Eurasian Watermilfoil Management: Measuring Feasible Success of Biological Control

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Introduction and Goals

Eurasian watermilfoil (*Myriophyllum spicatum*) is an aquatic invasive species whose infestation produces a variety of negative effects in North America. It was introduced to North America in the 1940s, and it was first identified in Minnesota in Lake Minnetonka in 1987. By 1992, the plant was found to have infested 60 Minnesota lakes, and according to most recent surveying, it now infests 160 Minnesota bodies of water. It is a submersed vascular plant that is highly prolific and grows in a vast range of temperatures and environmental conditions, with the potential of forming an entire new milfoil colony from a single plant segment. It is easily spread via watercraft, birds, other animals and vehicles and has therefore become incredibly difficult to control. Eurasian watermilfoil currently has confirmed existence in 45 U.S. States.

Minnesota DNR

United States Geological Survey

Why is controlling Eurasian watermilfoil so imperative? As Eurasian watermilfoil spreads at incredibly rapid rates, it becomes a detriment to recreational water use such as boating, fishing, swimming, and other aquatic activities. It also inhibits the growth of native species, both plant and animal. The problematic consequences of milfoil infestation result in the accumulation of several costs; cost to manage, local business costs, declining property values, lost species variety, and possible lost area development opportunities. The key issue is that millions of dollars wind up being spent on controlling Eurasian watermilfoil in America every year.

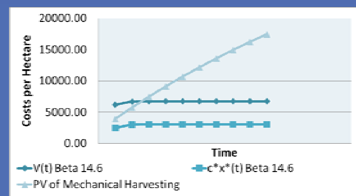
Efforts to control Eurasian watermilfoil are currently undertaken using the physical method of mechanical harvesting or by chemical control. These methods are temporary and must be repeated multiple times each growth season. The more novel approach of biological control, using the milfoil weevil (*Euhrychiopsis lecontei*), has the potential for long-term, and even permanent successful suppression of Eurasian watermilfoil.

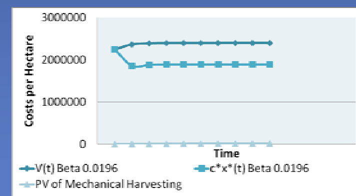
The goal of this research was to format a working model to estimate costs of management under certain probabilities of success using the biological method for controlling Eurasian watermilfoil.

Results of Modeling:

Costs of Biological Control verses Mechanical Harvesting:

Recursion Modeling -10 years





Biological control becomes more cost efficient after T-1: Feasible

Beta=14.6					
Time	V(t)	x*(t)	c*x*(t)	P(success)	PV of Mechanical Harvesting
T	6170.24	0.246	2485.186	0.8088	3804.75
T-1	6683.94	0.298	2979.006	0.8956	5718.82
T-2	6716.88	0.303	3031.754	0.9025	7446.50
T-3	6721.08	0.304	3037.153	0.9033	9091.96
T-4	6722.63	0.304	3037.702	0.9034	10658.95
T-5	6722.69	0.304	3037.758	0.9034	12151.38
T-6	6722.69	0.304	3037.763	0.9034	13572.75
T-7	6722.70	0.304	3037.764	0.9034	14926.40
T-8	6722.70	0.304	3037.764	0.9034	16215.64
T-9	6722.70	0.304	3037.764	0.9034	17442.47

Costs are too high: Not feasible

Beta=0.0196					
Time	V(t)	x*(t)	c*x*(t)	P(success)	PV of Mechanical Harvesting
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Result Considerations & Next Steps

As β becomes smaller, a longer time horizon is required for biocontrol to become plausibly cost effective and compare favorably to mechanical harvesting. A higher β indicates a lower optimal stocking rate, *x*(t)*, and a higher optimal probability of success when introduced into the model. Suggested stocking rates could be reduced if weevil populations already exist in the infested area, which would alter the gathered alpha and beta parameters and result in lower optimal stocking rates.

Future Goals:

Raise probability of success through incorporating beta parameters based on the presence of encouraging conditions for weevil survival and success.

$$P(\text{success}) = \left(\frac{e^{\alpha+\beta_1 * x_1+\beta_2 x_2+\beta_3 x_3}}{1+e^{\alpha+\beta_1 * x_1+\beta_2 x_2+\beta_3 x_3}}\right)$$

Look further into costs associated with declining values of lakeshore property on infested lakes, as well as property values' effects on local area development. Further consider and assign value to business losses caused by Eurasian watermilfoil infestations: equipment sales/rental, dining and lodging, activities, park revenue, etc.

Methods

Form criteria for the ideal lake qualities that would encourage successful biological control (weevil survival):

- •Low priority site (Up to 10 year time horizon ok)
- •High macrophyte levels (provides coverage for weevil breeding)
- •Low sunfish predation (sunfish 2.5" to 7.8" can feed on weevil)
- •Overwintering habitat available (fairly dry and close)
- •Low milfoil resistance (plant quality is appealing to weevil)
- •20-25˚C for 65-100% weevil hatching success

Use model to estimate control costs:

Estimate success probabilities for 2 suggested weevil stocking rates:

- •300 weevils per square meter – high end estimate of Ray Newman, University of MN
- •.3 weevils per square meter – Enviroscience Company

$$P(S_{t+1}=0 \mid S_t=1, x_t, \alpha, \beta) = \frac{e^{\alpha+\beta x_t}}{1+e^{\alpha+\beta x_t}}$$

Use estimates to find alpha and beta parameters:

α: chance of success with no stocking

β: chance of success at recommended rate

•Using P(success)=0.1

α= -2.2

Then,

β=0.0196, using initial x(t) at 300 to find x*(t)

β=14.6, using initial x(t) at .3 to find x*(t)

Full Value Function (Costs per hectare):

$$\min_{x_t} V(S_t, x_t) = (d * S_t + c_1 x_t) + \left(\frac{1}{1+r}\right)\left(\frac{e^{\alpha+\beta * x_t}}{1+e^{\alpha+\beta * x_t}}\right) * V(0, t+1) + \left(\frac{1}{e^{\alpha+\beta * x_t}}\right) * V(1, t+1)$$