

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