8-2002

Arsenic in Drinking Water and Public Opinion on Wildlife Management as Case Studies Illustrating Natural Resource Policy

Jessica Sargent-Michaud

ARSENIC IN DRINKING WATER AND PUBLIC OPINION ON WILDLIFE MANAGEMENT AS CASE STUDIES ILLUSTRATING NATURAL RESOURCE POLICY

By

Jessica Sargent-Michaud

B.S. University of Maine, 2000

A THESIS

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

(in Ecology and Environmental Sciences)

The Graduate School

The University of Maine

August, 2002

Advisory Committee:

Kevin J. Boyle, Libra Professor of Environmental Economics, Advisor

Jonathan D. Rubin, Associate Professor of Resource Economics and Policy

Jeffery S. Kahl, Director, Senator George J. Mitchell Center for Environmental and Watershed Research

ARSENIC IN DRINKING WATER AND PUBLIC OPINION ON WILDLIFE MANAGEMENT AS CASE STUDIES ILLUSTRATING NATURAL RESOURCE POLICY

By Jessica Sargent-Michaud

Thesis Advisor: Dr. Kevin J. Boyle

An Abstract of the Thesis Presented
in Partial Fulfillment of the Requirements for the
Degree of Master of Science
(in Ecology and Environmental Sciences)
August, 2002

There are various ways to approach policy planning. This thesis consists of two Maine natural resource issue case studies illustrating different approaches to policy analysis. The first, a case study of arsenic contamination, is an example of a study that assembles information and provides that information to the public to influence public behavior. The second, a case study of wildlife management, is an example of a study that surveys the public to collect information on the public's opinions and attitudes to influence agency behavior towards the public.

Arsenic in drinking water in Maine is a public health concern. There may be as many as 30,000 private wells in Maine with arsenic levels in excess of the current federal standard, 0.01 mg/L.

The arsenic study was undertaken to help health officials and homeowners assess the relative costs associated with treatment alternatives for private well water with elevated levels of arsenic. Annual costs of reverse osmosis, activated alumina, bottled water, rented and purchased water coolers were compared. Costs were calculated based on households from one to four residents.

The least expensive treatment option for a single-person household is to purchase one-gallon jugs of bottled water. For households larger than one person the least expensive treatment option consistently is to install a reverse osmosis point of use system. The second least cost option for a single person household is to purchase 2.5-gallon jugs of bottled water. For households larger than one person the second-best option is to install a point of use activated alumina system. Point of entry systems and water coolers were not cost effective. Before taking specific actions to mitigate exposure households should carefully investigate specific features of the systems they are considering and the exact cost to their household.

In the second study, perceptions of the Maine Department of Inland Fisheries and Wildlife (MDIF&W) were explored. As part of the agency's goals to provide high quality recreational opportunities, improve customer satisfaction, education and awareness of wildlife issues, and maintain a high level of responsiveness to customer's needs, MDIF&W elicited public opinion on how they were doing overall and on specific management issues. Wildlife managers are finding that agencies using public opinion to form policy decisions often enjoy high public support.

Here we investigate the public's knowledge and opinions regarding wildlife management in Maine. We found that respondent knowledge of who actively manages

wildlife in Maine exceeds that of Maryland, South Carolina and Alabama, states where similar studies had been conducted. High agency recognition does not necessarily translate into equally high ratings of satisfaction with agency management activities. In addition, more than 25% of respondents answered "don't know" to factual questions, yet most were willing to give opinions on how management should be conducted. Low satisfaction ratings and more than 25% respondents answering "don't know" emphasizes the need for increased public education regarding management efforts.

DEDICATION

This thesis is dedicated to my husband Derek who has read countless drafts and never been afraid to ask why.

ACKNOWLEDGEMENTS

I first need to thank Dr. Kevin Boyle who believed in me before I did and pushed me to become the professional I am today. My gratitude also goes out to Mark Anderson who was my first contact with the University and one of the most memorable. I would like to take this opportunity to thank Andrew Smith, SM, ScD, State Toxicologist for the Maine Bureau of Health, for sharing his expertise and guidance throughout the arsenic research process.

TABLE OF CONTENTS

LIST OF TABLES

Chapter 1

INTRODUCTION

Maine is a state rich in natural resources. With such an endowment often the question is raised how to best manage those resources. The case studies presented here are examples of two different ways policy issues can be addressed, providing information and utilizing public opinion. The first, arsenic contamination, is an example of a management agency collecting information from private sources, interpreting that information and making it available to the effected public to aid in their decision making process. The second case study, wildlife management perception, is an example of a management agencies collection of opinion from the public and interpreting that information to aid in their own decision making process.

Arsenic in Maine drinking water has become a public health concern. The primary health concern with long-term ingestion of well water with elevated arsenic levels is an increased risk of cancer (bladder, lung and skin) (Subcommittee of National Research Council, 2001). There may be as many as 30,000 private wells in Maine with arsenic levels in excess of the current federal standard, 0.01 mg/L (Maine Bureau of Health, 2000).

The arsenic study was undertaken to help health officials and homeowners assess the relative costs associated with treatment alternatives for private well water with elevated levels of arsenic. Annual costs of reverse osmosis (RO), activated alumina (AA), bottled water (BW), rented (RWC) and purchased (PWC) water coolers were

compared. Costs were calculated based households with one, two, three and four residents (the average Maine household has 2.39 residents).

In the second study the public's perceptions of the Maine Department of Inland Fisheries and Wildlife (MDIF&W) were explored. As part of the agencies goals to provide high quality recreational opportunities, improve customer satisfaction, education and awareness of wildlife issues, and maintain a high level of responsiveness to customers' needs MDIF&W elicited public opinion on how they were doing overall and on specific management issues. Wildlife managers are finding that agencies using public opinion to form policy decisions often enjoy high public support.

Public opinion of Maine resident's knowledge and satisfaction of wildlife management in Maine was investigated. This study is unique in that it considers public's knowledge of, and satisfaction with management activities jointly; no other study has looked at all these issues together. This study uses preference data from a mail survey of adult residents to examine public knowledge of who actively manages fish and wildlife in Maine, how the MDIF&W spends its budget and opinions regarding how MDIF&W should spend its budget, satisfaction with the management of game and nongame species as well as opinions on the allocation of effort between game and nongame species. As an auxiliary analysis, the characteristics of people who answered "don't know" to survey questions were also investigated.

Both of these studies provide valuable information to policy makers. It is important that both MDIF&W and the Bureau of Health have this information to aid in the decision making process to avoid making incorrect assumptions and misdirected policy.

Chapter 2

COST COMPARISONS FOR ARSENIC CONTAMINATION AVOIDANCE ALTERNATIVES FOR MAINE HOUSEHOLDS ON PRIVATE WELLS

Introduction

Arsenic in drinking water in Maine has become a public health concern. For every 100 private household wells in Maine approximately 11 (Maine Bureau of Health, 2000) have arsenic levels higher than the current federal and Maine drinking water standard of 0.01 mg/L, and half of Maine households get their drinking water from private wells (U.S. Census Data, 1990). This means there may be as many as 30,000 private wells in Maine with arsenic levels in excess of 0.01 mg/L. Arsenic concentrations as high as 5 mg/L have been observed in some tests of water from private wells in Maine (Maine Bureau of Health, 2000). Clusters of wells with levels in the 0.01 to 0.05 mg/L range have been reported in the towns of Buxton, Hollis, Northport and Standish (Marvinney *et al.*, 1994).

The primary health concern with long-term ingestion well water with elevated arsenic levels is an increased risk of cancer (bladder, lung and skin). Both lung and skin cancer in this instance are cause by consumption of arsenic contaminated water not inhalation or contact (Subcommittee of National Research Council, 2001). Most recent estimates of increased cancer risk from lifetime consumption of water with arsenic concentration levels in excess of 0.01 mg/L are on the order of 3 per 1,000.

Since 1999, there have been stepped-up efforts to increase awareness of arsenic in well water in Maine. This has led to an increase in well testing and demand for treatment

technologies to reduce arsenic levels in well water (Andrew Smith, State Toxicologist, personal communication).

This study was undertaken to help Maine homeowners with private wells assess the relative costs associated with treatment alternatives. Public water systems are required to have mitigation systems in place so that arsenic in their water that supplies do not exceed the allowable level of 0.01 mg/L (EPA, 2000). The decision for private wells of what treatment system to install has been left largely in the hands of the homeowner.

Treatment Alternatives

The instillation and operating cost of all treatment alternatives available in Maine were evaluated.

- Reverse Osmosis
  - Point of Use - water is treated at a specific faucet, typically the kitchen sink.
  - Point of Entry - all of the water that enters the household is treated.
- Activated Alumina
  - Point of Use - water is treated at a specific faucet, typically the kitchen sink.
  - Point of Entry - all of the water that enters the household is treated.
- Bottled Water - purchased at grocery or retail stores for drinking and cooking.
  - Gallon jugs.
  - Two and a half gallon jugs.
  - Packages of bottle sizes ranging from 6 to 34 oz with quantities available from six-packs to cases.
- Water Coolers
  - Rental - provided by a water cooler service to be used for drinking and cooking.
    - Cold water cooler with a 6-gallon jug.
    - Hot & cold water cooler with a 6-gallon jug.
  - Purchase - purchased at a retail store to be used for drinking and cooking.

Reverse osmosis (RO) is an established treatment mechanism where water passes through a synthetic, semi-permeable membrane. The RO membrane allows water to pass, but blocks both dissolved and suspended inorganic and organic contaminants, one of which is arsenic (EPA, 1998). Acitvated alumina (AA) uses an electrostatic attraction between the alumina surface and the contaminant, in this case arsenic, to purify the water (EPA, 1998). The AA element is a tank of granular hydrated aluminum oxide (Al_2O_3) that has been heat-treated. The particles are irregular and porous and have an extremely high surface to volume ratio, which allows for the treatment of a large volume of water.

While a Point of Use (POU) system treats all water at one tap, a Point of Entry (POE) system has the added convenience of treating all tap water in a household. However, concerns have been raised about the effectiveness of RO POE systems and their potential for failure as the increased levels of water treated by the POE system tends to break down the filter membrane rapidly. AA systems are designed to treat larger volumes of water than RO systems, which removes the concern about the effectiveness of the AA POE system.

If water is acidic or has elevated levels of mineral content (water hardness), then a water softener needs to be installed in order for RO and AA systems to work properly (EPA, 1998, confirmed by firms that sell the systems).

There are two types of arsenic found in well water in Maine, tri-valent and penta-valent. RO has a 50% removal rate of tri-valent arsenic (Andrew Smith State Toxicologist, personal communication), and de-ionization cartridges are used to increase the RO systems effectiveness of removing tir-valent arsenic. Reverse osmosis removes

90% of penta-valent arsenic. Activate alumina does not require de-ionization as it is designed to remove both tri-valent and penta-valent arsenic. We assume all technologies are effective at reducing arsenic levels in well water to below 0.01 mg/L.

The term bottled water includes water sealed in a container for human consumption that is labeled as mineral, artesian, ground, purified, deionized, distilled, reverse osmosis, sparkling or spring waters (Code of Federal Regulations- Food and Drugs, 21CFR165.110 (a-b)). The Food and Drug Administration is responsible for regulating all bottled water. The maximum allowable concentration of arsenic in bottled water is the same as the EPA's tap water standard of 0.01 mg/L (EPA, 2002). To date, all bottled water, regulated to be sold in Maine, tested by the Maine Department of Health has had arsenic concentrations below detection limit (Scott Whitney, Compliance Officer, Drinking Water Program, personal communication).

Purchases of bottled water have the convenience of being widely available from a variety of retail stores and can be placed by all water taps in a household. Bottled water has the disadvantage that it must be purchased at regular intervals and stored.

Water coolers have the convenience of having water available in bulk systems, but there must be a sufficient space for the cooler to be located in the household, which may not be adjacent to the primary water tap used for drinking and cooking water.

Previous Literature

Harrington and Portney (1987) proposed a model that defines the maximum an individual would pay to avert exposure to pollution. The following model is a stylized version of their model and is used to define maximum willingness to pay (WTP) for a

household to avoid exposure to arsenic in drinking water. It defines the conditions under which a household would choose to implement a least cost mitigation strategy.

The model below is a lifetime model for a one-person household that assumes all variables are known to the individual. The individual's utility (U(•)) is a function of non-health related goods (X), leisure time (L) and time spend ill (S).

$$U = U(X, L, S) \tag{1}$$

S (illness) is defined as:

$$S = S(A, D). \tag{2}$$

The individual's decision problem can be expressed as maximizing utility subject to an income constraint and a time constraint:

$$\max_{X, L, D} \quad U(X, L, S) \tag{3a}$$

s.t.

$$I = wT - wL - wS = P_x X - D - M(S) \tag{3b}$$

$$T = W + L + S \tag{3c}$$

where I is income, T is total time available, W is time spent working, w is the wage rate, P_x is the price of all other goods (X), A is the level of arsenic contamination, D is the defensive or averting expenditure and M is medical expenditures.

The indirect utility function resulting from this maximization problem, V, provides the maximum utility possible for the parameters of the choice problem.

$$V = V(I, A, P_x, D, M, w) \tag{4a}$$

Substituting for I and suppressing all other terms, maximum willingness to pay is defined as:

$$V(wT - wL - wS(A^{'}, WTP) - M(S^{'}) - WTP, A^{'}) \qquad (4b)$$

$$= V(wT - wL - wS(A^{0}, \emptyset) - M(S^{0}), A^{0})$$

If averting behavior lowers the initial level of pollution (A^0) to A', utility increases as long as averting cost is less than or equal to WTP. Equation (4) assumes the technology effectively averts the risk of arsenic contamination so medical expenses ($M(S^{'})$) are equal to zero.

Courant and Porter hypothesized that averting expenditures provide a lower bound estimate of the total costs imposed by pollution, and the divergence between defensive expenditures and the total costs of pollution arises from consequences of pollution which cannot be avoided (1981). In fact, the level of defensive expenditure may be either a lower or upper bound estimate of the households WTP for less pollution, depending on the properties of the technology under which averting expenditure achieves its purpose. If the averting technology does not remove all exposure then averting expenditures will be an underestimate of WTP. When the averting technology removes exposure to multiple pollutants, then averting expenditures can overestimate WTP for a single pollutant.

When averting technology cannot fully avert exposure to a pollutant, medical expenditures ($M(S'')$) will be greater than zero and averting expenditures (D_{WTP}) will be less than WTP. That is:

$$V(wT - wL - wS(A^{''}, D_{WTP}) - M(S^{''}) - D_{WTP}, A^{''}) \qquad (5)$$

$$\neq V(wT - wL - wS(A^{0}, \emptyset) - M(S^{0}), A^{0})$$

where $A^0 > A'' > A'$ and $M(S'') > 0$. The individual will choose to employ defensive technology, even when they cannot effectively avert, as long as $D_{WTP} \leq WTP$.

This study explores the least cost technology, D, for avoiding arsenic in drinking water for households on private wells. This information will help households decide whether to employ D; they will do so only when the least cost technology is less than or equal to their WTP for the removal of arsenic contamination.

Data Collection

Treatment systems considered were identified by conversations with representatives of the Maine Bureau of Health and water treatment companies. Cost data were obtained from firms that sell reverse osmosis and activated alumina, rent water coolers, and from stores that sell bottled water. Cost-effectiveness results are based on data averages for each of the respective treatments. Costs were calculated for the reverse osmosis and activated alumina systems with and without the concurrent installation of a water softener. In addition to calculating costs for each treatment alternative, costs were calculated based households with one, two, three and four residents (the average Maine household size 2.39 residents).

Data on RO were collected during the months of July and August 2001 by a phone survey of firms in Maine know to sell and install these systems. Firms were called a second time to clarify cost quotes. Four water treatment firms gave cost quotes. One firm's costs were excluded as they were much higher than the other firms and their cost quotes included substantial additional services that were not included in the cost quotes provided by the three other firms.

Data on AA were collected at the beginning of September 2001 by phone survey of firms in Maine that install RO or were known to install AA only. Three firms install AA and provided cost quotes.

Data on bottled water were collected during July 2001 by visiting grocery and retail stores that sell large volume bottles or packages in the Bangor area. A student visited four stores in the area and recorded the prices for the various sizes of bottles and packages of multiple bottles; very little variation in the prices of the similar sized bottles was observed.

Data on water coolers was collected during July 2001 by phone survey. All firms known to provide water delivery services were contacted for pricing information for cold, and hot and cold water units using six gallon water jugs. All six firms provided cost quotes for the rental of cold water units and five firms reported cost quotes for rental of hot and cold water units. Four stores in the Bangor area were visited to collect data on the cost of purchasing a water cooler, only one store had hot and cold water units available for purchase.

Cost Analysis

It was assumed that POU and bottled water systems need to treat between 365 and 1,460 gallons of water each year to meet the drinking and cooking needs of Maine households of varied sizes; a typical person consumes one gallon of water a day. A single-person household would require 365 gallons of water annually and a four person household would require 1,460 gallons of water annually. A POE system needs to treat between 36,500 and 146,000 gallons of water per year based on the assumption that the

typical person uses 100 gallons of water per day. A single-person household would require 36,500 gallons of water annually and a four person household would require 146,000 gallons of water annually.

RO and AA costs, for POU and POE systems, were calculated based on procedures developed by the U.S. EPA to evaluate the costs of treatment alternatives (EPA, 1998). Cost assumptions and analysis procedures used for this study are explained in detail in Appendix A.

RO and AA, POU and POE, costs were calculated based on the purchase price of the treatment device including the cost of installation and a 15% contingency fee applied to these costs to cover any unexpected site costs. These purchase prices were annualized over their expected lifetimes using a 10% discount rate. Annual maintenance costs were added. These systems also require an annual test of the water to insure that arsenic levels are below the 0.01 mg/L standard. A second cost calculation was made based on the need to pre-treat water with a softener for maximum system efficiency. A third cost calculation was made for RO systems based on the need to use de-ionization for maximum removal of tri-valent arsenic.

RO POE costs were calculated for both systems that cost \$5,000 and \$10,000 because these costs are substantially different with substantially different water treatment capacities. The average capacity for the \$5,000 system was 250 gallons of water per day. The average capacity for the \$10,000 system was 850 gallons of water per day. Since households have different water treatment requirements we included both systems separately rather than averaging them together. To account for the differences between system treatment capacities the cost per gallon treated was calculated, using vendor

treatment capacity estimates multiplied by the average capacity of the system category ($5,000 or $10,000). The average price for an average capacity system was then used as the purchase price for each category.

Costs for the RO and AA systems do not vary by household size as the capacity of the systems are capable of handling the usage by a household of four people. Neither installation nor maintenance costs are based on the volume of water consumed by the households.

The following steps were taken to estimate bottled water and water cooler costs. Bottled water costs were calculated by multiplying the average cost per gallon by the number of gallons consumed per household, producing the estimated purchase price of water (e.g. 365 * $0.88/ gallon for a one-person household).

Rented water cooler costs included annual rental costs and the cost of electricity, in addition to the purchase price of water. Purchased water cooler costs included the purchase price of water, the purchase price of the cooler annualized over 5 years at a 10% discount rate, and the cost of electricity.

Results

The least expensive treatment option for a single-person household is to purchase one-gallon jugs of bottled water ($321 annually) (Table 2.1). For households larger than one person the least expensive treatment option consistently is to install a RO POU system ($411 annually).

The second least cost option for a single person household is to purchase 2.5-gallon jugs of bottled water ($358 annually), and the third-best option, for an additional $53, is

to install a POU RO system. For households larger than one person the second-best option is to install a POU AA system ($518 annually).

Table 2.1 Total Annual Costs of Treatment Technologies for Maine Households

Type of Avoidance Method	Point of application/ Bottle size	Total Annual Costs Single Resident Household	Total Annual Costs Two-person Household	Total Annual Costs Three-person Household	Total Annual Costs Four-person Household
RO	POU	$ 411	$ 411	$ 411	$ 411
RO	POE $5,000 system	1,248	1,248	1,248	1,248
RO	POE $10,000 system	2,539	2,539	2,539	2,539
AA	POU	518	518	518	518
AA	POE	2,542	2,542	2,542	2,542
BW	1 Gal.	321	642	964	1,285
BW	2.5 Gal.	358	715	1,073	1,431
BW	Packaged	1,179	2,358	3,537	4,716
RWC	6 Gal. Cold	579	893	1,208	1,555
RWC	6 Gal. Hot & Cold	675	989	1,304	1,618
PWC	6 Gal. Hot & Cold	571	885	1,202	1,516

* RO- Reverse Osmosis, AA- Activated Alumina, BW- Bottled Water, RWC- Rented Water Cooler, PWC- Purchased Water Cooler, POU- Point of Use and POE- Point of Entry

Sensitivity analysis was performed for including a water softener for RO and AA or de-ionization cartridge for RO (Table 2.2). The sensitivity analysis did not change the least expensive treatment options for households. The least expensive treatment option for households larger than one person continues to be a RO system if either a softener or de-ionization is required.

The sensitivity analysis showed that softener costs increased the total annual cost of AA systems much more than RO systems. This is due to higher vendor quotes for softener for AA systems than RO systems.

Table 2.2 Sensitivity Analysis

Type of Avoidance Method	Point of Application	Total Annual Cost
RO	POU w/Softener	$ 572
RO	POU w/ De-Ionization	456
RO	POE $5,000 w/Softener	1,538
RO	POE $5,000 w/ De-ionization	1,276
RO	POE $10,000 w/ Softener	2,820
RO	POE $10,000 w/ De-ionization	2,567
AA	POU w/Softener	1,189
AA	POE w/Softener	2,727

* RO- Reverse Osmosis, AA- Activated Alumina, POU- Point of Use and POE- Point of Entry

The total annual cost for reducing arsenic contamination levels in Maine's 30,000 households to 0.01 mg/L or below was found to be $12,330,000 assuming average household size is equal to the Maine households average size and the average system does not need de-ionization or water softener. When calculated using RO as the least cost technology.

Discussion

The cost-effectiveness results reported above are intended to help people understand the relative costs of the various options for mitigating exposure to arsenic in drinking water from private wells. Mitigation costs can vary for any household with unique aspects of installing an RO or AA system in the home (for example small space requiring two smaller holding tanks rather than one large), other services provided by the installer and changes in market prices for the treatment systems or for bottled water. Before taking specific actions to mitigate exposure to arsenic in water from private wells,

households should carefully investigate specific features of the systems they are considering and the exact cost to their household.

For all household sizes, except a single resident, installation of a POU RO system is the most cost-effective option. The RO system avoids the inconvenience of having to regularly buy water, store the jugs, and not having access to potable water at the primary tap in the household. Besides being the most cost effective, RO is one of few systems currently certified for arsenic removal by the National Science Foundation (Andrew Smith, Maine State Toxicologist, personal communication).

Thus, relative ranking of systems shows that RO is the most cost effective, followed by AA and one-gallon jugs of water, respectively for households larger than one person. The costs of RO and AA systems do not vary by the number of people in a household ($411 and $518). In contrast, the cost of bottled water increases as the number of people in the household increases. For a household with four people, the annual cost of buying bottled water is more than four times greater than a POU RO system.

POE systems and water coolers were not found to be cost effective under any of the study's conditions.

No consideration was given to any differences between technologies effectiveness of removing arsenic. We assume all technologies are capable of removing arsenic contamination from drinking water. Assuming arsenic contamination is being effectively removed WTP should be estimated derived Equation (4). While regular testing by the state monitors arsenic levels in bottled water, households installing RO or AA systems must have their water tested on an annual basis to insure that these systems are effectively removing tri-valent and penta-valent arsenic. If households are not testing

their water annually it must be assumed that arsenic contamination is not being removed effectively and WTP should be estimated using Equation (5). Willingness to pay for households that do not use the system correctly, for example drinking water from faucets other than those with POU systems, must also be estimated using Equation (5).

The averting cost estimated here is not likely to be a good estimate of the average households willingness to pay to avoid arsenic exposure. Following Courant and Porter it is not possible to estimate how far off estimates of willingness to pay are likely to be because no individual household behavior information is known. The estimate would be within the lower and upper bounds, as cost of illness would be the lower bound and averting expenditures are not an overestimate, the averting technologies do not improve health beyond removing the contamination. Individuals have the choice of whether to implement the systems or not, some may choose to take the risk and not to purchase a system. These non-implementing households bring the mean WTP below that of the cost of averting expenditures, giving no further information on the true WTP.

Chapter 3

PUBLIC PERCEPTIONS OF WILDLIFE MANAGEMENT IN MAINE

Introduction

Many biologists question why the public needs to be involved in scientific management (Decker, Kruger, Baer, Knuth, & Richmond, 1996). The reality is that public support is vital for funding, political support and adherence to new laws and regulations to protect and enhance wildlife. Managers are finding that they must work within a complex, interconnected web of biological and sociological forces (Decker & Chase, 1997), and agencies that use public opinion to form policy decisions often enjoy high public support for their agency (deVos, Shroufe & Supplee, 1998).

Studies have shown that understanding the needs and desires of diverse stakeholders may be the most crucial type of knowledge for an agency's survival in the 21st century (Decker & Enck, 1996). Phillips, Boyle and Clark (1998) found that judgment by managers is not a good proxy for direct, objective data on public preferences. Only when a broad array of the public's knowledge and opinions are considered in the decision making process can an agency enjoy high satisfaction among clientele groups (Decker & Chase, 1997). It is also important that the public understands the mission of the agency (Decker et al., 1996).

While a number of studies (Duda, 1998; Rossi & Armstrong 1999; Duda & Colquitt, 1991; Duda et al., 1998; Duda & Young, 1994; Mays, 1996) have investigated the public's knowledge of wildlife management activities and satisfaction with these management activities individually, no studies could be identified that examined these

considerations collectively in one case study. Here, we investigate Maine resident's knowledge of and satisfaction with fish and wildlife management in Maine. Specifically, we consider:

- The public's knowledge of who actively manages fish and wildlife in Maine.
- The public's knowledge of how the Maine Department of Inland Fisheries and Wildlife (MDIF&W) spends its budget and opinions regarding how MDIF&W should spend its budget.
- Public satisfaction with the management of game and nongame species.
- Public opinion on the allocation of effort between game and nongame species.

As an auxiliary analysis, we investigate the characteristics of people who answered "don't know" to the survey questions. In the next section we overview results from previous studies on these topics and then move on to reporting the results of our study.

Previous Research

Wildlife management agency recognition has been investigated in Alabama, Maryland, and South Carolina (Table 3.1). The results indicate that the majority of people are not familiar with the state agency that manages their fish and wildlife resources (Duda et al., 1998). The percent correctly identifying the wildlife management agency in their state ranged form a low of 6% in South Carolina (Duda, 1998) to a high of 16% in Alabama (Rossi & Armstrong, 1999).

When Vermont residents were asked to indicate what wildlife management activities should receive more time and money (Table 3.1), the top three priorities were land acquisition (47%), endangered species management (46%), and law enforcement (42%) (Duda, 1998). Georgia residents were most supportive of endangered species management (72%), education about wildlife (70%), habitat acquisition (67%) and law enforcement (65%) (Duda & Colquitt, 1991). Idaho residents responded that more time and money should be dedicated to conserving and protecting water resources (65%), education about wildlife (54%) and protecting wildlife resources (52%) (Duda et al., 1998; Duda & Young, 1994).

Table 3.1 Survey Questions Employed in Various States (Types of Responses in Parentheses)

	Agency Recognition	Expenditures	Satisfaction Rates	Game and Nongame Management Effort
Alabama	What is the name of the state agency that has the primary responsibility for managing and protecting wild animals in Alabama? (Open-ended response)			
Georgia		I'm going to list some of these programs and I'd like you to tell me if you feel that much more, more, about the same, less, or much less time and money should be spent on the following programs. (Time & money for thirteen categories)		In general, do you think big game animals such as deer, bear, and wild turkey are: (Three categories for protection) Do you think small game animals such as rabbit, squirrel, and dove are: (Three categories for protection)
Idaho			How well does the Dept. manage supply of game for hunting? (Five categories for game supply) How well does the Dept. manage and protect the state's wildlife resources? (Six categories for wildlife protection)	
Maine	Which of the groups below do you think currently plays an <u>active role</u> in managing Maine's fish and wildlife? (Fourteen groups to rate)	How much money do you think the Dept. <u>currently</u> spends on each of the activities listed below? (Money for fourteen categories) How much money do you think the Dept. <u>should</u> spend on each of the activities listed below? (Money for fourteen categories)	Do you think that the Dept. does a satisfactory job of game management in Maine? (Four categories for game management) Do you think that the Dept. does a satisfactory job of nongame management in Maine? (Four categories for nongame management)	How do you think the Dept. <u>currently</u> allocates its effort between game and nongame management? (Six categories for effort allocation) How do you think the Dept. <u>should</u> allocate its effort between game and nongame management? (Six categories for effort allocation)
Maryland	What agency is responsible for managing and protecting wild animals in Maryland? (Open-ended response)			
Missouri			Is Missouri making good progress in protecting its wild animal and plant species? (Wild species protection categories unknown) Should the Missouri Dept. of Conservation make an effort to restore endangered species? (Endangered species restoration categories unknown)	
South Carolina	What agency is responsible for managing and protecting fish, game, nongame and natural resources in South Carolina? (Open ended-response)			
Vermont		What programs should receive more time and money? (Time & money for nine categories)		

The public typically rates the performance of state fish and wildlife management agencies as good on the scale of excellent, good, fair or poor. The majority of residents believed Missouri was making good progress in protecting its wild animal and plant species (78%), but felt that more is needed to restore endangered species (75%) (Mays, 1996). Sixty-six percent of Idaho residents rated the performance of the Idaho Department of Fish and Game at or above fair in terms of managing the supply of game animals for hunting, and a majority (77%) rated the departments performance at or above fair in managing and protecting the state's wildlife resources (Duda & Young, 1994).

Very few studies have been conducted on public perception of the allocation of management effort between game and nongame species. A survey of Georgia residents found that 48 percent of residents believe big game species needed greater protection, whereas nongame species were safe and well protected (70%) (Duda & Colquitt, 1991).

While the results vary from state to state due to different question frameworks and response formats, the collective results suggest that the public does not know who manages wildlife in their states, but give wildlife management activities high performance ratings. Habitat acquisition, endangered species protection and law enforcement appear to be high priority activities.

We include "don't know" responses to avoid forcing people with out opinions on specific topics to answer particular survey questions, and perhaps avoiding them not responding at all to the survey. Studies conducted on various topic areas have shown that "don't know" responses vary with socioeconomic characteristics (Durand & Lambert, 1988; Francis & Bucsh, 1975).

Methods

We conducted a mail survey of adult Maine residents using a sample obtained from the Maine Department of Motor Vehicles. The sample included 5,000 individuals who held a Maine driver's license, which represents over 90% of the adult population in Maine. Four versions of the survey were randomly assigned to subsamples of 1,250 people. A mistake was found in the addresses of 297 individuals in one of the subsamples and had to be excluded from the study. Versions 1 thru 3 of the survey were applied to subsamples of 1,250 individuals, but version 4 was applied to a smaller sample of 953.

The survey was designed and administered according to the Dillman "Tailored Design Method" (2000). The survey was pre-tested in two focus groups and was sent out for peer review prior to distribution.

The first mailing of the survey was by regular mail. A reminder postcard was sent one week after the first mailing. About three weeks after the first mailing, a second survey was sent to nonrespondents. After seven weeks, those who still had not responded were sent a third copy of the survey instrument. A total of 2,606 completed surveys were returned for an overall response rate, excluding undeliverables, of 65%.

The questionnaire was designed to elicit respondent's views on who manages wildlife in Maine, on how money is and should be spent to manage wildlife, satisfaction with game and nongame management, and the allocation of management effort between game and nongame species. Socioeconomic characteristics collected include age, sex, education, household size, income, Maine land ownership and years of residency.

To address the study objectives respondents were asked to answer questions outlined in Table 3.1. Respondents were asked to indicate whether they thought each of 14 groups actively managed fish and wildlife in Maine. The response categories were "does manage", "does not manage" and " don't know". To elicit respondents' views on budget activities respondents were given a list of 14 categories and asked to indicate, on a four-point scale, how much money they thought MDIF&W currently spent on each category. The response categories were "a lot", "some", "very little", "none" and "don't know". Using the same 4-point scale, respondents were then asked how they think MDIF&W should spend its budget on each of the fourteen categories. Respondents were asked to indicate if they thought the MDIF&W did a satisfactory job of game and nongame management. The response categories were "yes" they are doing a satisfactory job of game management, "too much effort into game management", "too little effort into game management". For nongame management the categories were "yes" they are doing a satisfactory job of nongame management, "too much effort into nongame management", "too little effort into nongame management" and "don't know". Lastly, respondents were asked to indicate how they thought MDIF&W allocated management effort between game and nongame species, and how they thought this effort should be allocated. Responses were on a five-point scale ranging from "nearly all to game" to "equal" to "nearly all to nongame", and a "don't know" category was included.

Results

The average respondent was 48 years of age, had lived in Maine for 23 years, and had an average household income before taxes in 1997 of $46,300. Fifty-six percent of

respondents were male. Sixty-four percent of respondents had some education beyond high school. Respondents were more likely to be male (56% vs. 49%), have a college degree (36% vs. 19%), and have a higher income ($46,300 vs. $33,140) than the adult population of Maine (U.S. Census, 2000). Most respondents owned land in Maine and replied that Maine's fish and wildlife were "very important" to them.

Virtually all respondents (93%) indicated that the MDIF&W actively managed fish and wildlife in Maine (Table 3.2). Seven percent of respondents did not know if MDIF&W actively managed fish and wildlife in Maine. Respondents who answered, “don’t know” were more likely to have less education ($\chi^2_{(7, 1310)}$= 27.83), have an income of less than $10,000 ($\chi^2_{(14, 1186)}$= 36.87) and think that Maine’s fish and wildlife is not important ($\chi^2_{(2, 1306)}$= 11.72) than those who chose MDIF&W. Most respondents (78%) also indicated that the U.S. Fish and Wildlife Service actively manages fish and wildlife in Maine. No other group was listed by at least 50% of the respondents. Groups who indirectly manage wildlife through their land-management practices, paper companies and farmers for example, were not seen by respondents as actively managing wildlife.

Table 3.2 Respondents' Views of Who Actively Manages Fish and Wildlife in Maine

Groups	Does Manage	Does Not Manage	Don't Know
Maine Department of Inland Fisheries & Wildlife[a]	93%	1%	7%
U.S. Fish and Wildlife Service	78	7	15
Maine Audubon Society	45	30	25
Maine State Parks	43	32	25
Sportsman Alliance of Maine	42	31	27
Maine Forest Service	39	36	25
The Nature Conservancy	33	32	35
Paper Companies	25	50	25
Farmers	25	52	23
Maine Department of Environmental Protection	24	50	26
Local Communities	24	49	27
Owners of Small Woodlots	23	51	25
U.S. Environmental Protection Agency	19	52	30
Land Use Regulation Commission or Maine Department of Conservation	15	51	34

[a]Rows may not sum to 100% due to rounding.

When it comes to budget allocations, over 50% of respondents thought "a lot" or "some" money was spent on law enforcement, followed by equipment, office operations, search and rescue activities, and stocking fish (Table 3.3).[1] The public's perception of how money should be spent differs from how they thought it was spent. Generally people felt that less money should be spent on law enforcement, equipment, hunting/fishing license sales, other license sales (boat, ATV, and snowmobile), and office

[1] The objective was not to get an exact budget allocation, but to identify relative perceptions on allocations and desires for allocation.

operations (Table 3.4). Generally people felt that more money should be spent on buying land, endangered species, search and rescue, stocking fish, scientific research, managing game, managing nongame, education and developing new laws.

Table 3.3 Respondent's Views on How Much of the Maine Department of Inland Fisheries &Wildlife's Budget Is Spent on Selected Activities

Activities[a]	Amount of Spending				
	A lot	Some	Very Little	None	Don't Know
Law enforcement	37%	32%	6%	1%	25%
Equipment (computers, vehicles, ect.)	33	33	7	1	26
Office operations	29	37	7	1	26
Search and rescue	25	39	10	1	26
Stocking fish	14	45	15	2	24
Buying land	12	30	24	6	28
Developing new laws	11	29	29	3	28
Boat, ATV, snowmobile license sales	10	40	22	3	26
Hunting/fishing license sales	9	43	21	2	26
Endangered species	9	38	22	3	27
Managing game	9	39	22	3	28
Scientific research	8	40	22	3	27
Managing nongame	7	32	28	5	28
Education	5	27	28	3	27

[a]Respondents were asked to evaluate each activity. Rows may not sum to 100% due to rounding

Table 3.4 Respondent's Views on How Much of the Maine Department of Inland Fisheries &Wildlife's Budget Should be Spent on Selected Activities

Activities[a]	Amount of Spending				
	A lot	Some	Very little	None	Don't know
Law enforcement	43%	43%	6%	1%	8%
Buying land	39	36	12	5	8
Endangered species	34	42	13	3	9
Search and rescue	33	48	10	2	7
Stocking fish	31	52	9	1	7
Scientific research	25	50	15	1	8
Managing game	24	42	19	7	8
Managing nongame	24	43	19	6	8
Education	24	49	18	2	7
Developing new laws	22	45	21	5	8
Equipment (computers, vehicles, ect.)	12	63	15	1	8
Boat, ATV, snowmobile license sales	9	49	30	5	7
Hunting/fishing license sales	8	51	30	4	7
Office operations	3	60	27	3	8

[a]Respondents were asked to evaluate each activity. Rows may not sum to 100% due to rounding.

In Maine the majority of the budget is actually spent on law enforcement, stocking fish, administration (which include both office operations and equipment), and managing game species (Record, 2000). Some of the low ranked activities, e.g. equipment and office operations, are important components of and support for the more highly rated activities.

Most respondents indicated that MDIF&W was doing a satisfactory job of game management (57%) (Table 3.5). Fifty one percent of respondents indicated that

MDIF&W was doing a satisfactory job of nongame management. At least one out of four respondents indicated that they did not know if MDIF&W was doing a satisfactory job of either game or nongame management. Of those who made a choice other than "don't know", clear majorities think a satisfactory job was being done for game (77%) and nongame (71%) management. We tested whether equal numbers of unsatisfied respondents felt there was too much effort into game and nongame management or that there was too little effort into game and nongame effort. Respondents who were not satisfied thought that there was not enough game or nongame management effort ($\chi^2_{(4,436)}$= 96.82) rather than too little effort. Those who responded "don't know" to if MDIF&W was doing a satisfactory job of game management were more likely to be women ($\chi^2_{(1, 1326)}$= 61.14), have lower education ($\chi^2_{(7, 1324)}$= 47.49), and think Maine fish and wildlife is very important ($\chi^2_{(2,1322)}$= 12.13) than those who indicated a satisfaction level. Those who responded "don't know" to if MDIF&W was doing a satisfactory job of nongame management were more likely to be women ($\chi^2_{(1, 1326)}$=18.08), have lower education ($\chi^2_{(7,1324)}$= 17.79), and think Maine fish and wildlife is very important ($\chi^2_{(2,1322)}$= 8.84) than those who indicated a satisfaction level.

Table 3.5 Respondent's Evaluations of the Maine Department of Inland Fisheries &Wildlife's Management of Game and Nongame Species

Does the Maine Department of Inland Fisheries &Wildlife do a satisfactory job of game management?[a]	
Yes	57%
No, too little effort into game management	12
No, too much effort into game management	5
Don't know	26
Does the Maine Department of Inland Fisheries &Wildlife do a satisfactory job of nongame management?[a]	
Yes	51%
No, too little effort into nongame management	18
No, too much effort into nongame management	2
Don't know	28

[a]Responses to each question may not sum to 100% due to rounding.

Thirty-nine percent of respondents thought that MDIF&W put nearly all or somewhat more effort into game management, while 38% did not know how management was allocated between game and nongame (Table 3.6). Those who responded "don't know" were more likely to be women ($\chi^2_{(1,\ 1316)}$= 11.01), have an income of less than $10,000 ($\chi^2_{(14,\ 1190)}$= 50.96) and be non-hunters ($\chi^2_{(4,\ 1314)}$=12.95), than those who chose how MDIF&W currently allocates effort between game and nongame. When respondents who rarely hunt were removed from the analysis the hunter variable became insignificant. Suggesting the differences in "don't know" responses occur because of those who rarely hunt.

Table 3.6 Respondent's Evaluations of the Maine Department of Inland Fisheries &Wildlife's Allocation of Management Effort Between Game and Nongame

How does the Maine Department of Inland Fisheries &Wildlife currently allocate its effort between game and nongame?[a]	
Nearly all to game management	11%
Somewhat more to game management	28
Equal allocation	18
Somewhat more to nongame management	5
Nearly all to nongame management	<1
Don't know	38
How should the Maine Department of Inland Fisheries &Wildlife allocate its effort between game and nongame management?[a]	
Nearly all to game management	8%
Somewhat more to game management	19
Equal Allocation	42
Somewhat more to nongame management	11
Nearly all to nongame management	3
Don't know	14
Don't care	3

[a]Responses to each question may not sum to 100% due to rounding

In comparison, 42% of respondents thought that MDIF&W should allocate effort equally between game and nongame management, 27% would like to see more effort on game management and only 14% said "don't know". Those who responded "don't know" were more likely to have lower education ($\chi^2_{(7, 1314)}= 17.15$) and have a income of less than \$10,000 ($\chi^2_{(14, 1188)}=30.40$) than those who indicated how MDIF&W should allocate effort.

Implications

On the issue of who actively manages fish and wildlife, respondent knowledge in Maine exceeds that of Maryland, South Carolina and Alabama (Table 3.7). This may be due to a number of factors. Maine is a rural state with a high percentage of residents interacting with the agency. Maine has a population of 966,000 with nearly 511,000 residents participating in wildlife related recreation (U.S. Department of the Interior, 1996). Maryland, South Carolina and Alabama are considered more urban with smaller percentages of their populations participating in wildlife related recreation (see Table 3.7). MDIF&W is a broad agency that includes the licensing of snowmobiles and boats, and search and rescue, whereas the other state agencies may have narrower responsibilities. While resident interest in wildlife agencies and agency contact with the public are both likely to affect agency recognition, the fixed response categories used in our survey rather than the open ended categories used in the other studies reported are also likely to have resulted in a higher percentage identifying MDIF&W.

One area where the study results are in general agreement across states, despite the differences in the question wording, response format and population patterns, is spending priorities (Table 3.7). Public priorities focus on endangered/nongame species, education and land acquisition.

Table 3.7 State Population Dynamics and Response Formats

State	Participation In Wildlife Related Recreation %	Population Rural %	Agency Recognition	Satisfaction Rates	Expenditures	Management Effort
Alabama	38	40	16% Identified			
Georgia	35	37			• Endangered species management • Education about wildlife • Habitat acquisition	• 20% More to large game • 32% More to small game • 20% More to nongame
Idaho	55	43		• 66% satisfaction with game management • 77% satisfaction with wildlife management	• Water resources • Education about wildlife • Protecting wildlife resources	

Table 3.7 Continued

State	Participation In Wildlife Related Recreation %	Population Rural %	Agency Recognition	Satisfaction Rates	Expenditures	Management Effort
Maine	53	55	93% Identified	• 57% Satisfaction with game management • 51% satisfaction with nongame management	• Buying Land • Education • Managing Nongame	• 27% More to game • 14% More to nongame
Maryland	39	19	14% Identified			
Missouri	47	31		• 78% satisfaction with wild species management		
South Carolina	38	45	6% Identified			
Vermont	53	68			• Land acquisition • Endangered species management • Law enforcement	

High agency recognition does not necessarily translate into high satisfaction with agency management activities. Satisfaction with wildlife management in Idaho and Missouri exceed that of Maine (Table 3.7). While no single question was systematically asked in any two states (Table 3.1), the summary results in Table 3.7 suggest that differences do occur in public perceptions of wildlife management across states. This suggests that a single survey instrument that is designed to systematically investigate differences across states would be an important contribution to the literature.

Public opinion on the allocation of effort between game and nongame species is a little studied topic. The one other state found to study public opinion on game and nongame allocation, Georgia, is similar to Maine in that there is no majority opinion of either game or nongame needing more management effort.

Analysis of "don't know" responses showed that these respondents were more likely to be women, non-hunters, have less education, think that fish and wildlife is very important or have incomes of less than $10,000 than those who gave an opinion regarding management questions. Women and non-hunters are not traditional clientele of wildlife management agencies (Boyle & Clark, 1996, 1996, and U.S. Department of the Interior). Those respondents with less education may respond "don't know" because they have difficulty answering the questions. Thus, respondents who answer "don't know" may not be well informed about wildlife management or may have difficulty answering survey questions. If these respondents were not allowed to respond "don't know" to the questions, they may have answered just to complete the survey or not

returned the survey. Either of these outcomes would introduce bias into the survey results.

While there are similarities between states there are also major differences. A systematic study of why these differences in public perceptions and opinions occur could help to improve wildlife management efforts in individual states. We recommend a consistent survey instrument with fixed response categories where possible and allowing people to answer don't know.

Chapter 4

CONCLUSION

The research presented in the proceeding chapters provides important information for Maine resource managers. It also generates questions to be answered by additional research.

Looking at two case studies each using different approaches to real public policy issues facing Maine management agencies today provides a practical opportunity to delve into applications of environmental policy. The first case study, arsenic contamination, showed how management agencies could use private business information to assist private homeowners to decide on the best (if any) averting technology to use. The second case study, wildlife management, demonstrated how management agencies could use information gathered from the public to better meet their own goals.

The first essay provides a starting point for recommendations on arsenic contamination avoidance treatment technologies but consideration was not given to any differences between technologies effectiveness of removing arsenic. All technologies were assumed to be capable of reducing arsenic levels in well water to below 0.01 mg/L, which may not be the case for individual household wells. Before taking specific actions to mitigate exposure to arsenic in water from private wells, households should carefully investigate specific features of the systems they are considering and the exact cost to their household.

The results of the wildlife essay suggest that the results of the Maine study are considerably different from other states studied previously. A systematic study of why differences in public perceptions and opinions occur amongst states could help to

improve wildlife management efforts in individual states. A consistent survey instrument with fixed response categories (where possible) that allows people to answer, "don't know" is recommended.

Future research in cost calculations for arsenic remediation technologies should include incorporating differences in removal rates and effectiveness of the various technologies. This research should be undertaken to improve the accuracy and reliability of recommendations. Additional research on public perception of wildlife management should include cooperative studies between state management agencies to compare "don't know" respondent characteristics and emerging trends. This approach would help to improve wildlife management in each state.

REFERENCES

Apyron Technologies Inc. 2000. "The Complete Arsenic Treatment Solution." http://www.apyron.com/bulletins/arsenicProducts.html, November 2001.

Bartik, T. 1988. "Evaluating the Benefits of Non-marginal Reductions in Pollution Using Information on Defensive Expenditures." *Journal of Environmental Economics and Management*. 15: 111-127.

Boyle, K. J., & Clark, A. G., 1996. "Hunting Data Documentation Report." *Department of Resource Economics and Policy Staff Paper* REP 468. 1-52.

Courant, P., & Porter, R. 1981. "Averting Expenditures and the Cost of Pollution." *Journal of Environmental Economics and Management.* 8: 321-329.

deVos, J. C. Jr., Shroufe, D. L., & Supplee, V. C. 1998. "Managing Wildlife by Ballot Initiative: the Arizona Experience." *Human Dimensions of Wildlife.* 3(2): 60-66.

Decker, D. J., Krueger, C. C., Baer, R. A. Jr., Knuth, B. A., & Richmond, M. E. 1996. "From Clients to Stakeholders: A Philosophical Shift for Fish and Wildlife Management." *Human Dimensions of Wildlife.* 1(1): 70-82.

Decker, D. J., & Enck, J. W. 1996. "Human Dimensions of Wildlife Management: Knowledge for Agency Survival in the 21st Century." *Human Dimensions of Wildlife.* 1(2): 60-71.

Decker, D. J., & Chase, L. C. 1997. "Human Dimension of Living With Wildlife - A Management Challenge of the 21st Century." *Wildlife Society Bulleti.n* 25(4): 788-795.

Dillman, D. A. 2000. *Mail and Electronic Surveys: the Tailored Design Method* (2nd ed.). New York : John Wiley & Sons.

Duda, M. D. 1996. "Public Opinion on Natural Resource Issues." *Responsive Management.* Harrisonburg, VA. 4. http://www.responsivemanagement.com/env_opinions.html. June 23, 2000.

Duda, M. D., Gruver, B. J., Jacobs, S., Mathews, T., Lanier, A., Augustus, O., & Bissell, S. J. 1998. "Wildlife and the American Mind: Public Opinion on and Attitudes Toward Fish and Wildlife Management." *Responsive Management.* Harrisonburg, VA. 1-828.

Duda, M. D., & Colquitt, K. 1991. "The Public and Wildlife Management in Georgia: Survey I." *Responsive Management.* Harrisonburg, VA. 1-172.

Duda, M. D., & Young, K. C. 1994. "Idaho Resident's Opinions and Attitudes Toward the Idaho Department of Fish and Game." *Responsive Management,* Harrisonburg VA. 1-142.

Durand, R.M., & Lambert, Z.V. 1988. "Don't Know Responses in Surveys: Analyses and Interpretational Consequences." *Journal of Business Research.* 16: 169-188.

Francis, J.D., & Busch, L. 1975. "What We Don't Know About 'I Don't Knows'." *Public Opinion Quarterly.* 30: 207-218.

Harrington, W., & Portney P.R. 1987. "Valuing the Benefit of Health and Safety Regulations." *Journal of Urban Economics.* 22(1): 101-112.

Maine Bureau of Health. 2000. "Have You Tested Your Well for Arsenic? Why You Should Test Well Water for Arsenic." http://www.state.me.us/dhs/etp/Asposter.pdf, 2001.

Maine Bureau of Health. 2000. "Have You Tested Your Well for Arsenic? Health Information for Private Well Users." http://www.state.me.us/dhs/etp/ASBROCH3.pdf, 2001.

Marvinney, R., Loiselle, M., Hopeck, J., Braley, D. & Krueger, J. 1994. "Arsenic in Maine Groundwater: An Example from Buxton Maine." In Proceedings FOCUS Conference on Eastern Groundwater Issues. 701-715.

Mays, A. 1996 (December). "Survey Tracks Missourians' Outdoor Attitudes." http://www.conservation.state.mo.us/news/out/1996/out12206.html.

Morales, K. H., Ryan, L., Kuo T.L., Wu, M.. & Chen, C.J. 2000. "Risk of Internal Cancers from Arsenic in Drinking Water." *Environmental Health Perspectives.* 108(7): 655-661.

Phillips, M. L., Boyle, K. J., & Clark, A. G. 1998. "A Comparison of Opinions of Wildlife Managers and the Public on Endangered Species Management." *Wildlife Society Bulletin.* 26(3): 605-613.

Record, R. 2000. "Financial Report: State of Maine Inland Fisheries and Wildlife." 7-15.

Rossi, A.N., & Armstrong, J.B. 1999. "Alabamian's Wildlife-Related Activities, Wildlife Management Perceptions, and Hunting Behavior." *Alabama Game and Fish Division.* 1-178.

Smith, A. 2001. State Toxicologist, Maine Bureau of Health. Personal Communication.

Subcommittee to Update the 1999 Arsenic in Drinking Water Report, Committee on Toxicology, Board on Environmental Studies and Toxicology, National Research Council. 2001. "Arsenic in Drinking Water: 2001 Update." Washington, D.C.: National Academy Press.

U.S. Census Bureau. August 2000. http://www.census.gov/cgi-bin/datamap/state?23

U.S. Department of the Interior, Fish and Wildlife Service, & U.S. Department of Commerce, Bureau of the Census. 1997. "1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation."

USEPA. 2000. "Arsenic in Drinking Water Rule Economic Analysis," Office of Drinking Water, Washington, D.C.

USEPA. 1998 (June). "Cost Evaluation of Small System Compliance Options: Point-of-Use and Point-of-Entry Treatment Units", draft, Standards and Risk Management Division, Office of Ground Water and Drinking Water, Washington, D.C.

USEPA. 2002 (January 18). "Frequently Asked Questions." Office of Water, Ground Water and Drinking Water. http://www.epa.gov/safewater/faq/faq.html#bw. 2002.

USEPA. 2000. "Technologies and Costs for Removal of Arsenic from Drinking Water," Targeting and Analysis Branch, Standards and Risk Management Division, Office of Ground Water and Drinking Water, Washington, D.C.

Van Houtven, G.L. & Cropper, M.L. 1994. "When Is a Life Too Costly To Save? The Evidence From Environmental Regulations," *Resources*. 6-11.

Whitney, S. 2002 (February).Compliance Officer, Drinking Water Program, Division of Health Engineering, Maine Bureau of Health. Personal Communication.

APPENDIX A

MAINE COST ANALYSIS ASSUMPTIONS & COST EQUATIONS

EPA guidelines for cost evaluations were used for the analysis of point of use and point of entry reverse osmosis and activated alumina systems. This study structure was also followed for bottled water and water cooler cost estimates.

The EPA study assumes 1 gallon of water is consumed per person per day. Thus a POU system would need to treat 365 gallons per year for a one person household, 730 gallons for a two person household, 1,095 gallons for a three person household, and 1,460 gallons for a four person household each year to meet the drinking and cooking needs of the household.

The EPA study assumes 100 gallons of water used per person per day. Thus a POE system would need to treat 36,500 gallons for a one person household, 73,000 gallons for a two person household, 109,500 gallons for a three person household, and 146,000 gallons for a four person household each year to meet the drinking and cooking needs of the household.

Reverse Osmosis

1. Five vendors were contacted to obtain current pricing information for POU and POE treatment systems, assuming only one tap was equipped with a POU system.
    a. Average of cost quotes provided by vendors
        i. POU four vendors provided quotes.
        ii. POE three vendors provided quotes.
2. Annualized costs for water systems are developed.
3. Capital Costs of Devices
    a. Price quotes of treatment device plus installation provided by vendor.
        i. $851 POU element including installation.
        ii. $5,000 POE element (average capacity 250 gallons per day) including installation.
        iii. $10,000 POE element (average capacity 850 gallons per day) including installation.
    b. Life expectancies based on EPA study
        i. 5 years expected life of POU.
        ii. 10 years expected life of POE.
    c. Cost of softener provided by vendors
        i. $749 POU
        ii. $1,150 POE
    d. Cost of de-ionization provided by vendors
        i. $150 POU or POE
    e. 15% contingency fee applied to initial capital and installation costs to allow for unexpected site costs.
4. Annualize Capital Cost of Devices
    a. Annualized over expected lifetimes at a 10% discount rate.
5. Maintenance Costs
    a. Assumed to be done by a trained professional.

b. Quotes provided by vendors.
    i. \$87 POU
    ii. \$312 POE

6. Sampling & Lab Analysis
    a. Assumed water tested annually by a professional at same time as maintenance.
    b. \$12.00 arsenic test
7. Total Annualized Costs

$$TA= (P*(1+C))* [R/ (1- (1 + R)^{-L})] + M + S$$

where:

TA= Total Annual Household Cost
P= Purchase Price Including Installation
C=Contingency Fee (15%)
R=Interest Rate (10%)
L=Lifespan of the system (5 years for POU or 10 years for POE)
M=Annual Maintenance Cost
S= Annual Sampling Cost

Softener and de-ionization costs were added to P, the purchase price including installation, when calculating total annual household cost with softener or de-ionization.

Activated Alumina

The EPA study assumes 1 gallon of water is consumed per person per day a POU system would need to treat 365 gallons for a one person household, 730 gallons for a two person household, 1,095 gallons for a three person household, and 1,460 gallons for a four person household each year to meet the drinking and cooking needs of the household.

The EPA study assumes 100 gallons of water used per person per day a POE system would need to treat 36,500 gallons for a one person household, 73,000 gallons for a two person household, 109,500 gallons for a three person household, and 146,000 gallons for a four person household each year to meet the drinking and cooking needs of the household.

1. Six vendors were contacted to obtain current pricing information for POU and POE treatment systems. Assumed only one tap was equipped with a POU system.
    a. Average of cost quotes provided by vendors
        i. POU three vendors provided quotes.
        ii. POE three vendors provided quotes.
2. Annualized costs for water systems are developed.
3. Capital Costs of Devices
    a. Price quotes of treatment device plus installation provided by vendor.
        i. $1,017 POU system including installation.
        ii. $3,633 POE system including installation.
    b. Life expectations provided by vendors
        i. 3 years expected life of POU.
        ii. 3 years expected life of POE.
    c. Cost of softener provided by vendors
        i. $1,450 POU
        ii. $1,400 POE
    d. 15% contingency fee applied to initial capital and installation costs to allow for unexpected site costs.
4. Annualized Capital Cost of Devices
    a. Annualized over expected lifetimes at a 10% discount rate.
5. Maintenance Costs
    a. Assumed to be done by a trained professional.
    b. Quotes provided by vendors.
        i. $48 POU
        ii. $862 POE
6. Sampling and Lab Analysis
    a. Assumed water tested annually by a professional at same time as maintenance.
    b. $12.00 for arsenic test.
7. Total Annualized Costs

Bottled Water

The EPA study assumes 1 gallon of water is consumed per person per day a household would need to purchase 365 gallons for a one person household, 730 gallons for a two person household, 1,095 gallons for a three person household, and 1,460 gallons for a four person household each year to meet their drinking and cooking needs.

1. Four grocery and retail stores were visited to obtain current pricing information for all bottled water sizes available.
   a. Average of quotes provided by vendors.
2. Annualized costs are developed.
3. Capital costs
   a. Purchase price of water
      i. $0.88/ one-gallon jugs of water.
      ii. $2.46/ two and a half gallon jugs of water.
      iii. $3.23/ gallon for packaged bottles of water.
   b. No contingency fee added.
4. Annual Capital Cost
   a. Subtotaled
5. Maintenance Costs
   a. N/A
6. Total Costs

Bottled Water

TA= (W/G)*(1+C)*CO

where:

TA= Total Annual Household Cost
W= Purchase Price Per Unit
G= Gallons Per Unit
C=Contingency Fee (15%)
CO=Gallons Consumed Per Household

Water Cooler

The EPA study assumes 1 gallon of water is consumed per person per day a household would need to purchase 365 gallons for a one person household, 730 gallons for a two person household, 1,095 gallons for a three person household, and 1,460 gallons for a four person household each year to meet their drinking and cooking needs.

1. Five delivery services and one retail store were contacted to obtain water cooler prices for available units
    a. Average of quotes provided by vendors.
2. Annualized costs are developed.
3. Capital Costs of Devices
    a. Purchase price of water
        i. $5.17 per 6-gallon jug of water.
    b. Rental price quotes for a year or purchase price of the water cooler
        i. Assuming that households recover any deposits.
        ii. $118 rental price for cold water coolers.
        iii. $158 rental price for hot & cold water coolers.
        iv. $206 to purchase price of a hot & cold water cooler.
    c. Subtotaled
    d. Life expectancies based on vendor warrantee
        i. 5 years
    e. No contingency fee
4. Annualized Capital Cost of Devices
    a. Annualized over expected lifetime at 10% discount rate for the purchased water cooler.
    b. Subtotal for rented water coolers.
5. Maintenance Costs
    a. Cost of electricity for water coolers
        i. Cold water coolers-100 watts
            1. $0.16708 per kilowatt hour[2]
        ii. Hot & Cold water coolers- 38 watts
            1. $0.16708 per kilowatt hour
6. Total Annualized Costs

[2] Electricity costs were estimated from firm reports on energy consumption and published electricity rates of Maine providers.
Maine Standard Offer Supply Rates and Providers,
http://www.state.me.us/mpuc/Electric%20Supplier/Standard%20Offer%20Rate.htm#, (August 2001)
Maine Standard Offer Rates and Supply,
http://www.bhe.com/elec_suppliers/rates_elec.html#RESIDENTIAL, (August 2001)

Rented Water Cooler

$$TA = 12(R) + ((W/G) * CO) + (8760*K*E)$$

where:

TA= Total Annual Household Cost
R= Monthly Rental Cost
W= Price Unit of Bottled Water
G= Gallons Per Unit
CO= Gallons Consumed Per Household
K= KW Used Per Hour
E= Price Per KW Hour

Purchased Water Cooler

$$TA = (P*(1+C))* [R/ (1- (1 + R)^{-L})] + ((W/G) * CO) + (8760*K*E)$$

where:

TA= Total Annual Household Cost
P= Purchase Price
C= Contingency Fee (15%)
R= Interest Rate (10%)
L=Lifespan of the unit (5 years)
W= Price Unit of Bottled Water
G= Gallons Per Unit
CO= Gallons Consumed Per Household
K= KW Used Per Hour
E= Price Per KW Hour

APPENDIX B

HOUSEHOLD COST DATA BY HOUSEHOLD SIZE & TREATMENT METHOD

Table B.1 Cost Evaluation for a One Person Household

Type of avoidance method*	Point of application/ Bottle Size	Purchase price, including installation	Rental cost	Purchased water cost	Contingency cost (15% of system cost)	Total capital cost (Purchase or Rental + Contingency)	Annualized total capital cost (10% interest rate)	Annual maintenance cost, including electricity	Annual sampling cost	Total annual O&M costs	Total annual costs (annual capital cost + annual maintenance cost + annual sampling cost)
RO	POU	$ 1,067	N/A	N/A	$ 160	$ 1,227	$ 324	$ 75	$ 12	$ 87	$ 411
RO	POU w/ softener	1,600	N/A	N/A	240	1,840	485	75	12	87	572
RO	POE $5,000 system	5,000	N/A	N/A	750	5,750	963	300	12	312	1,248
RO	$5,000 w/softener	6,550	N/A	N/A	983	7,533	1,226	300	12	312	1,538
RO	POE $10,000	11,900	N/A	N/A	1,785	13,685	2,227	300	12	312	2,539
RO	$10,000 w/softener	13,400	N/A	N/A	2,010	15,410	2,508	300	12	312	2,820
AA	POU	1,017	N/A	N/A	153	1,169	470	36	12	48	518
AA	POU w/ softener	2,467	N/A	N/A	370	2,837	1,141	36	12	48	1,189
AA	POE	3,633	N/A	N/A	545	4,178	1,680	850	12	862	2,542
AA	POE w/softener	4,033	N/A	N/A	605	4,638	1,865	850	12	862	2,727
BW	1 Gal.	0.88	N/A	$ 321	N/A	321	N/A	N/A	N/A	N/A	321
BW	2.5 Gal.	2.46	N/A	358	N/A	358	N/A	N/A	N/A	N/A	358
BW	Packaged	3.23	N/A	1,179	N/A	1,179	N/A	N/A	N/A	N/A	1,179
RWC	6 Gal. Cold	N/A	$ 118	315	N/A	433	N/A	146	N/A	146	579
RWC	6 Gal. Hot & Cold	N/A	158	315	N/A	473	N/A	202	N/A	202	675
PWC	6 Gal. Hot & Cold	206	N/A	315	N/A	521	54	202	N/A	202	571

* RO- Reverse Osmosis, AA- Activated Alumina, BW- Bottled Water, RWC- Rented Water Cooler, PWC- Purchased Water Cooler, POU- Point of Use and POE- Point of Entry

Table B.2 Cost Evaluation for a Two Person Household

Type of avoidance method*	Point of application/ Bottle Size	Purchase price, including installation	Rental cost	Purchased water cost	Contingency cost (15% of system cost)	Total capital cost (Purchase or Rental + Contingency)	Annualized total capital cost (10% interest rate)	Annual maintenance cost, including electricity	Annual sampling cost	Total annual O&M costs	Total annual costs (annual capital cost + annual maintenance cost + annual sampling cost)
RO	POU	$ 1,067	N/A	N/A	$ 160	$ 1,227	$ 324	$ 75	$ 12	$ 87	$ 411
RO	POU w/ softener	1,600	N/A	N/A	240	1,840	485	75	12	87	572
RO	POE $5,000 system	5,000	N/A	N/A	750	5,750	963	300	12	312	1,248
RO	$5,000 w/softener	6,550	N/A	N/A	983	7,533	1,226	300	12	312	1,538
RO	POE $10,000	11,900	N/A	N/A	1,785	13,685	2,227	300	12	312	2,539
RO	$10,000 w/softener	13,400	N/A	N/A	2,010	15,410	2,508	300	12	312	2,820
AA	POU	1,017	N/A	N/A	153	1,169	470	36	12	48	518
AA	POU w/ softener	2,467	N/A	N/A	370	2,837	1,141	36	12	48	1,189
AA	POE	3,633	N/A	N/A	545	4,178	1,680	850	12	862	2,542
AA	POE w/ softener	4,033	N/A	N/A	605	4,638	1,865	850	12	862	2,727
BW	1 Gal.	0.88	N/A	$ 642	N/A	642	N/A	N/A	N/A	N/A	642
BW	2.5 Gal.	2.46	N/A	715	N/A	715	N/A	N/A	N/A	N/A	715
BW	Packaged	3.23	N/A	2,358	N/A	2,358	N/A	N/A	N/A	N/A	2,358
RWC	6 Gal. Cold	N/A	$ 118	629	N/A	747	N/A	146	N/A	146	893
RWC	6 Gal. Hot & Cold	N/A	158	629	N/A	787	N/A	202	N/A	202	989
PWC	6 Gal. Hot & Cold	206	N/A	629	N/A	835	54	202	N/A	202	885

* RO- Reverse Osmosis, AA- Activated Alumina, BW- Bottled Water, RWC- Rented Water Cooler, PWC- Purchased Water Cooler, POU- Point of Use and POE- Point of Entry

Table B.3 Cost Evaluation for a Three Person Household

Type of avoidance method*	Point of application/ Bottle Size	Purchase price, including installation	Rental cost	Purchased water cost	Contingency cost (15% of system cost)	Total capital cost (Purchase or Rental + Contingency)	Annualized total capital cost (10% interest rate)	Annual maintenance cost, including electricity	Annual sampling cost	Total annual O&M costs	Total annual costs (annual capital cost + annual maintenance cost + annual sampling cost)
RO	POU	$ 1,067	N/A	N/A	$ 160	$ 1,227	$ 324	$ 75	$ 12	$ 87	$ 411
RO	POU w/ softener	1,600	N/A	N/A	240	1,840	485	75	12	87	572
RO	POE $5,000 system	5,000	N/A	N/A	750	5,750	963	300	12	312	1,248
RO	$5,000 w/softener	6,550	N/A	N/A	983	7,533	1,226	300	12	312	1,538
RO	POE $10,000	11,900	N/A	N/A	1,785	13,685	2,227	300	12	312	2,539
RO	$10,000 w/softener	13,400	N/A	N/A	2,010	15,410	2,508	300	12	312	2,820
AA	POU	1,017	N/A	N/A	153	1,169	470	36	12	48	518
AA	POU w/ softener	2,467	N/A	N/A	370	2,837	1,141	36	12	48	1,189
AA	POE	3,633	N/A	N/A	545	4,178	1,680	850	12	862	2,542
AA	POE w/ softener	4,033	N/A	N/A	605	4,638	1,865	850	12	862	2,727
BW	1 Gal.	0.88	N/A	$ 964	N/A	964	N/A	N/A	N/A	N/A	964
BW	2.5 Gal.	2.46	N/A	1,073	N/A	1,073	N/A	N/A	N/A	N/A	1,073
BW	Packaged	3.23	N/A	3,537	N/A	3,537	N/A	N/A	N/A	N/A	3,537
RWC	6 Gal. Cold	N/A	$ 118	944	N/A	1,062	N/A	146	N/A	146	1,208
RWC	6 Gal. Hot & Cold	N/A	158	944	N/A	1,102	N/A	202	N/A	202	1,304
PWC	6 Gal. Hot & Cold	206	N/A	944	N/A	1,150	54	202	N/A	202	1,202

* RO- Reverse Osmosis, AA- Activated Alumina, BW- Bottled Water, RWC- Rented Water Cooler, PWC- Purchased Water Cooler, POU- Point of Use and POE- Point of Entry

Table B.4 Cost Evaluation for a Four Person Household

Type of avoidance method*	Point of application/ Bottle Size	Purchase price, including installation	Rental cost	Purchased water cost	Contingency cost (15% of system cost)	Total capital cost (Purchase or Rental + Contingency)	Annualized total capital cost (10% interest rate)	Annual maintenance cost, including electricity	Annual sampling cost	Total annual O&M costs	Total annual costs (annual capital cost + annual maintenance cost + annual sampling cost)
RO	POU	$ 1,067	N/A	N/A	$ 160	$ 1,227	$ 324	$ 75	$ 12	$ 87	$ 411
RO	POU w/ softener	1,600	N/A	N/A	240	1,840	485	75	12	87	572
RO	POE $5,000 system	5,000	N/A	N/A	750	5,750	963	300	12	312	1,248
RO	$5,000 w/softener	6,550	N/A	N/A	983	7,533	1,226	300	12	312	1,538
RO	POE $10,000	11,900	N/A	N/A	1,785	13,685	2,227	300	12	312	2,539
RO	$10,000 w/softener	13,400	N/A	N/A	2,010	15,410	2,508	300	12	312	2,820
AA	POU	1,017	N/A	N/A	153	1,169	470	36	12	48	518
AA	POU w/ softener	2,467	N/A	N/A	370	2,837	1,141	36	12	48	1,189
AA	POE	3,633	N/A	N/A	545	4,178	1,680	850	12	862	2,542
AA	POE w/softener	4,033	N/A	N/A	605	4,638	1,865	850	12	862	2,727
BW	1 Gal.	0.88	N/A	$1,285	N/A	1,285	N/A	N/A	N/A	N/A	1,285
BW	2.5 Gal.	2.46	N/A	1,431	N/A	1,431	N/A	N/A	N/A	N/A	1,431
BW	Packaged	3.23	N/A	4,716	N/A	4,716	N/A	N/A	N/A	N/A	4,716
RWC	6 Gal. Cold	N/A	$ 118	1,258	N/A	1,376	N/A	146	N/A	146	1,555
RWC	6 Gal. Hot & Cold	N/A	158	1,258	N/A	1,416	N/A	202	N/A	202	1,618
PWC	6 Gal. Hot & Cold	206	N/A	1,258	N/A	1,464	54	202	N/A	202	1,516

* RO- Reverse Osmosis, AA- Activated Alumina, BW- Bottled Water, RWC- Rented Water Cooler, PWC- Purchased Water Cooler, POU- Point of Use and POE- Point of Entry

BIOGRAPHY OF THE AUTHOR

Jessica Sargent-Michaud was born in Waterville, Maine on April 5, 1979. She was raised in Skowhegan, Maine and graduated from Skowhegan Area High School and Bloomfield Academy in 1997. She attended the University of Maine and received a Bachelors of Science in Natural Resources in 2000. She continued her studies at the University of Maine in Ecology and Environmental Science.

After receiving her degree she will be joining Industrial Economics Inc., in Cambridge, Massachusetts as an Associate to begin her career as an environmental consultant. Jessica is a candidate for the Master of Science degree in Ecology and Environmental Science from The University of Maine in August, 2002.