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Understanding Watershed Behavior

In short, twenty centuries of progress have brought the average citizen a vote, a national anthem, a Ford, a bank account, and a high opinion of himself, but not the capacity to live in high density without befouling and denuding his environment...Nor a conviction that such capacity, rather than such density, is the true test of whether he is civilized. **Aldo Leopold (1933), *Game Management***

Since Leopold wrote these words in 1933, over 50 million new households have formed in America. By conservative estimates, we have added 45 million yards, 125 million cars and trucks, 15 million septic systems, and 25 million dogs during the last half century. In his time, Aldo Leopold imagined that the foremost practitioner of the land ethic would be the farmer, the game warden or perhaps the woodlot owner. He simply could not have envisioned that the most important practitioner would ultimately become the suburban and rural landowner, who individually lords over a few hundred square feet, but cumulatively dominates the watershed.

It is a maxim of watershed science that each of us is personally responsible for contributing some of the pollutants that run off our lawns, streets and parking lots. Runoff pollution is the major cause of water quality problems in most urban watersheds. While runoff pollution is not usually sudden or dramatic, it leads to the gradual degradation of urban waters — degraded streams, eutrophic lakes, closed beaches and shellfish beds, and polluted drinking water supplies.

It is a curious tendency of our species, however, that when we study urban watersheds, we rarely study ourselves, despite the fact that these watersheds are our primary habitat. We seldom take the trouble to measure the cumulative impact of our individual behaviors on the watershed. In this article, we summarize our sketchy understanding of human behaviors in suburban and rural watersheds, based on an analysis of over twenty recent surveys of watershed residents. These surveys asked residents about their basic behaviors in six broad areas: lawn fertilization, pesticide application, dog walking, septic cleaning, car washing, and fluid changing. Prior research indicates that each of these behaviors are common in most watersheds and can have a strong impact on water quality.

Our early experience in trying to restore urban watersheds suggests that we can never meet our water quality goals for streams, lakes and estuaries until we can convince urban, suburban and rural landowners to change their behaviors and practice a better watershed ethic. Such a watershed ethic is critical if we are to protect or improve the quality of our urban watersheds. The article concludes by outlining some of the possible elements of a watershed ethic that might guide the actions of suburban and rural landowners.

The six watershed behaviors profiled in this article are not the only ones that can have a strong influence on watershed quality, but they are the ones we happen to know the most about. Other individual behaviors that can influence water quality are listed in Table 1.

The frequency of any individual behavior can differ from watershed to watershed, based on population density and the level of income, education, and awareness of its residents. What is particularly troubling, however, is that many of the most potentially polluting behaviors are practiced by affluent, well-educated and environmentally aware members of our society. These behaviors are rooted in our collective desire for a clean, well-manicured and tidy suburban environment – a nice green lawn, a shiny car, a pest-free yard or a clean driveway. Indeed, many watershed behaviors have become worse in recent years, driven by the rapid growth in the tools and products to improve and beautify the suburban landscape.

Table 1: Other Key Individual and Household Behaviors that Potentially Influence Watersheds

Leaf Disposal/Composting
Disposal of Household Hazard Wastes
Hosing and Power-washing
Landscaping Practices
Car Emissions Testing
De-icing
Watering/Irrigation
Sidewalk/Driveway Sweeping
Maintenance of Common Stormwater Facilities and Conservation Areas

Lawn Fertilization

It has been estimated that there are 25 to 30 million acres of turf and lawn in the United States (Robert and

Roberts, 1989, Lawn and Landscape Institute, 1999). To put this statistic in perspective, consider that if lawns were classified as a crop, they would rank as the fifth largest in the country on the basis of area, after corn, soybeans, wheat, and hay (USDA, 1992). In terms of fertilizer inputs, nutrients are applied to lawns at about the same application rates as those used for row crops (Barth, 1995a).

Research has indicated that nutrient runoff from lawns has the potential to cause eutrophication in streams, lakes, and estuaries (see Schueler, 1995b). Nutrient loads generated by suburban lawns can be significant, since recent research has shown that lawns produce more surface runoff than previously thought (see article 36).

Lawn fertilization is among the most widespread watershed behaviors we engage in. In our survey of resident attitudes in the Chesapeake Bay, 89% of citizens owned a yard, and of these, about 50% applied fertilizer every year (Swann, 1999). The average rate of fertilization in 10 other resident surveys was even higher, at 78%, although this could reflect the fact that these surveys were biased towards predominantly suburban neighborhoods, or excluded non-lawn owners (Table 2).

Several studies have measured the frequency with which we fertilize our yards. In the Chesapeake Bay survey, fertilizers were applied almost twice a year (1.7) with spring and fall being the most popular seasons for fertilization. In five other surveys, fertilizers were applied an average of 2.3 times year, and most frequently in the spring. It should be noted that the spring is not considered an optimal season to apply fertilizers from an agronomic standpoint.

A significant fraction of homeowners can be classified as "over-fertilizers" who apply fertilizers to their lawns two or more times a year. In the Chesapeake Bay survey, over-fertilizers comprised 52% of all those that applied fertilizers to their yard. Other studies have put the number of over-fertilizers at 65% to 70% of all

Table 2: Lawn Care Practices - A Comparison of 11 Homeowner Surveys

Study	Respondents	% Fertilizing	% Soil Testing	Other Notes
Chesapeake Bay *Swann, 1999*	656	50%	16%	1.73 times/year
Maryland *Smith, 1996*	100	88%	15%	58% grasscycle
Maryland *Kroll and Murphy, 1994*	403	87% *	na	
Virginia, *Aveni, 1998*	100	79%	> 20%	
Maryland, *HGIC, 1996*	164	73%	na	2.1 times/year
Michigan, *De Young, 1997*	432	75%	9%	1.9 times/year 69% grasscycle
Minnesota *Morris and Traxler, 1996*	981	75%	12%	2.1 times/year 40% grasscycle
Minnesota, *Dindorf, 1992*	136	85%	18%	78% grasscycle
Wisconsin, *Kroupa, 1995*	204	54%	na	2.4 times/year
Washington, *Hardwick,1997*	406	67%	na	
Florida, *Knox* et al.*, 1995*	659	82%	na	3.2 times/year 59% grass cycle

** Fertilization rates were significantly lower in small urban lots (less than 2500 square feet); survey results from these smaller lots were excluded from this table.*
na = not asked

fertilizers (Morris and Traxler, 1996; Knox *et al.*, 1995). Clearly, many homeowners, in a quest for quick results or a bright green lawn, are applying more nutrients to their lawns than they actually need.

From a demographic standpoint, the primary fertilizer is a middle-aged man in the 45-54 age group (BHI, 1997). These individuals place a very high value on lawns. For example, when residents were asked their opinions on over 30 statements about lawns in a Michigan survey, the most favorable overall response was to the statement "a green attractive lawn is an important asset in a neighborhood" (De Young, 1997). Nationally, homeowners spend about 27 billion dollars each year to maintain their own yard or pay someone else to do it (PLCAA, 1999). In terms of labor, a majority of homeowners spend more than an hour a week taking care of the lawn (Aveni, 1994; De Young, 1997).

Unlike farmers, suburban and rural landowners are often ignorant of the actual nutrient needs of their lawns. According to surveys, only 10 to 20% of lawn owners take the trouble to perform soil tests to determine whether fertilization is even needed (Table 2). The majority of lawn owners are not aware of the phosphorus or nitrogen content of the fertilizer they apply (Morris and Traxler, 1996) or that leaving grass clippings on the lawn can reduce or eliminate the need to fertilize.

Our ignorance about lawn nutrients is not surprising given where we get our information on lawn care. Study after study indicates that product labels, store attendants and lawn care companies are the primary and almost exclusive source of lawn care information for the average consumer. Consumers also rely on direct mail and word of mouth as the primary factor when choosing a lawn care company (Swann, 1999; AMR, 1997).

Not many residents understand that lawn fertilizer can cause water quality problems – overall less than one fourth of residents rated it as a water quality concern (Syferd, 1995 and Assing, 1994), although ratings were as high as 60% for residents living adjacent to lakes (Morris and Traxler, 1996, MCSR, 1997). Interestingly, in one Minnesota survey, only 21% of homeowners felt their own lawn contributed to water quality problems, while over twice as many felt their neighbor's lawn did (MCSR, 1997).

In recent years, many communities have attempted to educate residents about lawn care and nutrients. The education message they send, however, is often ambiguous and complex, and typically is geared more to better turf management than better water quality. This is evident in outreach materials that consistently promote a message to use less fertilizer, fertilize in the right season, test soils, use slow-release fertilizer or grasscycle and keep clippings on lawn. This educational approach sometimes requires residents to understand a lot more about nutrient management than they can read off a label.

Conspicuously absent is a much stronger message that promotes a low or zero input lawn. It seems appropriate that watershed education programs strongly advocate no chemical fertilization, reduced turf area and the use of native plants adapted to the ecoregion (Barth, 1995), if only to balance the pro-fertilization message that is so effectively marketed by the lawn care industry.

Pesticide Application

When Rachel Carson first wrote *Silent Spring*, many Americans were alerted to the dangers of pesticides in the urban environment. Yet, pesticides are still frequently found in the waters of many urban streams, in settings as diverse as Georgia, Texas, California, Maryland, and Wisconsin. The pesticides of greatest concern are insecticides, such as diazinon and chloropyrifos, and a group of herbicides (CWP, 1999 and Schueler, 1995a). Even very low levels of these pesticides can be harmful to aquatic life. The major source of pesticides in urban streams are home applications to kill insects and weeds in the lawn and garden. Table 3 compares surveys on residential pesticide use in 11 different regions of the country in terms of insecticides and herbicides. At first glance, it appears that pesticide application rates vary greatly, ranging from a low of 17% to a high of 87%.

Some patterns do emerge, however. For example, insecticides tend to be applied more widely in warm weather climates where insect control is a year-round problem (such as Texas, California, and Florida). Anywhere from 50 to 90% of residents reported that they had applied insecticides in the last year in warm-weather areas. This can be compared to 20 to 50% levels of insecticide use reported in colder regions where hard winters can help keep insects in check.

In contrast, herbicide application rates tend to be higher in cold weather climates to kill the weeds that arrive with the onset of spring (60 to 75% in the Michigan, Wisconsin and Minnesota surveys). Resident surveys also indicate that many residents lack awareness that their lawn care program actually uses herbicides. This confusion stems from the recent growth of "weed and feed" lawn care products that combine weed control and fertilization in a single bag. In one Minnesota study, 63% of residents reported that they used weed and feed lawn products, but only 24% understood that they were applying herbicides to their lawn (Morris and Traxler, 1996). In addition, many residents are unaware of the pesticide application practices that their lawn care company applies to their yard, preferring to leave it up to the professionals (Knox *et al.*, 1995).

The widespread use of pesticides on urban lawns and gardens is somewhat curious since surveys tell us that the public has a reasonably good understanding of the potential environmental dangers of pesticides. Several surveys indicate that residents do understand envi-

Table 3: A Comparison of 11 Surveys of Residential Insecticide and Weedkiller Use

Study	N	Region	Use Insecticides	Use Herbicides	Notes
Chesapeake Bay *Swann, 1999*	656	#	21%	- -	70% use private sector info
Maryland *Kroll and Murphy,1994*	403	#	42%	32%	
Virginia *Aveni, 1998*	100	#	66%	- -	
Maryland, *Smith, 1994*	100	#	23%	n/a	55% use product labels
Minnesota, *Morris and Traxler, 1997*	981	C	- -	75%	1.3 times/year
Michigan, *De Young, 1997*	432	C	40%	59%	
Minnesota, *Dindorf, 1992*	136	C	- -	76%	
Wisconsin, *Kroupa, 1995*	204	C	17%	24% **	63% use a weed and feed product
Florida, *Knox et al, 1995*	659	W	83%	- -	
Texas, *NSR, 1998*	350	W	87%	- -	
California, *Scanlin and Cooper, 1997*	600	W	50%	- -	

(#) Mid-Atlantic surveys, (C) Cold-weather surveys (W) Warm-weather surveys
*(**) Note difference in self reported herbicide use and those that use a weed and feed product.*

ronmental concerns about pesticides and consistently rank them as the leading cause of pollution in the neighborhood (Elgin DDB, 1996).

The education message sent about pesticides is often very complex. Outreach materials often promote a message to use less pesticides, apply them properly or practice integrated pest management. This approach requires residents to understand a lot more about pesticides than they are likely to read off a product label. As was the case with fertilizer, product labels are the primary and often dominant source of information about pesticides. Nearly 90% of homeowners rely on commercial sources of information to guide their pesticide use (Swann, 1999). From a watershed standpoint, it may be wise to articulate a simple but strong message that pesticides should be applied only as a last resort, or not at all.

Dog Walking

One biological index that never declines after a watershed develops is the dog population. In our survey of Chesapeake Bay residents, we found about 40% of households own a dog. A dog owner, however, is not always a dog walker. Just about half of all dog owners actually walk their dog. Of the half that do walk their dog, about 60% claim to pick up after their dog (Swann, 1999), which is generally consistent with other studies (Table 4). Men are also prone to pick up after their dog less often than women (Swann, 1999). The virtuous dog walkers that clean up after their dogs usually dispose of the fecal matter in the trash can, toilet, compost pile or down a storm drain inlet (Hardwick, 1997; HGIC, 1998).

Failure to clean up after a dog can cause both water quality and public health problems, and many commu-

Table 4: A Comparison of Three Resident Surveys About Cleaning Up After Dogs

Maryland *HGIC, 1996*	62% always cleaned up after the dog; sometimes 23%; never 15%. Disposal method: trash can (66%); toilet (12%); other 22%
Washington Hardw*ick, 1997*	Pet ownership 58% 51% of dog owners do not walk dogs 69% claimed that they cleaned up after the dog 31% do not pick up Disposal methods: trash can 54%; toilet 20%; compost pile 4% 4% train pet to poop in own yard 85% agreed that pet wastes contribute to water quality problems
Chesapeake Bay *Swann, 1999*	Dog ownership 41% 44% of dog owners do not walk dogs Dog walkers who clean up most/all of the time 59% Dog walkers who never or rarely clean up 41% Of these, 44% would not clean up even with fine, complaints, collection or disposal methods 63% agreed that pet wastes contribute to water quality problems

nities have responded by adopting "pooper scooper" laws. Dogs have been found to be a major source of fecal coliform and pathogens in many urban watersheds (Schueler, 1999), which is not surprising given their population, daily defecation rate, and bacteria/pathogen production.

Residents seem to be of two minds when it comes to dog waste. While a strong majority agree that dog waste can be a water quality problem (Hardwick, 1997; Swann, 1999), they generally rank it as the least important local water quality problem (Syferd, 1995 and MSRC, 1997). This finding strongly suggests the need to dramatically improve watershed education efforts to increase public recognition about the water quality and health consequences of dog waste.

It is worth noting that many residents are very reluctant to change the way they handle dog waste. According to the Chesapeake Bay survey, 44% of dog walkers who do not pick up indicated they would still refuse to pick up even if confronted by complaints from neighbors or fines, or provided with more sanitary and convenient options for retrieving and disposing of dog waste. Table 5 lists factors that compel residents to pick up after their dog, along with some interesting rationalizations for not doing so.

This strong resistance to handling dog waste suggests that an alternative message may be necessary: to practice rudimentary manure management by training dogs to use areas that are not hydraulically connected to the stream or close to a buffer.

Car Washing

Outdoor car washing has the potential to result in high loads of nutrients, metals and hydrocarbons during dry weather conditions in many watersheds, when the detergent-rich water used to wash the grime off our cars flows down the street and into the storm drain. Not much is known about the water quality of car wash water, but it is very clear that car washing is a common watershed behavior. Three recent surveys have asked residents where and how frequently they wash their cars (Table 6).

According to the surveys, roughly 55 to 70% of households wash their own cars, with the remainder using a commercial car wash. A full 60% of residents could be classified as "chronic car-washers," i.e., they wash their car at least once a month (Smith, 1996 and Hardwick, 1997). Between 70 and 90% of residents reported that their car wash-water drained directly to the street, and presumably, to the nearest stream.

Residents are typically not aware of the water quality consequences of car washing, and do not understand the chemical content of the soaps and detergents they use. Car washing is also a very difficult watershed behavior to change, since it is hard to define a better alternative without asking people to pay to use

Table 5: Dog Owners Rationale for Picking Up or Not Picking Up After Their Dog (HGIC, 1996)

Reasons for not picking it up:	**Reasons for picking up:**
Because it eventually goes away	It s the law
Just because	Environmental reasons
Too much work	Hygiene/health reasons
On edge of my property	Neighborhood courtesy
It s in my yard	It should be done
It s in the woods	Keep the yard clean
Not prepared	
No reason	
Small dog, small waste	
Use as fertilizer	
Sanitary reasons	
Own a cat or other kind of pet	

Table 6: A Comparison of Three Surveys About Car Washing

Study	Car Washing Behavior
Maryland *Smith, 1996*	60% washed car more than once a month
California *Pellegrin, 1998*	73% washed their own cars 73% report that wash-water drains to pavement
Washington *Hardwick, 1997*	56% washed their own cars 44% used commercial car wash 91% report that wash-water drains to pavement 56% washed car more than once a month 50% would shift if given discounts or free commercial car washes

a commercial car wash that treats its wash water. Some potential alternative messages that might work are to wash cars less frequently, wash them on grassy areas, and to buy phosphorus-free detergents and non-toxic cleaners.

Fluid Changing

Dumping automotive fluids down storm drains can be a major water quality problem, since only a few quarts of oil or a few gallons of anti-freeze can have a major impact on small streams and wetlands during low flow conditions. Historically, the major culprit has been the backyard mechanic who changes his or her own automotive fluids. The number of backyard mechanics who change the oil and antifreeze in their cars, however, has been dropping steadily in recent decades. With the advent of the $20 oil change special, only about 30% of car owners change their own oil or anti-freeze anymore (Table 7).

Backyard mechanics have traditionally been the target of community oil recycling and storm drain stenciling programs. These programs appear to have been quite effective, since over 80% of backyard mechanics claim to dispose or recycle these fluids properly. Most backyard mechanics are more prone to recycle oil than antifreeze, and of those that have improperly disposed of either fluid, most used the trash can rather than the storm drain. It is important to keep in mind that any self-reported information on dumping or disposal methods needs to be taken with a grain of salt, given that people often feel the need to give the socially accepted or expected survey response. Nevertheless, it does seem clear that the previous watershed education efforts have made oil and antifreeze dumping socially unacceptable. By our estimates, only one to five percent of the general population now engages in such behavior.

Septic System Maintenance

About one in four American households relies on septic systems to dispose of their wastewater. Depending on soil conditions and other factors, septic systems have a failure rate ranging from five to 35%, with failure discharging untreated or partially treated wastewater into groundwater (Schueler, 1999). Even properly operating septic systems produce elevated nutrient levels in shallow groundwater, which can degrade coastal and lake water quality (Ohrel, 1995).

Until recently, homeowner awareness about septic system maintenance was poorly understood. The Chesapeake Bay survey was one of the first to examine how frequently residents maintain their septic systems. An interesting finding from the survey was the advanced age of the average septic system in the ground: about 27 years, or about seven years beyond the design life of an unmaintained system. Roughly half of the owners were classified as "septic slackers," as they indicated that they had not inspected or cleaned out their system in last three years (which is the minimum recommended frequency).

Septic systems are a classic case of "out of sight, out of mind." A small but significant fraction (12%) of septic system owners had no idea where their septic system was located on their property. In addition, only 42% of septic system owners had ever requested advice on how to maintain their septic system, and these owners relied primarily on the private sector for this advice (e.g., pumping service, contractors, and plumbers). Like many other watershed behaviors, there was a sharp difference between resident attitudes and their actual practice. For example, while 70% of septic system owners agreed with the statement that "inspection and routine clean out of septic systems is necessary to protect water quality in the Chesapeake Bay," more than half had not done so in the last three years (Swann, 1999).

A key element of the watershed ethic involves taking personal responsibility for the quality of home wastewater through regular inspections and pumpouts. The watershed ethic also includes the responsibility for rehabilitating and upgrading septic systems as they grow older. This can entail a costly investment every few decades or so, but is critical since many existing septic systems are approaching the end of their designed lives. Rural and suburban landowners may have to accept the notion that they must also pay the operating and capital costs for advanced sewage treatment that city dwellers have done for decades.

Articulating a Watershed Ethic for the Suburban and Rural Landowner

Despite the enormous growth of the environmental movement and a generation of universal environmental education in our schools, we have not articulated a

watershed ethic that applies to the suburban and rural landowner. As watershed professionals, we have been quite clumsy and timid in defining what it takes to live properly within a watershed. We need to come to some agreement about what personal responsibilities might comprise a watershed ethic for our time. With this in mind, we offer the following tentative list to stimulate more discussion:

- Inspect septic systems annually, and pump them out regularly
- Apply no fertilizer or pesticides to lawns
- Minimize turf area and avoid growing lawns in regions where the climate cannot sustain them without supplemental irrigation
- Gradually replace lawns with native trees, shrubs and ground covers
- Cultivate lawns with the primary goal of absorbing the runoff from roofs
- Take responsibility for disposing of the wastes of pets and hobby livestock
- Choose vehicles with low emissions and inspect them regularly
- Choose, in where we live, to reduce the miles we travel and prevent sprawl
- Be sensible in water use, as the cumulative demand for water during dry weather dramatically affects the flow of urban streams and rivers
- Use a commercial car wash, or at least wash cars on lawns using phosphorus-free detergents
- Avoid using hoses or leaf-blowers near the street or storm drain
- Maintain any stormwater practices, buffers or conservation areas present in neighborhoods

These simple steps help to minimize our collective impact on the watershed, but represent only the first steps of a watershed ethic. We can and should play an active stewardship role by advocating better local watershed protection and working together to restore degraded streams, lakes and estuaries. Stewardship takes many forms, whether it is a stream walk, a vote, citizen monitoring, storm-drain stenciling, tree planting or joining a local watershed organization.

Many elements of the watershed ethic run contrary to our current notions of suburban taste and social status, and may initially resist change. For example, it may be a few years before you hear, "Hey neighbor, I am really impressed by all the biodiversity you produced on your lawn," or, "The filthiness of your car really expresses your concern for the environment, Dad," or, "My, how well Rover is buffer-trained."

But it is also reasonably certain that our culture can learn to practice a much better watershed ethic than we do now, if we create a stronger watershed message and learn to deliver it more effectively. ***- TRS***

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Table 7: Comparison of Three Surveys of Fluid Changing by Backyard Mechanics

Study	Oil Changing	Antifreeze Changing
Maryland *Smith, 1996*	93% report oil recycling 7% did not recycle	83% reported oil recycling 17% did not recycle
California *Pellegrin, 1998*	30% do it yourselfers 12 to 15% report improper disposal, most put it in trash, but about 3 to 5% put it in storm drain system	18% do it yourselfers, 43% report improper disposal: 23% let it run to street 6% dump into storm drain
California *Assing, 1994*	28% do it yourselfers 17% report improper disposal (most in trash)	not asked

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