CHARACTERIZATION OF LIVESTOCK MANAGEMENT PRACTICES IN THE TIVOLI BAYS WATERSHEDS

A Final Report of the 1996 Tibor T. Polgar Fellowship Program

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ABSTRACT

Nonpoint source (NPS) pollution continues to attract attention as the focal point of contaminant abatement efforts. Achieving sustained improvements in water quality will require a better depiction of the connections between land use and pollution loads than is now available. It also will depend upon the design and implementation of more effective, place-based policies and programs. This study surveyed livestock owners in the Saw Kill and Stony Creek watersheds of the Hudson River Valley in New York to learn more about their objectives and management practices and to provide data for the development and testing of a Spatially Eplicit Delivery MODel (SEDMOD) for NPS pollutants. In face-to-face interviews, farmers were also asked about environmental quality issues. Existing policies anticipate voluntary participation in cost sharing programs as the means of reducing agricultural impacts on water resources. Opinions expressed by the farmers we surveyed indicated that few of them identified environmental problems in connection with their type of farming. Their concerns focused primarily on non-farm activities (e.g., residential or commercial development) or other types of farming. There was some interest (60%) in voluntary participation in the abatement programs promoted by agricultural agencies but less interest (50%) in accepting government funding. The wide variety of site conditions, farm management objectives, and owner profiles may present substantial challenges for effective policy formulation. This is particularly important when those policies originate at federal or state levels and build upon entrenched views of the problems or possible solutions. Our study results suggest that policy makers and resource managers need to be as creative and flexible as the farmers they hope to influence.

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INTRODUCTION

During the past twenty-five years there has been a nationwide improvement in water quality. Much of this positive change can be attributed to reduction in pollutant discharges from industrial and municipal point sources. Until recently, less attention has been devoted to the more widely distributed, nonpoint sources (NPS) that now cause a larger proportion of water quality degradation. Among the nonpoint sources, agricultural activities are potentially the primary source for a variety of pollutants found in surface water and groundwater (Meyers et al. 1988). Fertilizers and pesticides used for various crops find their way off the farm in overland and subsurface flow (Hatfield and Keeney 1994). Animal waste from barnyards, feedlots, and pasture land, or when spread on cropland, often increases the concentration of pathogenic bacteria in surface waters (OTA 1995).

We see two principal aspects to pollution management in the agricultural sector. The *first* involves the development of a more accurate, site-specific depiction of the connections between farm-based activities and the generation of NPS pollution. The *second* involves the development and implementation of effective, customized abatement policies and practices. The varied nature of agricultural sites and activities makes it difficult to characterize how pollution develops from farm practices and how those practices might be modified to reduce the adverse impacts. Progress is being made, however, in developing models that predict the proportional contribution of particular sites (Fraser et al. 1996; Runge 1995).

Some models have largely focused on the micro site – with much computational detail pertaining to a small area. They often have large data requirements and are difficult to calibrate and verify on heterogeneous watersheds. Other models or analytical methods represent larger areas with less detail but have the advantage of more closely matching the spatial scale of many management activities. Ongoing efforts in the Saw Kill and Stony Creek watersheds, of Tivoli South Bay and Tivoli North Bay, respectively, build upon advances in geographic information system (GIS) technology and increasingly detailed satellite data to improve the effectiveness of modeling.

Reichheld and Barten (1992) used a GIS database developed from 1:12,000 scale black and white aerial photography, Soil Conservation Service (SCS) soil surveys, and U.S. Geological Survey (USGS) digital elevation model to identify sites that potentially contribute the most sediment to the Saw Kill. They estimated nearly sixty percent of the total annual soil erosion (20,900 tons) occurred on three sites that comprised less than one percent of the watershed area. Fraser and Barten (1995) developed a comprehensive GIS database for these watersheds in preparation for field and modeling studies. Fraser and others (1996) are developing and testing an algorithm called SEDMOD – Spatially Explicit Delivery Model. This project will use the data and information presented in this paper, the Tivoli Bays GIS database, and field measurements of bacterial concentrations and other water quality constituents. Fecal coliform bacteria concentrations are a useful marker for NPS pollution as well as a prime ecosystem and public health concern. Once validated, SEDMOD will help to accurately identify problem areas and to evaluate watershed management alternatives.

In addition to biophysical data and information, the development and selection of abatement alternatives should actively consider what is appropriate and viable with respect to the socioeconomic circumstances of the farmers (Ervin 1996). Although this seems obvious, it has sometimes been overlooked by command and control government programs.

OBJECTIVES

This study was undertaken to characterize livestock management practices in the Saw Kill and Stony Creek watersheds, located in Dutchess and Columbia Counties in New York (Figure 1). These watersheds are the principal tributaries to the Tivoli Bays, located at river mile 100 on the east shore of the Hudson River. A more detailed site description can be found in the studies cited above. Working directly with farmers provided the opportunity to identify and evaluate factors influencing their choices of management practices, rather than relying on more general sources of information (e.g., U.S. Census data) over larger areas (e.g., block groups, towns, or counties). The detailed

livestock data and management information will also contribute to interpretation of bacterial concentration data that is being used in the development and testing of SEDMOD (Fraser et al. 1996) (Figure 2).

METHODS

A questionnaire was developed for use in face-to-face interviews with farmers (Figure 3). Meetings with New York State Agricultural Extension staff and others provided information about farm planning programs and projects in the region. District staff also aided in the effort to identify the livestock owners in the Saw Kill watershed. Referrals from farmers and travel through the watershed helped to identify most of the remaining owners. Care was taken to include all of those operating in the subwatersheds being used for the SEDMOD project (Figure 2). All the farmers were contacted by telephone; all agreed to interviews that were scheduled at their convenience.

RESULTS AND DISCUSSION

Interviews were completed for twenty six farmers. This is a *census* of all of the farmers in the Saw Kill watershed and may or may not be a representative *sample* of some larger population of the Hudson River Valley.

Table 1 summarizes the livestock and real property data for each respondent. Of the more than 2000 animals on these 26 farms, there are 850 cattle – 580 dairy and 270 beef – 1,159 sheep, and 18 horses. All five of the dairy farms are full-time operations. In contrast, all ten of the beef operations are part of other operations on a given farm or are conducted on a part-time basis by someone who also works off of the farm. The two largest sheep farms (of the five in the watershed) are full-time as well. Three farms were solely for horses; two were orchards; one grew Christmas trees.

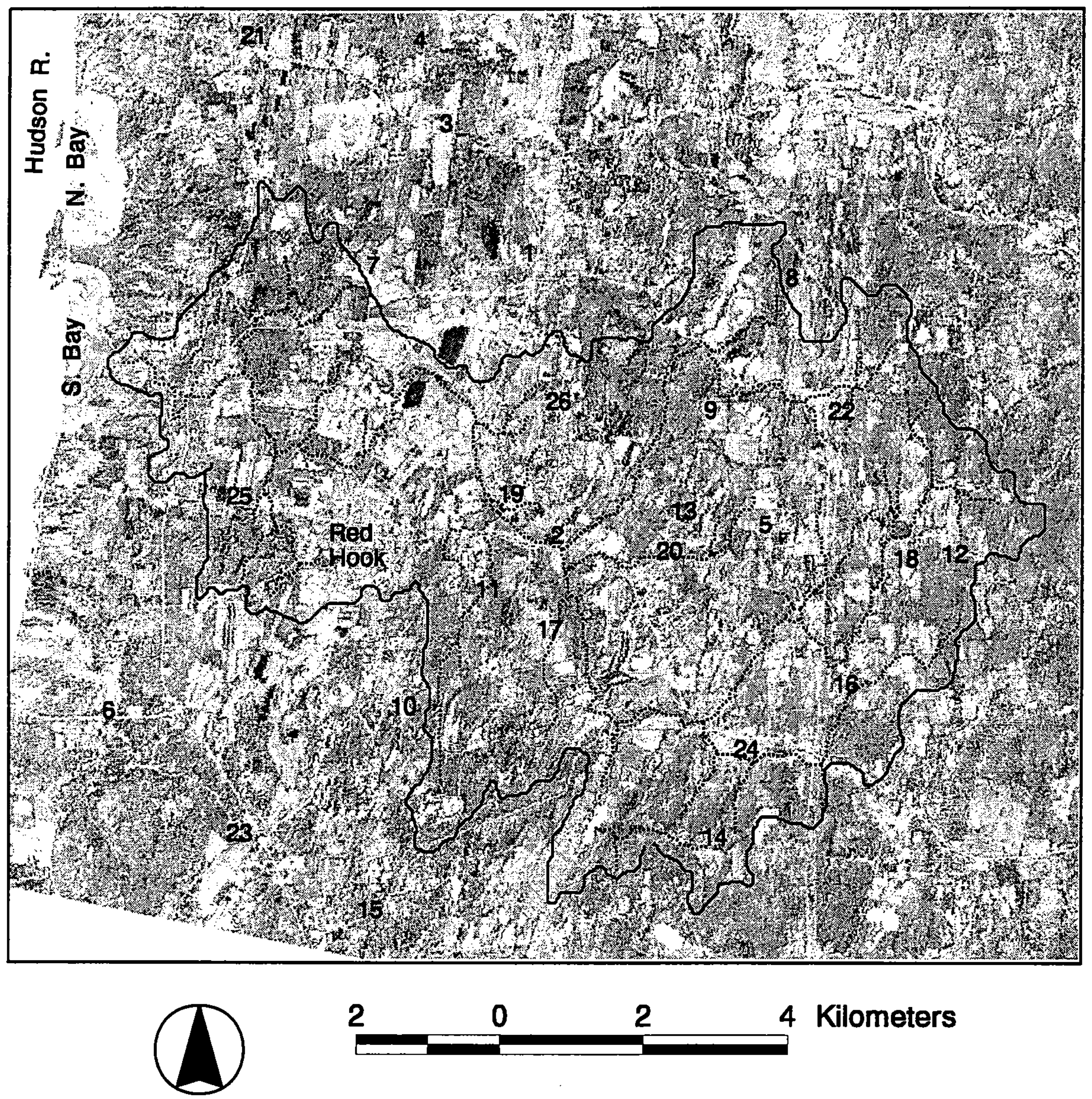

FIGURE 1. SPOT satellite image of the study area in Dutchess and Columbia Counties, NY showing the Saw Kill watershed, Tivoli Bays, Hudson River, and the location of farms (using their ID number). Produced by Robert Fraser, Yale University, Hydrology Lab.

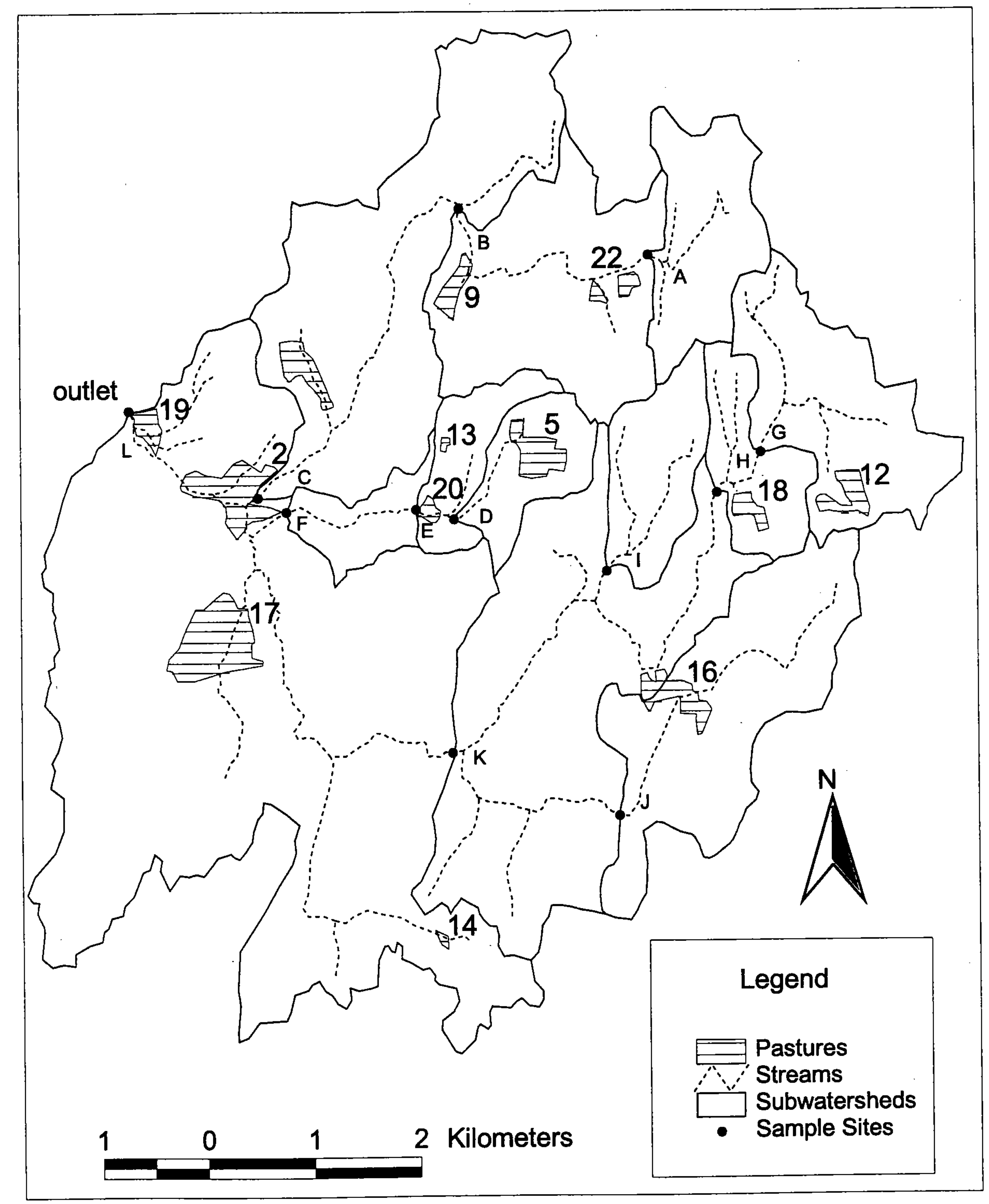

FIGURE 2. Location map of the pastures (with farm ID numbers) within the subwatersheds used for the development and testing of SEDMOD (Fraser et al. 1996). Subwatersheds A and I are controls. The flow sequences through the subwatersheds from the headwaters to the outlet are: A →B →C →L; D →E →F →L; I →K →L; G →H →K →L; and J →K →L. Produced by Robert Fraser, Yale University, Hydrology Lab.

FIGURE 3. Questionnaire for interviews with farmers.

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Tivoli Bays Watersheds Agricultural Use Survey

Questionnaire/Farm ID #_____
Farm name: ____________________
Address: ____________________
____

Data desired on management practices:

1) What is the total acreage of your farm?

2) How many acres are devoted to:
- woodland ______
- cropland ______
- hay ______
- pasture ______
- buildings and barnyards ______
- (locate areas on aerial photos)

3) Are there ponds or streams on or adjacent to the farm? (locate on aerial photos)
Within which land use are they located?

4) What kinds of animals do you have currently?

	Quantity	Next year
Cattle		
dairy	______	______
beef	______	______
Sheep	______	______
Horses	______	______
Others ________	______	______
________	______	______

How do these numbers change over time?

5) What do you feed the animals?

6) Where do you keep the animals, and how many are in each space?
Where are any calves located?

7) How does the location change during the day, month and year?

8) Do any animals have direct access to ponds or streams?
If not direct access, how close are they?

9) Do you collect the manure of any of the animals and what do you do with it?

10) What crops do you plant?

11) What tillage methods do you use?

12) What materials are applied to the field or directly to the crop?

Operator Data:

13) Age ______
14) Gender ______
15) Family Status ______
children ______

16) Farm related income and sources
Proportion of farm income to total family income

17) Education level
Agricultural education
Agricultural experience
Family farming history on this land

18) Sources of information
Extension agents
Educational programs
Publications
Other farmers

19) Have you or would you participate in conservation or farm planning?

20) Have you or would you use any government funding for conservation or farm improvements?

Characterization of environmental issues:

20) Are there issues regarding environmental or water quality that are of concern to this area?

21) How substantial are these issues?

22) What do you think would be the best response to these issues?

23) If that response was not possible, what would be the next best alternative?

TABLE 1. Livestock practices of farmers in the Tivoli Bays watersheds, Hudson River Valley, NY, including type of animals, acreage available and stocking densities

Farm ID#	Type	Herd Size	Total Acreage	Pasture Acreage	Minimum Density[1]	Maximum Density[2]
1	dairy	140	550	35	4.0	30
2	"	130	350	50	2.6	4
3	"	120	460	80	1.5	20
4	"	100	819	250	0.4	12
5	"	90	150	30	3.0	10
Mean for n=5		116	466	89	2.3	15
6	beef	50	250	40	1.2	1.2
7	"	50	240	20	2.5	2.5
8	"	43	300	76	0.6	1.6
9	"	33	61	24	1.4	3.0
10	"	30	150	20	1.5	1.5
11	"	25	270	25	1.0	2.0
12	"	25	120	30	0.8	0.8
13	"	12	300	40	0.3	0.3
14	"	3	450	10	0.3	0.3
15	"	2	100	2	2.0	2.0
Mean for n=10		27	224	29	1.2	1.5
16	sheep	600	155	150	4.0	20
17	"	414	131	91	4.5	20
18	"	65	240	50	1.3	15
19	"	60	103	12	5.0	10
20	"	20	6	5	4.0	4
Mean for n=5		232	127	62	3.8	14
21	horse	10	340	6	1.7	1.7
22	horse	5	81	20	0.25	0.25
23	horse	3	70	10	0.3	0.3
24	trees		225			
25	fruit		225			
26	fruit		130			

[1] Minimum density is calculated by dividing the total number of animals by the total pasture acreage.
[2] Maximum density is calculated from data provided by respondent that indicates the largest number of animals on the smallest pasture.

Earlier studies of bacterial transport and fate from a livestock areas have shown, as expected, the direct relation between the quantity and concentration of manure (Tiedemann et al. 1988) and the access of animals to the receiving water (Howell et al. 1995). The quantity and concentration of manure is, in turn, a function of the type and density of animals on the site. These data are presented in Table 1. On all of the farms studied, the animals had direct access to streams or ponds within some or all of their pastures. In several instances, especially the sheep farms, the animals also had access to water in stock tanks in the upper pastures.

Pasture management

The extent of forage management and movement of animals among pastures varies with the type of farm. The beef farmers are not running intensive operations and, therefore, the cattle are not crowded on their pastures. The animals are not moved frequently nor is heavy fertilization needed to increase or improve the forage. The number of animals a given farmer is finishing (feeding with grain in a confined space) for market is small, so they do not represent a large increase in density. These factors are reflected in the limited variability shown among the beef herds.

The dry cows (bred cows that have been allowed to stop producing milk prior to calving) and replacement heifers (young females that are being raised to supplement the adult herd) on the dairy farms are pastured in a manner similar to the beef cattle. The milk cows are put out to pasture between milkings (approximately 5:00 A.M. and 4:00 P.M.). This is primarily as an alternative to keeping them in the barn all the time, not to provide them with sufficient forage to be a significant part of their diet. The night pasture is usually different from the day pasture and often smaller, accounting for the highest densities among the dairy herds and among all of the surveyed sites. These sites for the milking herds are rarely, if ever, changed, so these higher densities can produce a substantial loss of vegetative cover.

Historical context for the dairy farms

All of these operations represent a midpoint between the diversified, small-scale farms common at the turn of the century and the large scale dairy operations of today. On the former, herds of twenty to fifty cows were milked by hand and the field work was done without machines. It is probable that there was as much as ten acres of land (largely pasture) per animal. Large dairy farms, like those now found in western New York, often have herds of one thousand cows with less than one acre of land per animal. Every aspect of the operation is mechanized and conducted at high levels of intensity. Managing manure, fertilizer and pesticides without contaminating surface water or groundwater is a complex challenge for these farms. The farmers in this study are not operating at this level of intensity but they are milking more cows than their fathers once did. They are also using more of their land to grow corn and hay for feed. As noted earlier, pastures have become space to keep the cows in between milkings and do not comprise a significant proportion of their feed. Hence, the amount and concentration of manure, as well as soil disturbance and overland flow, has increased compared to the more diversified farms in the early 1900s.

Sheep farms

The sheep farmers want their animals to gain a substantial portion of their feed intake from pasture forage. Hence, they manage and fertilize their pastures more aggressively. Sheep farmers divide their flocks into ewes for wool and lamb production, rams for wool and breeding service, replacement lambs (the same as replacement heifers), and market lambs. Sheep can chew down the pasture grass to a point that severely limits its capacity to grow back, so the flocks are rotated frequently to maintain maximum forage quality. The average minimum density is higher than for dairy herds, but these are smaller animals so the manure concentration may not be greatly increased. Even though the densities are high, the pastures are actively managed to protect forage quality. This helps to limit soil compaction, overland flow, and soil erosion from these sites.

Manure, crops, and agrichemicals

In almost all cases, the animals (cattle, sheep, and horses) were confined in barns at times. The manure accumulated in the barns is removed periodically and, in all but one case, spread somewhere on the farm. This might occur on cropland where the manure will be mixed into the soil before planting or, more often, on hay or pasture land where it is simply spread over the surface. None of the farms generated quantities of manure in the barns that were large enough to justify liquid manure handling or disposal.

Responses to questions about land uses other than pastures and about other materials applied to the land are summarized in Table 2. Much of the hay raised was for use by the animals on the farm; the surplus hay was sold. All the dairy and some of the beef farmers were raising corn for their own livestock. Some raised field corn or sweet corn to sell. All the farmers growing sweet corn or other fruit and produce for human consumption used pesticides, as did the one Christmas tree grower. None of the sheep farmers and only half of the beef farmers used herbicides and fertilizers.

Characteristics of the farmers

This group of Hudson Valley farmers includes a wide variety of people (Table 3). Several have taken up full-time or part-time farming after training and working in other professions. Three were former I.B.M. employees. Some of those coming from other professions, and many of the other respondents have had prior farming experience. The dairy farms were all family farms, with all but one having the prospects of continuing interest by the next generation. For the other operations, even when practiced on family farms, there was little carry over from the operations of a prior generation. More than half felt they were making a profit though few relied solely on the farm for their families' financial support. Table 4 summarizes some of the key demographic data.

Farm programs and environmental quality issues

Since many pollution abatement programs, including cost sharing, are implemented by state or federal farm related agencies, we asked the farmers about past involvement. Of those who had not had contact, sometimes it was because they felt they were too small to make it worthwhile. Sometimes the lack of formal contact was a conscious decision to avoid involvement. This latter attitude was even more adamantly stated in regard to accepting money from agencies. Some farmers did not want to expose themselves to the restrictions and obligations that they anticipated would come with the money.

TABLE 2. Cropping practices used by farmers in the Tivoli Bays watersheds, Hudson River Valley, NY, including crops grown and materials applied.

Farm ID#	Farm Type	Crops Grown			Material Applied			
		Hay	Corn	Other	Manure	Fertilizer	Herbicides	Pesticides[1]
1	dairy	*	*	fruit	*	*	*	*
2	"	*	*		*	*	*	
3	"	*	*		*	*	*	
4	"	*	*	produce	*	*	*	
5	"	*	*		*	*	*	
6	beef	*	*	produce	*	*	*	*
7	"	*	*		*	*	*	
8	"	*			*			
9	"	*			*			
10	"	*	*		*	*	*	
11	"	*	*	wheat	*	*	*	*
12	"	*			*			
13	"	*			*			
14	"	*				*		
15	"	*			*			
16	sheep				*			
17	"	*			*			
18	"	*			*			
19	"	*			*			
20	"				*			
21	horse	*			*	*		
22	horse	*			*			
23	horse	*		produce		*	*	*
24	trees			trees		*	*	*
25	fruit		*	fruit		*	*	*
26	fruit		*	fruit		*	*	*
Total	26	21	10	8	21	15	13	7

[1] Pesticides may be insecticides and fungicides.

TABLE 3: The educational and experiential background of farmers in the Tivoli Bays watersheds, Hudson River Valley, including profitability, portion of family income and involvement with agricultural agencies.

Farm ID#	Farm Type	Age M/F	Educ. Level	Ag Ed[1]	Farm Exp.[2]	Family Farm[3]	Farm Agency[4]	Agency $[5]	Profit Made[6]	%Family Income[7]
1	dairy	45M	B.S.	Y	Y	Y	Y	Y	Y	100
2	"	78M	B.S.	Y	Y	Y	Y	Y	Y	100
3	"	65M	H.S.	N	Y	Y	N	N	Y	100
4	"	39M	H.S.	N	Y	Y	N	N	Y	100
5	"	74M	H.S.	N	Y	Y	N	N	Y	100
6	beef	40M	B.S.	N	Y	Y	N	N	Y	100
7	"	79M	H.S.	N	Y	N	N	N	N	0
8	"	76M	H.S.	N	Y	Y	N	N	N	0
9	"	47M	B.S.	N	N	N	N	N	N	0
10	"	35M	H.S.	N	Y	Y	Y	Y	Y	50
11	"	67M	B.S.	N	Y	N	Y	Y	Y	50
12	"	55M	H.S.	N	Y	Y	N	N	N	0
13	"	39M	B.S.	Y	Y	N	Y	Y	N	0
14	"	35M	B.A.	N	N	Y	Y	Y	Y	5
15	"	39M	H.S.	Y	Y	N	Y	Y	N	0
16	sheep	52F 56M	B.A. B.A.	N	N	N	Y	Y	Y	75
17	"	56F	M.D.	N	N	N	N	N	Y	25
18	"	40F	MBA	N	N	N	Y	N	N	0
19	"	55F	B.A.	N	Y	Y	Y	Y	N	0
20	"	45F	B.A.	N	N	N	N	N	N	0
21	horse	55M	B.S.	N	N	N	Y	Y	Y	75
22	horse	56M	B.S.	N	Y	N	Y	N	N	0
23	horse	37M 35F	B.S. B.A.	N	N	N	Y	Y	Y	10
24	trees	47M	B.S.	Y	Y	Y	Y	Y	Y	50
25	fruit	67M	H.S.	N	Y	N	Y	N	Y	75
26	fruit	55M	B.S.	N	N	N	Y	Y	Y	75

[1] Formal agricultural education.
[2] Farm experience before working on this farm.
[3] Presently working the farm the respondent was raised.
[4] Has or would work with various farm agencies.
[5] Has or would accept cost share money from farm agencies.
[6] The respondent indicates the farm is making a profit or not.
[7] Farm income relative to total family income.

TABLE 4. A summary of demographic data for 26 farms in the Tivoli Bays (Saw Kill and Stony Creek) watersheds, Hudson River Valley, NY (number of observations and percentage of sample).

Range of ages	35 to 79
Agricultural education	5 (20%)
Agricultural experience	18 (70%)
Working the family farm	13 (50%)
Declaring a profit	16 (60%)
Total family income from the farm	5 (20%)
Use agency services for planning	16 (60%)
Accept agency subsidies	13 (50%)

The final part of the interview explored the respondents' concerns about environmental quality issues and what actions were needed or preferred. Their responses have been compiled in Table 5. An interesting element in these responses is the extent to which the focus regarding environmental quality was directed *off* the farm. Only six saw any issues of concern that were connected to *their* type of farming. Only two of these six farmers thought direct regulation might be needed to address the issue they identified. Almost all of the farmers felt there were no issues of major significance or issues that represented a threat to the viability of farming in their area. Among those who supported some type of regulatory response, most of that was directed toward threats to environmental quality not originating on farms (e.g., residential or commercial development). This type of regulation was often in the form of zoning restrictions that would prevent contamination of water from inappropriate development. Support for farm regulation was largely limited to support for existing pesticide statues. There were few farm related issues beyond pesticide management. Little support was offered for any type of regulatory response beyond what already exists.

Improved data and information for related studies

Direct interviews with farmers in the Saw Kill watershed have provided details that will contribute to the development and testing of SEDMOD. Information about the actual numbers of animals in the subwatersheds being sampled for bacteria concentrations was found to vary substantially from estimates of animal numbers attempted from the road side. In one instance, a site thought to be devoid of domestic animals was, in fact, occasionally used for beef cattle. In another case, because the herd was divided between two pastures (one out of sight of the road) the number of sheep was consistently underestimated by fifty percent (≅ 300 animals).

Policy and management implications

If ambient water quality is the cumulative result of numerous land use decisions, these interviews offer the opportunity to understand the people whose independent decisions affect significant portions of the watershed. It is evident from Tables 1 through 5 that <u>*variability*</u> is one of the predominant characteristics of these farmers. Even with high variability in their background and current practices, most of these farmers feel that environmental quality issues are not major threats in this region and do not warrant more aggressive intervention. There were indications that attitudes about some potential problems, such as those associated with pesticide use, have evolved over time (through negative experiences) to raise the overall level of concern. Still, most of the concerns expressed focused on non-farm activities or a type of farming different from that practiced by the respondent. Their ideas about appropriate abatement approaches also differed to some extent, with remarkably similar people holding some of the more disparate views. Two younger dairy farmers, working their families' farms (ID#'s 1 and 4), had substantially different views about what problems might exist – especially in regard to working with farm agencies to solve problems. The farmer (#1) with a B.S. in agriculture from Cornell expressed concern about NPS pollution; The farmer (#4) with a high school education did not. There appear to be substantial challenges for policy makers in understanding and responding to these differences in order to increase participation in abatement efforts. Whether this inherent variability has significant consequences for improving water quality in this area depends upon the extent to which:

TABLE 5: Attitudes of farmers in the Tivoli Bays watersheds, Hudson River Valley, NY, concerning environmental quality concerns, including attitudes on severity of risk, threat to farming, and preferred response.

Farm ID#	Farm Type	Environmental Quality Concerns[1]				Significance[2]			Threat to Farmers[2]			Response[3]		
none		none	non-farm	other farms	this farm	none	min	maj	none	min	maj	none	vol	reg
1	dairy				*		*		*					*
2	”		*		*	*				*				*
3	”		*				*			*				*
4	”		*		*		*				*		*	
5	”		*				*		*			*		
6	beef		*				*		*			*		
7	”	*				*			*			*		
8	”			*				*			*			*
9	”		*			*				*		*		
10	”		*	*			*			*			*	*
11	”			*				*		*				*
12	”			*			*		*			*		
13	”		*	*			*			*			*	
14	”			*			*			*				*
15	”	*				*			*			*		
Table continues on next page														
Table continued from previous page														
16	sheep	*				*			*			*		
17	”			*	*	*			*				*	
18	”			*				*			*			*
19	”		*				*		*					*
20	”		*			*			*			*		
21	horse	*				*			*			*		
22	horse		*	*			*		*				*	
23	horse				*		*		*				*	
24	trees		*				*		*					*
25	fruit			*			*		*					*
26	fruit				*		*						*	*
Total	26	4	12	10	6	8	15	3	13	8	3	9	8	11

[1] Concerns ranged from none to non-farm ones to ones focused on other farms and finally, to those focused on the type of farming practiced by the respondent.
[2] Responses were grouped into categories of: none, minor, or major.
[3] Responses were grouped into categories of: none required, voluntary actions sufficient, and regulations required.

(1) the farm practices involved are, in fact, detrimental, (2) voluntary participation by the farmers is critical to the success of abatement efforts, and (3) participation will be affected by the attitudes expressed in this survey.

Most current policies addressing agricultural NPS pollution simply assume the farmers have a shared perception of the problems (with resource managers, scientists, and the public) and a willingness to voluntarily participate in abatement programs. This is *not* apparent among the farmers interviewed in these watersheds (Table 5). As an example, a handbook recently prepared by the New York State Department of Environmental Conservation (1996) as a guide to developing watershed management plans for controlling NPS pollution, anticipates that local committees, working with generic tables, so-called models, and BMPs, can "target" critical source areas of pollution and identify the appropriate alternatives for land owners to adopt. Even with a reasonable level of public participation in this process, as recommended by the handbook, many of the farmers interviewed in this study would not appear to be receptive to being informed, during or after the evaluation process, about changes they should undertake to comply with some new standard.

SUMMARY

While offering some useful insights to livestock practices in the Saw Kill and Stony Creek watersheds and to the farmers involved, this study also generates several significant questions and topics for further study. They include, but are not limited to, the following.

1. How can data on livestock use enhance the ability of models (e.g., SEDMOD) to predict source areas and proportional contributions to NPS pollution?
2. Can a spatially explicit model accurately depict connections between farm practices and specific water quality constituents?
3. Do the attitudes of farmers observed in these watersheds affect the potential success of abatement efforts?

4. What are effective means for involving farmers in all phases (design, development, implementation, monitoring, adaptation) of abatement efforts?
5. Are the Tivoli Bays watersheds unique in important ways or do they represent a broader area?

Answers to these and other questions hold the key to crafting an effective approach to NPS pollution abatement in the Hudson River Valley and beyond. The variation in site conditions, farm management objectives, and landowner profiles combine to create substantial challenges to creating effective policies, especially when those policies originate at federal or state levels and build upon entrenched views of the problems or possible solutions. Policy makers and resource managers need to be as diverse, creative, and flexible as the farmers they hope to influence. This could include a variety of approaches such as:

- Property tax credits as an alternative or in addition to cost sharing.
- Providing fencing and planting stock for stream restoration.
- Publishing a quarterly newsletter or fact sheets tailored to local conditions.
- Arranging study tours of stewardship farms.
- Providing scholarships to meetings such as "Animal Agriculture and the Environment" being held in Rochester, NY, in December of 1996.

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