Bioeconomic Modeling of the Invasive Aquatic Plants *Hydrilla verticillata* (hydrilla), *Eichhornia crassipes* (water hyacinth), and *Pistia stratiotes* (water lettuce) and their impacts on angler effort on Florida lakes

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Abstract

The invasive aquatic plants *Hydrilla verticillata* (hydrilla), *Eichhornia crassipes* (water hyacinth), and *Pistia stratiotes* (water lettuce) have the potential to negatively impact recreational use of Florida lakes if consistent, adequate control expenditures are not made. In the mid-1990's, Florida significantly reduced its spending on invasive aquatic plant control measures, which resulted in a significant increase in needed control expenditures in subsequent years. This paper attempts to formalize a relationship between coverage of these invasive aquatic plants and angler effort on Florida lakes using data on 38 lakes over 20 years. Estimated regression coefficients are used to simulate control alternatives, and expenditure cost-benefit comparisons are made.

Key Words: **Hydrilla, water hyacinth, water lettuce, bioeconomic, invasive, control**

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Introduction

The proliferation of invasive species in the United States is widely recognized as a burgeoning problem for the local and regional ecosystems of this country. Invasive species are a particular problem for Florida and Hawaii, given that the physiographic, climatic and geographic characteristics of these states make them relatively more vulnerable to the establishment of non-indigenous species than for other states. When considering the well-documented impacts of certain invasive species, such as damages caused by invasive aquatic plants in Florida, it is clear that the economic consequences of this issue resound with enormous potentiality. With continuing increases in both global trade and the domestic and international migration of people to Florida, it is reasonable to assume that such transmission pathways will keep contributing to the invasive species problem.

Therefore, the issue of invasive species is one in which much more attention (and budgetary expenditures) will likely be focused on in the near future. Simply stated, the present level of expenditures (with the exception of water hyacinth) devoted to the management of a handful of invasive plant species is inadequate, even for those few being managed. For several reasons, the Florida Department of Environmental Protection (FDEP) has targeted water hydrilla one of its top management priorities of the 18 non-indigenous aquatic plants that infest the lakes and rivers of Florida. This plant pest has been the focus of management efforts in Florida for over two decades. However, much additional research is needed to assess the expected economic impacts and the policy responses necessary to combat the effects of existing invasive species like hydrilla, and recent arrivals such as the Asian green mussel.

The focus of this paper is on hydrilla, water lettuce, and water hyacinth, but this is a work in progress. So far, the work has been completed for hydrilla. Water hyacinth and water lettuce will receive similar treatment and the results will be reported in the final paper and presented at the AAEA meetings in July, 2005.

Modeling Hydrilla Management

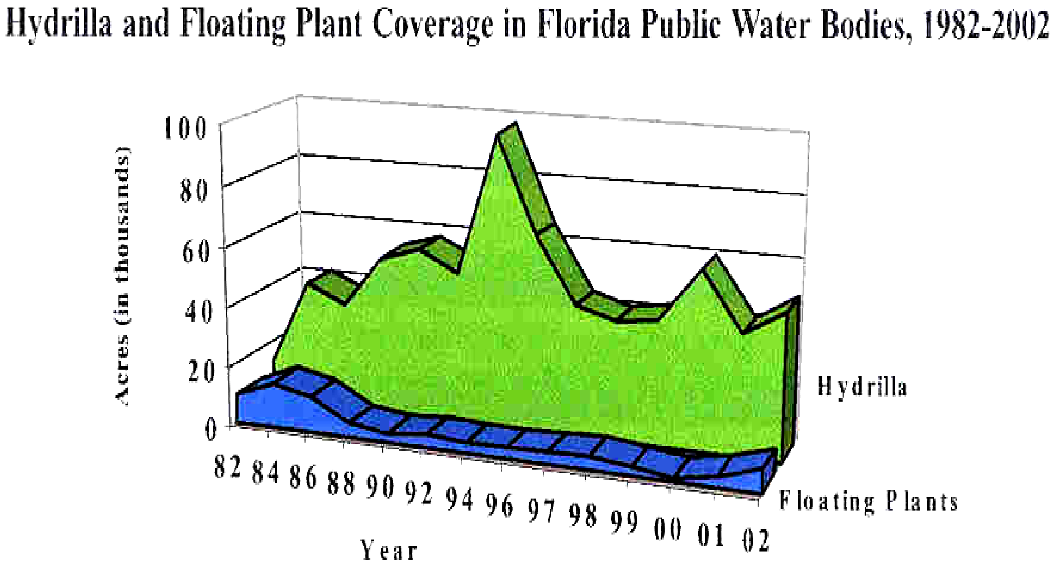
Hydrilla (*Hydrilla verticillata*) is a submerged aquatic plant probably introduced as an aquarium plant in the 1950's, and first detected in Florida water bodies in 1960 (University of Florida, 2001; Blackburn et al., 1969, as referenced by Langeland, 1996). It has a rapid growth rate and spread quickly throughout the state. By the early-seventies, hydrilla had infested major water bodies of all the drainage basins of Florida; in 1995, it covered 40,000 hectares of water in 43% of the public lakes of Florida (Langeland, 1996).

The detrimental problems resulting from hydrilla have multiple dimensions. Adverse ecological impacts, such as the displacement of native species (both related and unrelated), leading to a reduction in the loss of native bio-diversity may cause severe disruption of complex natural ecosystems. Hydrilla can grow into thick mats that block sunlight to beneficial water plants, often creating an exotic monoculture. Results range from reduced lake productivity from a fish population standpoint to reduced dissolved oxygen levels and fish kills. Hydrilla can also harm non-aquatic species by covering nesting and egg laying areas, blocking access to water, shelter, and food sources.

Economic impacts can follow close behind such detrimental ecological changes, affecting both the quality (and/or quantity) of public goods, and the interests of private entities. Hydrilla mats can interfere with or prevent boating navigation, swimming and fishing in lakes and rivers. Reduced sport fish populations coupled with access problems can significantly reduce sport fishing effort. This reduction of recreational benefits derived from public waterways (and the costs of managing offensive invasive species) highlights the public good dimension. Hydrilla can also directly private citizens and businesses. Hydrilla can block water intakes of power generation and agricultural irrigation works, jam turbines and dams, and fill up flood control canals and ditches reducing their effectiveness. Infestations resulting in reduced recreational use and aesthetic value of waterfront property can reduce property values, and can lead to higher mitigation costs.

Hydrilla is particularly insidious because it forms underground tubers that complicate efforts to control this aquatic menace; thus, it is no accident that Schardt (1997) advocates maintenance control as the most economical way of dealing with hydrilla. In general, the management of hydrilla has benefited from the experience gained in the fight against water hyacinth, and Schardt believes that infestation can be maintained at low levels when an appropriate amount of money is spent (1997). Figure 1 compares the spatial coverage of hydrilla with other aquatic plants for the past twenty years.

Figure 1. Hydrilla Coverage 1982-2002



Source: 2001-2002 Aquatic Plant Management Report (FDEP, 2002).

The main problem is adequate and consistent allocation of money devoted to the management of this invasive specie (Langeland, 1996). According to the FDEP (2002), "Insufficient management funding allowed hydrilla to expand from 50,000 to 140,000 acres during the middle 1990s." Some studies have attempted to determine the economic impacts that hydrilla infestation have on fishing activities on particular lakes (Burruss Institute, 1998; Milon and Welsh, 1989; Milon et al., 1986), but apparently no study has attempted to generalize this effect in a way useful to policy makers. This paper is an *initial* attempt at formalizing a relationship between hydrilla coverage and recreational use of lakes in Florida. It is hoped that knowledge of such a relationship will lead to a more efficient allocation of scarce public funds. In North Florida, over 65 percent of boat trip activities are for fishing (Thomas and Statis, 2001). Therefore, it was felt that analyzing the effects of hydrilla on anglers would capture much of the economic impact of hydrilla infestation.

Data Used

A linear regression model was sought to evaluate the relative impact of hydrilla coverage on angler effort.

The Florida Fish and Wildlife Conservation Commission (FFWCC) performs surveys of angler effort and catch, known as Creel surveys, on many Florida lakes. Angler effort is an estimation of the number of hours anglers on a boat spent fishing, times the number of anglers. For example, if 3 anglers spent 4 hours fishing, the Creel survey would estimate 12 hours of angler effort. Angler effort is used as a proxy for recreational usage of lakes. Unpublished Creel data on 45 lakes collected from 1966-2002 were available from the five regional FFWCC offices.

The Florida Department of Environmental Protection (FDEP) performs annual aquatic plant surveys and maintains information on the prevalence of aquatic plants on Florida's public water bodies. The DEP provided unpublished hydrilla coverage data on 51 of Florida's lakes collected from 1983-2002.

Limnologists at the Florida Department of Environmental Protection (FDEP) suggested that our explanatory variables should include physical and biological differences between lakes that could account for much of the difference in angler effort. In particular, they suggested we include variables for lake trophic state index, lake size, lake access, and other amenities such as parking facilities.

Trophic state is a measure of the amount of plant and animal life that a lake can support, and is determined by calculating the trophic state index (TSI). The FDEP uses a Florida-specific trophic state index developed by Brezonik (1984) for its water quality surveys. The Florida-specific TSI calculates trophic state based on total nitrogen (mg/l), total phosphorous (μg/l), chlorophyll a (mg/m^3) for planktonic algae, and secchi depth (m) for water transparency (State of Florida, 1996). The University of Florida's LAKEWATCH program, which began in 1991, maintains a water quality database that includes the data necessary to calculate trophic state indices. We collected the data necessary to calculate the trophic state of each of lakes included in the Creel data from LAKEWATCH. Florida LAKEWATCH, along with FDEP, also provided surface area (acres) data for each lake.

Lake access is determined by availability of boat ramps and water levels. In 1996, there were an estimated 8,000 boat ramps in the state, but many of those were unavailable for public use and were limited to use by their owners or members of marinas or yacht clubs (Thomas and Stratis, 2001). The FFWCC operates about 1,300 boat ramps throughout the state that are available for public use, some with additional features such as parking (Thomas and Stratis). Data on boat ramps, parking, camping, and toilet facilities for each of the Creel lakes were collected from the FFWCC's website (FFWCC Website, 2003). Creel survey lakes with missing hydrilla coverage or trophic state values were excluded. Of the 45 original lakes, 38 lakes remained in the spreadsheet, with dates ranging from 1982-2002, for a total of 380 observations. Water level information was deemed unnecessary because Creel surveys do not occur when the surface water levels are too low for boat access.

Trophic State and Hydrilla Estimations

Data were compiled into an Excel spreadsheet. Each Creel survey was performed either in Spring, Summer, Fall, Winter, or Winter-Spring. Winter-Spring creel surveys lasted an average of 6.1 months, Winter 3.0 months, Summer 3.0 months, Spring 3.1 months, and Fall 2.9 months. Winter-Spring surveys were only conducted on 3 lakes. Since Creel surveys were conducted for different durations, Creel angler effort data were divided by the number of days over which the survey was conducted to arrive at the average angler effort per day of the Creel survey. Additionally, the data on the number of public boat ramps lanes, public parking spaces, and available camping and toilet facilities for each of the Creel lakes was included.

Trophic state indices were calculated using the Florida-specific TSI for each of the Creel lakes using the nitrogen, phosphorous, chlorophyll-a and secchi depth data from LAKEWATCH. Since only data since 1991 were available, attempting to match a specific TSI number to each Creel survey date was not possible without losing much of the Creel observations. Instead, we calculated a simple average of the trophic state index for each lake over 1991-2002 and assumed the long run trophic state of each lake to remain constant. Lake productivity increases from Oligotrophic to Meso-Oligotrophic, to Mesotrophic, to Eutrophic, to Hypereutrophic.

The FDEP usually performs its annual aquatic plant surveys during the last half of the year. In order to evaluate the effect of hydrilla coverage on fishing effort, it was necessary to predict what the average hydrilla coverage was for each lake for during each Creel survey. This required assuming a hydrilla growth model.

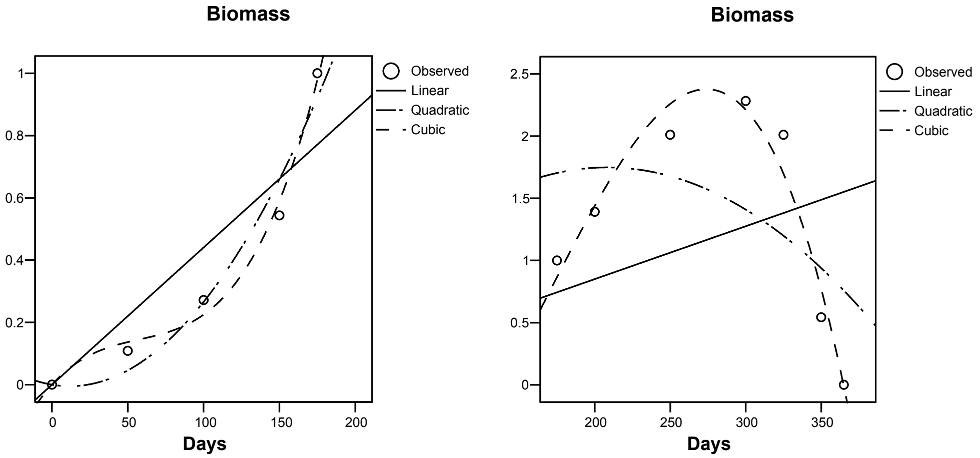
Hydrilla growth after January 1 on a lake happens in several stages, from initial growth of leaf material from tubers around day 75, to senescence (the loss of ability to carry out basic physiological processes) occurring from about day 261 thru 365 (Best and Boyd, 1996). There are very few in-depth studies of hydrilla growth. The most recent lake-wide study of hydrilla growth in Florida was by Bowes et al. (1979) in 1977 on Lake Orange. Using the Bowes et al. data, we estimated a temporal growth function for hydrilla. We noticed that the Bowes et al. data appeared to have at least two distinct growth patterns. The first, from 0 to about 180 days, was almost linear. The second, from about 181 to 365 days, was almost an arch. We indexed the Bowes et al. data so that the data point at 180 days=1 and using the curve estimation feature in SPSS, we estimated a growth function for each of these periods. The results are reported in Table 1 and

Figure 2. Both equations are statistically significant at p=.01, with an adjusted R2 greater than .975, suggesting a good explanatory equation.

Table 1. Estimation of Hydrilla Coverage Equation Coefficients

	0-175 Days		176-365 Days	
	Coefficient	SE	Coefficient	SE
Days	0.005392	0.002	-0.03527	0.007
Days sq	-7.49E-05	0.000	3.53E-04	5.89E-05
Days cu	4.34E-07	0.000	-7.02E-07	1.05E-07
Adj. R2	0.989		0.975	
F	163.07		92.08	
Sig F	0.002		0.000	

Figure 2. Curve Fit for the Hydrilla Growth Equation



Creel survey reports an average of angler effort during the survey period, so we determined what the average hydrilla coverage was during this period. To do this, we applied the growth equations to the FDEP hydrilla coverage data to get an estimate of hydrilla coverage at 180 days for each Creel observation. The average hydrilla coverage was calculated by first integrating the hydrilla growth equations to calculate the area under the growth equation curves during the duration of each Creel survey both before and after 180 days. Recall that the hydrilla growth equations were indexed to 1 at 180 days. We then summed the area in each period, multiplied by the estimate of hydrilla coverage at 180 days, and divided by the number of days of the Creel survey to get the average hydrilla coverage during the Creel survey.

Linear Regression Model

The model used to identify the factors influencing the angler effort on Florida lakes was constructed as follows:

$$\begin{aligned} \mathrm{E} = f(&\mathrm{HYDRILLA}, \mathrm{TROPHIC}, \mathrm{SEASON}, \mathrm{YEAR}, \mathrm{WACRES}, \\ &\mathrm{RAMPS}, \mathrm{PARKING}, \mathrm{TOILET}, \mathrm{CAMPING}) \end{aligned} \quad (1)$$

where E represents average angler effort per day, HYDRILLA represents the estimated average % coverage of hydrilla per day of the Creel survey, TROPHIC indicates the long-run trophic state as calculated by using the Florida-specific trophic state index, SEASON indicates the time of year the Creel survey was done, YEAR represents the when the Creel survey was conducted, WACRES represents the surface area of the lake in acres, RAMPS represents the number of public access boat ramps on the lake, PARKING represents the number of public parking spaces available, and TOILET and CAMPING indicate the availability of bathroom and camping facilities, respectively. HYDRILLA, YEAR, WACRES, RAMPS, and PARKING are continuous scale variables. Binary indicator variables are created to represent each of the possibilities for TROPHIC and SEASON, TOILET, and CAMPING.

The data set consists of cross-sectional and time-series observations, which are pooled to estimate the simple model depicted by Eq. (1). The estimated equation measures the impact of hydrilla coverage and the other variables on angler effort, such that

$$\begin{aligned} &\mathrm{E}_{\mathrm{i}} = \alpha_{\mathrm{i}} + \beta_1 \mathrm{HYDRILLA}_{\mathrm{i}} + \beta_2 \mathrm{WACRES}_i + \beta_3 \mathrm{YEAR}_{\mathrm{i}} + \beta_4 \mathrm{RAMPS}_i \\ &+ \beta_5 \mathrm{PARKING}_i + \gamma_1 \mathrm{TOILET}_i + \gamma_2 \mathrm{CAMPING}_{\mathrm{i}} + \gamma_3 \mathrm{TROPHIC}_{\mathrm{i}} + \gamma_4 \mathrm{SEASON}_{\mathrm{i}} + \varepsilon_i \end{aligned} \quad (2)$$

where *i* represents the *i*th lake. The individual effect is α_i, which is specific to each lake *i*. If the variance of the individual effects is zero, then no variation in α_i related to the cross-section is present, and ordinary least squares will yield consistent and efficient estimates of the parameters. Subsequent work will test for this, but for the purposes of this paper we assume this to be the case.

Ordinary least squares regression was run in SPSS 12.0 and tests for collinearity, heteroskedasticity, and autocorrelation showed no significant data problems. Inspection of the data suggested we add a HYDRILLA-squared variable. Parameter estimates for the empirical model of Eq. (2) were based on data set of time-series observations on a cross-section of lakes throughout Florida. Table 2 presents the estimated coefficients for the explanatory variables. The indicator variables for oligotrophic trophic state and Spring season were omitted to avoid collinearity problems.

Table 2. Estimates of the Effects of Explanatory Variables on Angler Effort

Variable	Description	Coefficients	Standard Error	t-ratio	Standardized Coefficients
Constant		32729.435	16011.794	2.044*	
HYDRILLA	Avg. % Hydrilla Coverage/day of Creel survey	-1142.822	581.119	-1.967*	-0.121
$HYDRILLA^2$	(Avg. % Hydrilla Coverage/day of Creel survey) squared	1121.451	714.368	1.570***	0.089
WACRES	Water Surface Area in Acres	0.007	0.001	13.433*	0.711
YEAR	Year of Creel Survey	-16.842	8.041	-2.094*	-0.064
RAMPS	Number of Public Ramps Available	-84.881	64.306	-1.320	-0.130
PARKING	Number of Public Parking Spaces Available	6.663	1.859	3.585*	0.318
TOILET	Indicator of Available Toilet Facilities	-97.487	93.449	-1.043	-0.048
CAMPING	Indicator of Available Camping Facilities	-45.613	133.497	-0.342	-0.014
TROPHIC1	Indicator of Oligo-Mesotrophic State	8.212	181.340	0.0452	0.025
TROPHIC2	Indicator of Mesotrophic State	344.679	111.491	3.092*	0.093
TROPHIC3	Indicator of Eutrophic State	-210.140	92.002	-2.284*	-0.091
TROPHIC4	Indicator of Hypereutrophic State	-156.316	103.363	-1.512	-0.046
SEASON1	Indicator of Summer	204.614	79.666	2.568**	0.070
SEASON2	Indicator of Fall	354.402	90.664	3.909*	0.111

SEASON3	Indicator of Winter	51.667	78.364	0.659	0.018
SEASON4	Indicator of Winter-Spring	626.874	199.185	3.147*	0.095

Number of Observations	380
Adj. R-squared	.791

* Statistically significant at a 95% confidence level

** Statistically significant at a 90% confidence level

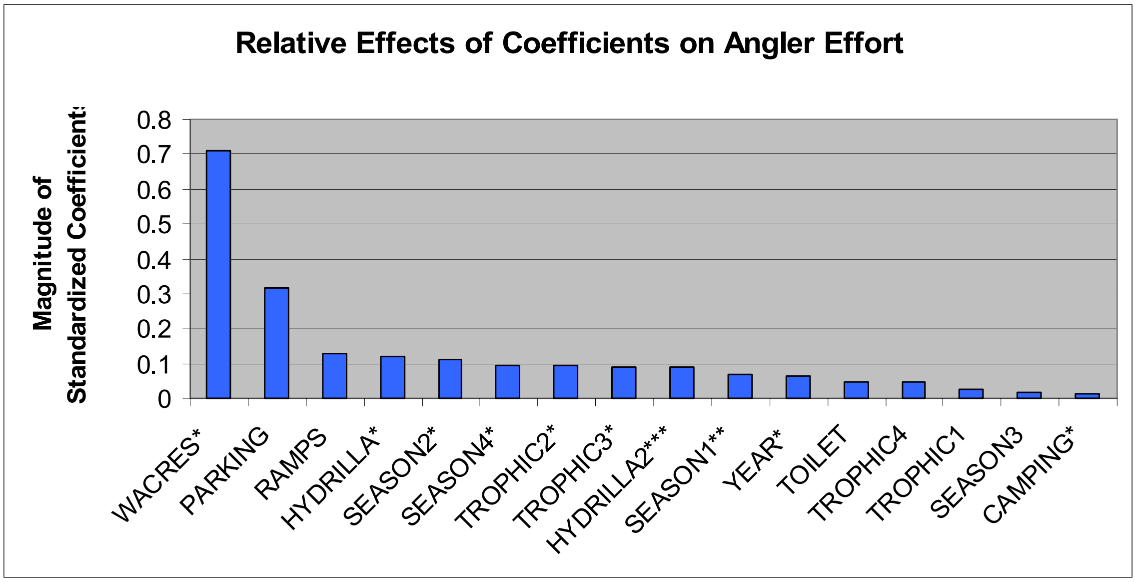
***Statistically significant at 88% confidence level

Interpretation of Coefficients

The findings suggest that approximately 79 percent of the variation in angler effort on Florida lakes is explained by the explanatory variables in the linear regression equation. Independent continuous variables HYDRILLA, WACRES, YEAR, and PARKING were statistically significant at the 95 percent confidence level. HYDRILLA^2 was significant at the 88% confidence level. Indicator variables TROPHIC2 (Mesotrophic), TROPHIC3(Eutrophic), SEASON2(Fall), and SEASON4(Winter-Spring) were significant at the 95 percent confidence level, while SEASON1(Summer) was significant at the 90 percent confidence level. The indicator variables for oligotrophic trophic state and Spring season were omitted from the regression to avoid collinearity problems.

The coefficients for of the independent variables are standardized for comparison and their relative magnitudes presented in Figure 3. Lake surface area (WACRES) had the largest influence on angler effort, with PARKING having almost half as much influence as WACRES, and HYDRILLA and HYDRILLA2 having less than half the influence of PARKING .

Figure 3. Relative Effects of Coefficients on Angler Effort



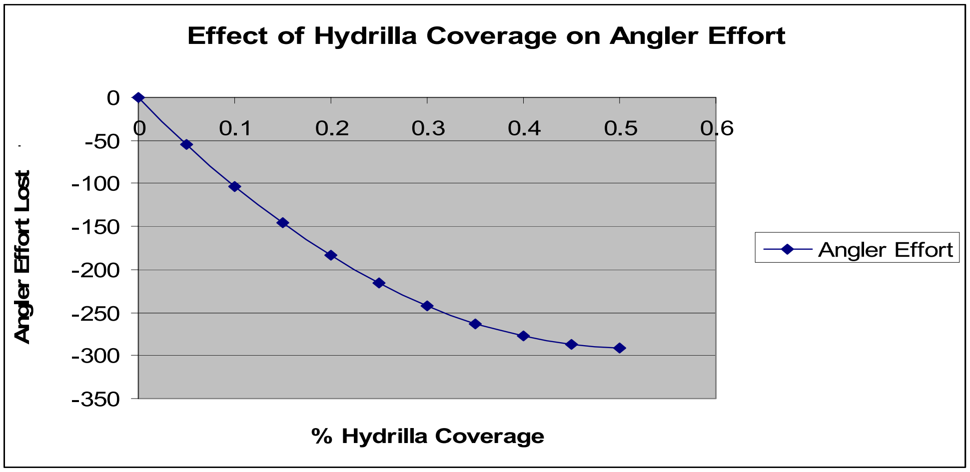
Trophic state coefficients are positive for oligo-mesotrophic and mesotrophic, and negative for eutrophic and hypereutrophic. According to the reported coefficients, angler effort on otherwise identical lakes is largest on mesotrophic lakes and smallest on hypereutrophic lakes. Bachmann et al. (1996) reported a reduction in fish species and fish weight for some sport fish from increases in trophic state on Florida lakes.

The coefficients for season are all positive. In order of magnitude, Winter-Spring, Fall, Summer, and Winter have positive effects on angler effort, indicating that there is relatively less angler effort in the spring (omitted indicator from regression). The coefficient for Winter-Spring is the largest coefficient of the season variables, and Winter is the smallest. In theory, the effect on angler effort in Winter-Spring should resemble that of the effects of Winter and Spring together. Since Winter has a small positive coefficient, and Spring is expected to have a negative coefficient, the coefficient for Winter-Spring should not have a large positive value. It is likely that there is an omitted variable that would account for this discrepancy. For example, perhaps Winter-Spring surveys were only performed on very large lakes. This issue needs to be investigated.

Negative coefficients for RAMPS, TOILET, and CAMPING may suggest recreational uses of the lake by non-anglers, for example by water skiers, which may reduce the quality of fishing, and thus reduce angler effort on that lake. PARKING has a positive sign, and appears to have a small effect on angler effort relative to RAMPS, TOILET and CAMPING, but its standardized coefficient suggests that it plays a large role in determining angler effort relative to all other coefficients except WACRES. The positive sign on WACRES may suggest that anglers prefer larger lakes, possibly because of perceived increased fish stocks on larger lakes, and possibly because it is less likely to find the lake overcrowded by skiers or other anglers on any particular day. Larger lakes may also be closer to population areas, reducing the travel costs associated with fishing. WACRES has over three times more influence in determining angler effort than HYDRILLA and HYDRILLA^2 according to these results.

The HYDRILLA coefficient suggests that a 1 percentage point increase in hydrilla coverage, for example from .02 to .03 of lake surface area would result in a decrease in fishing effort by 11.42 hours (the change in hydrilla coverage, .01, times the HYDRILLA coefficient, -1142.822). HYDRILLA^2 complicates the interpretation somewhat by requiring knowledge of both percentage change in hydrilla and a reference point for that change. For example, a change from .02 to .03 of lake surface area would result in an increase in fishing effort by .56 hours ($.03^2 - .02^2 = .0005$, times the HYDRILLA^2 coefficient of 1121.451). Taken together, a change in hydrilla coverage from .02 to .03 would lead to a reduction in fishing effort of 10.86 hours. Figure 4 shows the effect of hydrilla coverage on angler effort up to .5 lake coverage.

Figure 4. The Effects of Hydrilla Coverage on Angler Effort



This is largely consistent with the literature on hydrilla coverage and angler effort. For example, Colle et at. (1987) reported a significant negative correlation between hydrilla coverage and harvestable bluegill and redear sunfish populations on Orange Lake, Florida, while largemouth bass and black crappie were not significantly affected. Colle et al. also reported a nearly 85 percent decrease in total angler effort on Orange Lake, when hydrilla coverage increased from near 0 to almost 95% of the historically open-water region of the lake. According to the regression coefficients, continuous increases in hydrilla coverage will reduce angler effort, but the coefficients from this linear regression equation should not be interpreted too broadly. Most of the lakes included in the regression had hydrilla coverage at very low levels, most of those at zero percent coverage. The coefficients from this regression would suggest that fishing effort would begin to increase again above 50 percent hydrilla coverage, but this does not seem a likely event and was not the case on Orange Lake, Florida. It is more likely that the regression coefficients are not robust for high percentage hydrilla coverage, at which point lake access can be completely eliminated to most boats and angler effort lost would be much greater than this model predicts. We suggest that future looks at this topic may benefit from focusing more on lakes with higher hydrilla coverage.

Policy Implications

In the mid-1990s, the lack of user-friendly economic information on invasive species led to a drastic cut in invasive plant control funding within the state. Legislators, presumably unaware of the potential economic and ecologic impacts of unfettered invasive specie growth, decided to temporarily de-fund the invasive species control projects. This brief lapse in funding - especially the lapse in hydrilla maintenance control - allowed invasive species to rapidly reclaim many Florida waters and could have had dire consequences on Florida's ecosystems and tourism; it certainly made much higher levels of invasive specie control funding necessary in subsequent years (Judy Ludlow [FDEP], personal communication).

Assuming that the regression coefficients for HYDRILLA and HYDRILLA^2 are reliable, there are potential policy implications of these coefficients. Assume, for example, that the state must choose among three policy alternatives for managing hydrilla on a 50-acre lake with existing hydrilla coverage at 3 percent. Policy A spends twice what is necessary to maintain hydrilla at its current coverage of 3 percent, Policy B spends exactly what is necessary to maintain hydrilla at its current coverage, and Policy C spends half what is necessary to maintain hydrilla at its current coverage level. Assume further that due to hydrilla tubers, hydrilla coverage the following year is related to control expenditures in the current year such that if hydrilla expenditures are doubled then hydrilla the following year will be halved and if hydrilla expenditures are halved, then hydrilla the following year will double.

Using data made available by the FDEP[1] and the statistics software SPSS, we estimate a cost function for expenditures on hydrilla control:

$$C = f(T)$$

where C is the cost of chemical control of hydrilla as a function of acres treated, T, from 2001-2002. It is possible that spatial differences in density of hydrilla coverage occur, and that this would affect differential management costs per acre, but for simplicity in calculating the cost function we assume hydrilla densities to be uniform. The R-squared for the regression of this equation is .997, so it is estimated that 99.7 percent of the variation in chemical control of hydrilla during 2001-2002 was due to variation in the number of acres treated. All the variables are significant at the 95% confidence interval. The hydrilla variable in this equation is total acres of hydrilla rather than percent coverage.

According to the Florida Fish and Wildlife Conservation Commission, freshwater anglers on Florida lakes spent an average of $18.20 per hour in 1996, or $20.65 adjusted for 2002 dollars (FFWCC, 2003). A comparison of Policy A, B, and C over five years is provided in Table 3 and Figure 5.

Table 3. Comparison of Hydrilla Policy Alternatives

Year	CostA	Benefit$A	CostB	Benefit$B	CostC	Benefit$C
0	2473.81	0.00	1236.91	0.00	618.45	0.00
1	1236.91	338.36	1236.91	0.00	1236.90	-645.45
2	618.45	511.44	1236.91	0.00	2473.79	-1811.30
3	309.23	598.96	1236.91	0.00	4947.50	-3642.78
4	154.61	642.97	1236.91	0.00	9894.73	-5304.91
	Net Cost	-2701.29		-6184.53		-30575.81
	Change $	3483.25		0.00		-24391.28

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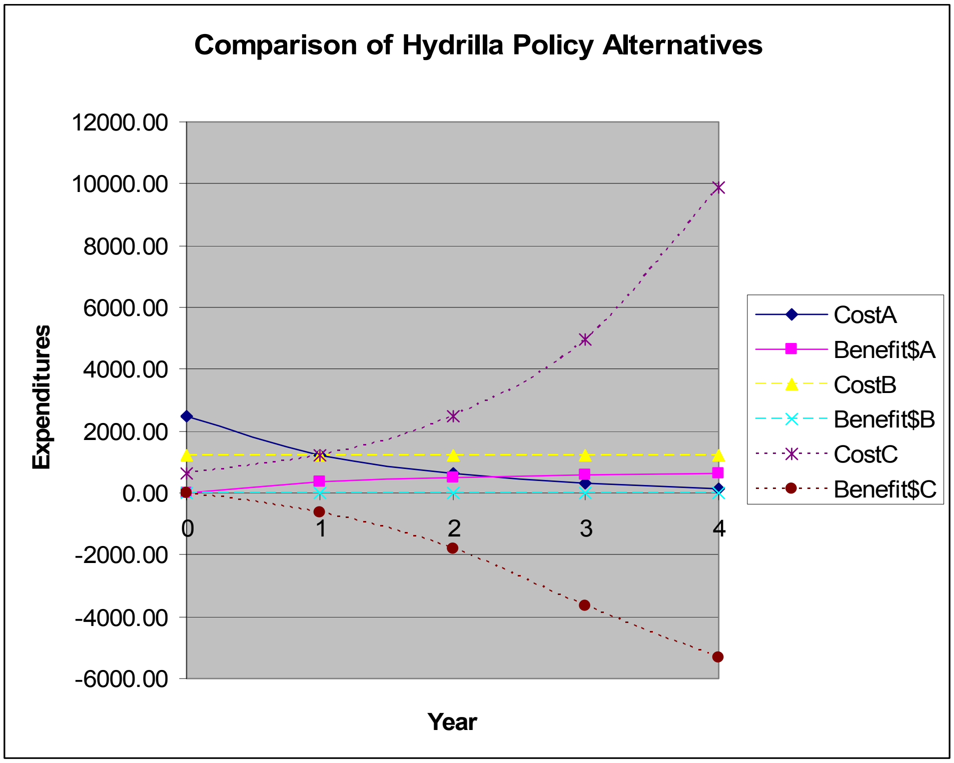
[1] The Florida Department of Environmental Protection's 2001-2002 Aquatic Plant Management Report lists the size of water body, acres of hydrilla treated, and amount spent for each water body in Florida marked for hydrilla control (FDEP, 2002).

Figure 5. Comparison of Hydrilla Policy Alternatives



All policies start with the same hydrilla coverage. Policy A spends twice what is needed each year to maintain hydrilla at its present level each year, resulting in a halving of the amount of hydrilla each subsequent year. Policy B spends exactly what is needed to keep hydrilla at its present coverage level. Policy C spends half what is needed to maintain hydrilla coverage at its present level, so that in the subsequent year, there is twice the hydrilla coverage.

A graphical comparison of the policies is particularly informative. Angler expenditure benefits of the policy are defined as positive deviations of angler expenditures from the initial level. With Policy A, the costs of hydrilla control steadily decline over the four years, finally reaching near zero in year four. After year 2, there is an associated angler expenditure benefit that remains above the cost of hydrilla control. Over four years, the estimated net benefit of Policy A over Policy B is $3483.25. With Policy C, there are some initial cost savings over Policy A and Policy B, but these are more than offset by the subsequent losses in angler expenditures and increased hydrilla control costs. Over four years, the net cost and losses associated with Policy C is $24,391.28. This comparison based solely on angler expenditures and hydrilla control costs reveals that maintenance control of hydrilla at low levels is more economically efficient.

As previously noted, the literature presents a case that the management of hydrilla in Florida is under-funded (Langeland, 1996; Schardt, 1997). The simulation above is for one lake. When considering the aggregated economic impact of all water bodies throughout the entire state, it is obvious that increased funding of hydrilla control is well within the public interest.

Further Work

The focus of the paper that will be presented at the AAEA meetings in July, 2005 is on hydrilla, water lettuce, and water hyacinth, but this is a work in progress. So far, the work has been completed for hydrilla. Water hyacinth and water lettuce will receive similar treatment and the results will be reported in the final paper and presented at the AAEA meetings.

Conclusion

Invasive aquatic plant control expenditures must be adequately and consistently maintained to avoid significant losses in angler effort and increases in control costs in subsequent years. Using data collected on 38 Florida lakes over 20 years, we estimate the effect of hydrilla, water hyacinth, and water lettuce coverage on fishing effort, controlling for other variables likely to affect angler effort, like lake size, trophic state, lake access, and season. Regression coefficients, along with estimated plant control costs and average angler expenditures per fishing hour are used to simulate the net costs and benefits of policy alternatives from assumed initial conditions. As expected, maintenance of hydrilla at low levels of coverage is more economically efficient than maintenance at high levels of coverage, both in terms of angler expenditures and hydrilla control costs. Similar analysis will be conducted for water hyacinth and water lettuce.

With ever-present state budget pressures, it is important to achieve maintenance control of these species so that long-run invasive specie control expenditures will be no higher than necessary to protect Florida’s economy and ecosystems.

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