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Unfinished Business in New England: A Comparative Assessment of Environmental Problems

Ecological Risk Work Group Report

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I. Introduction

The Ecological Risk Work Group (ERWG) evaluated 24 environmental problems to determine which areas present the greatest residual ecological risk to each of eight ecosystems in New England. Residual risk is defined as the risk posed by a problem, given current levels of control. The work group defined the ecosystems found in New England, developed a method to evaluate the impact of the different problem areas on these ecosystems, and then assigned problem areas to its members, according to their areas of expertise, for evaluation. Members developed papers that described the evaluation for their problem area. Finally, the work group discussed each problem area and developed a relative ranking delineating several broad categories according to the severity of ecological impacts.

The Ecological Risk Work Group also performed a limited analysis of welfare risks, focusing on impacts to ground water. We did not analyze economic factors such as the cost of alternative water supplies or the loss of income due to fish kills.

This report describes the methodology used by the Ecological Risk Work Group and discusses ranking issues and results.

II. Analytical Approach and Methodology

Ecological risk assessment is a procedure for estimating the probability of and severity of adverse effects on species, biotic communities, and ecosystem structure and function. Ecological risk assessment is similar to human health risk assessment in many respects. Both estimate the risk of adverse effects based on information concerning the sources of stressors (e.g., characterization of substances released and frequency and duration of release), the exposure of receptors to the stressors, and the responses of the exposed receptors. However, the formula most often adopted for estimating risks to human health (hazard multiplied by exposure predicts risk), while appropriate for ecological risk evaluation, is very difficult to apply in practice for many reasons, including the vast number of different receptors and levels of organization within ecosystems and the uncertainty in defining what constitutes ecosystem health. Rigorous quantitative ecological risk assessment was beyond the scope of the regional risk evaluation project. Our analysis borrowed from the broad concepts of ecological risk assessment to provide an analytical framework for evaluating a set of environmental problem areas. The approach is described in the following sections.

Methodology

The Ecological Risk Work Group compared the stressors associated with each problem area with the ecological receptors found in New England. Stressors are materials or activities that may have an adverse effect on some ecosystem. Most often stressors will be some form of pollution, e.g. ozone, pesticides, metals, and PCBs. Sometimes stressors may be natural events, such as erosion leading to the destruction of habitat. In other cases human activities, such as the filling of wetlands, are stressors. Receptors may be ecosystems (i.e., streams) or components of ecosystems such as fish or birds.

The work group gathered regional data to identify, as quantitatively as possible, the sources and volumes of stressors, the exposure routes, and the affected or potentially affected receptors. The final estimates of adverse effects are based on a combination of the available information and the best professional judgment of the work group member assigned to each problem area. These results were discussed, and in some cases modified, by the entire work group. The final comparative ranking was developed by the group. It represents our best professional judgment.

The primary source for the analytical approach used in this project was the ecological risk analysis performed as part of the National Comparative Risk Project (NCRP). There were two components to that effort: a study conducted by a panel of EPA experts, and a study conducted by the Ecosystems Research Center at Cornell University.

The Ecological Risk Work Group built on the NCRP definition of ecosystems and its evaluation of stressors for each problem area and how they affect ecosystems. The work group structured the comparative evaluation so that it could be tracked from beginning to end and so that each problem area would be treated consistently.

The work group followed five major steps in conducting its evaluation:

Step 1. Identify problem areas for which ecological risk will be evaluated and determine the stressors associated with each area.

Step 2. Identify the ecosystems of concern in New England.

Step 3. Evaluate the ecological risks for each stressor and ecosystem combination.

Step 4. Aggregate the risk estimates for all stressors in each problem area/ecosystem combination.

Step 5. Aggregate risks for each problem area across ecosystems and rank problem areas.

Step 1. Identify problem areas for which ecological risk will be evaluated and determine the stressors associated with each area.

The work group began with a list of 24 environmental problem areas. By definition, some of these problem areas presented low or no ecological risk and therefore were not analyzed further. Below is a list of problem areas considered inappropriate for further analysis by the work group:

- Radon, Indoor Air Pollutants Other than Radon, and Drinking Water (problem areas #4, #5, and #12)--These problem areas affect human health in the indoor environment.

- Radiation from Sources Other than Radon (problem area #6)--The definition of this problem area limits consideration to the impact on humans of non-ionizing radiation from non-occupational exposure.

- Discharges to Estuaries, Coastal Waters, and Oceans from All Sources (problem area #10)--From an ecological prospective, this problem area is a receptor. The work group divided it into two distinct ecosystems: estuaries and marine. (See Step 2.)

- Wetlands/Habitat Loss (problem area #11)--The work group dropped evaluation of discharges to wetlands from this problem area because wetlands are evaluated as an ecosystem. We redefined the problem area to be an analysis of the impact of habitat loss on all ecosystems.

- Lead (problem area #22)--Region 1 added lead to the list of problem areas because of its effect on human health. The work group analyzed the ecological impact of lead as part of its analysis of surface water discharges from Industrial Point Sources, Nonpoint Sources, and POTWs.

- Asbestos (problem area #23)--The work group believed there was insufficient evidence documenting ecological impact from asbestos contamination.

- Lakes, Ponds, and Impoundments (problem area #24)--From an ecological prospective, this problem area is a receptor. The work group analyzed it as an ecosystem.

- Pesticides--The problem areas Pesticide Residues on Foods (#20) and Pesticide Application (#21) were combined into a single problem area called "Pesticides."

Elimination of problem areas deemed inappropriate for ecological risk evaluation left the work group with the following 15 problem areas to evaluate:

#1. Criteria Air Pollutants
#2. Acid Deposition and Visibility
#3. Hazardous/Toxic Air Pollutants
#7. Industrial Point Source Discharges to Surface Waters
#8. POTW Discharges to Surface Waters
#9. Nonpoint Source Discharges to Surface Waters
#11. Habitat Loss
#13. RCRA Waste Sites
#14. Superfund Waste Sites
#15. Municipal Waste Sites
#16. Industrial Waste Sites
#17. Accidental Releases
#18. Releases from Storage Tanks
#19. Other Ground-Water Contamination
#20,21. Pesticide Residues and Pesticide Application

The work group leads for each problem area identified the major ecological stressors for each problem, using information developed by the Cornell Ecosystems Research Center.

Step 2. Identify the ecosystems of concern in New England.

In order to evaluate the problem areas, the Ecological Risk Work Group developed a list of ecosystems found in New England, basing the list on the ecosystem definitions found in the Cornell study. The work group deleted ecosystems not found in New England, combined certain categories of ecosystems where insufficient data would be available to characterize every category, and added certain "systems" of particular interest in New England. The final list of ecosystems for this analysis follows:

- Marine--all deep coastal waters, extending to international boundaries and including all near-coastal waters that are not estuaries
- Estuaries--the area where river wave currents meet the sea tides; New England has several major estuaries of national significance, including Long Island Sound, Narragansett Bay, Buzzard's Bay, and Massachusetts Bay
- Tidal Wetlands--all coastal wetlands that exhibit the effects of salt water
- Streams--all navigable waterways within Region I
- Lakes--all man-made and naturally occurring inland bodies of water
- Wetlands (freshwater)--all inland areas that exhibit the characteristics of a wetland, as defined by the Army Corps of Engineers
- Terrestrial Forests--all forested areas
- Agriculture--all land used for the commercial production of any crop

* * * * *

- Ground water--underground water in the saturated zone capable of supplying water to wells and springs
- Air--all ambient air

Ground water and air are not ecosystems as such, but they are important receptors of environmental stressors. Deterioration of air and ground-water resources are welfare losses rather than ecological losses. The work group decided to evaluate the problem areas' welfare impact on air and ground water. In the end, most of the effort focused on the impact of contaminated ground water on drinking-water resources. The work group limited its analysis to identifying threats to ground water, and it did not put a dollar value on ground-water losses.

Step 3. Evaluate the ecological risks for each stressor and ecosystem combination.

The severity of ecological risks posed by a stressor depends on the type and magnitude of changes to the structure and function of ecosystems (or ecosystem components) and the reversibility of these effects. The severity of the effects will therefore depend on the intensity of the exposure, the size or number of ecosystems at risk, and the hazard potential of the stressor. Thus, the overall impact of ecosystem-level effects is a function of several factors, including exposure and hazard.

- Factors involved in evaluating exposure are as follows:
  - Size of the area affected (for some ecosystem types such as lakes, volume may be a better measure of size)
  - Characteristics of releases and emissions, including sources, number, magnitude, frequency, duration, and form
  - Location, spatial extent, and distribution of releases and emissions
  - Magnitude and pattern of exposure to stressor
- Factors involved in evaluating hazard include the following:
  - Severity of effects caused by a stressor on the structure and function of the ecosystem, i.e., destruction of habitat, species diversity, endangered species
  - Reversibility of effect
  - Intensity of effect
  - Sensitivity/vulnerability of the target species/ecosystems
  - Trend (whether the hazard is likely to increase, remain stable, or decrease in the future, given current exposure)
  - Scale of effect
  - Uncertainty of effects
- Other factors considered in the risk evaluation were the following:
  - Value of the target species
  - The effect of controls now in place
  - Uncertainty of estimates
  - The percentage of problem covered by the evaluation

For each problem area, work group members identified major sources of stressors and discussed major damage pathways. Then, each participant developed an analysis of the effect of each stressor on each ecosystem in Region I.

Step 4. Aggregate the risk estimates for all stressors in each problem area/ecosystem combination.

In the evaluation process, work group members considered four criteria in evaluating the impact of each problem area on each ecosystem (including ground water and air):

1. The ecological hazard assessment, i.e., the *potential impact* of the problem area on the ecosystem

2. The reliability of the *data*, considering both quantity and quality

3. The *actual impact* in New England based on the known exposure levels

4. The *overall risk* the problem area presents to the ecosystem in New England, taking into account data reliability

The work group ranked the impact to each ecosystem from each problem area on a scale of 1 (low impact) to 5 (high impact). Work group members provided an estimate of the percentage of the problem covered, and the uncertainty, for each problem area.

Step 5. Aggregate risks for each problem area across ecosystems and rank problem areas.

After evaluating each problem area for its impacts on each ecosystem of concern, the work group members discussed the aggregation of these risks across ecosystems to rank problem areas. The group was not comfortable taking this step because we believed it involved making judgments about the value of various ecosystems. Still, the results of the ecosystem-specific rankings allowed the problems to be divided into groups of relatively high and medium risks. The problems initially eliminated from the analysis in Step 1 were considered to be of low ecological risk.

III. Ranking the Ecological Risks to Ecosystems

Several difficult issues arose as the Ecological Risk Work Group discussed the individual analyses of problem area impacts and attempted to rank those problems. First, we discussed the inclusion of ground water and air as ecosystems. They are not ecological systems by definition but are extremely valuable natural resources. We believed that excluding ground water would result in an unrealistic environmental risk evaluation for the Region I project. Yet it was not possible to use the same criteria for evaluating ground water and air as for evaluating the impacts to ecological systems, because ground water and air do not, within themselves, support plant or animal communities. After much discussion, it was decided to include ground water and air in the initial ranking and decide later how to incorporate them in the final ranking process.

We also had difficulty ranking three problem areas. These problem areas and the resolutions on ranking are discussed below:

- **Accidental Releases**--It is clear that major accidents can be catastrophic. However, it is difficult to judge the probability that an accidental release will occur and compare this probability with other risks. The only known accidental release with a major environmental impact occurred in Region I in 1977 in Buzzards Bay. Although no major accident has occurred in more than 10 years, the potential severity of an accidental release is very great. Because of the potential impact, ecological risk of accidental releases ranked high.

- **Pesticides**--Pesticides use is an approved process that with proper controls may be beneficial but that historically has not been managed properly. Pesticide application to lakes, forests, and freshwater wetlands is approved to control undesired problems such as mosquitoes or spruce budworm. The unknown secondary impacts of pesticides can have enormous adverse effects. Because of the history of adverse secondary impacts, such as DDT effects on wildlife, this problem ranked among the highest.

- **Hazardous/Toxic Air Pollutants**--Few data are available, but the recent studies of the Great Lakes and Chesapeake Bay indicate that these pollutants could have a significant impact on any large surface-water body. No conclusions about regional impacts can be drawn at this time because local data are not sufficient. Rather than attempt to evaluate the impacts, given that there are insufficient data and that recent data indicate a significant potential problem, we ranked this problem area as unknown (u).

Ecological Risk Ranking Results

The Ecological Risk Work Group developed a relative ranking of problem areas based on their estimated risk to eight ecosystems in Region I and to two environmental resources. Nine problem areas from the original list of 24 were not evaluated because they were determined to have minimal ecological impact or they were included as ecosystems or in other problem areas. These problem areas were considered to pose low ecological risks. Using the information we gathered on the potential impact of a problem area on each ecosystem, as well as data on regional effects, we ranked the impact to each ecosystem from each problem area on a scale of 1 (low) to 5 (high). We therefore conducted approximately 150 individual ecological risk evaluations (10 evaluations per problem area). Through this process, the work group identified seven environmental problem areas that have high impacts on specific ecosystems and seven problem areas having a high or medium-high risk to ground water (i.e., a score of 5 or 4). The work group believed that no clear-cut distinction exists from one category to the next highest or lowest category but that, in general, differences of two or more categories were significant. Table III-1 presents the ranking for each problem area and ecosystem combination.

The Ecological Risk Work Group attempted to rank one ecosystem against another, but came to a consensus that, within Region I, all ecosystems are of significant value and any comparative ranking would be judgmental. We did not believe that we could determine whether lakes are more valuable than estuaries or forests. Possibly at the state level this judgment could be made. Region I, depending on one's perspective, has a strong natural ecological resource in all eight ecosystems. One ecosystem that does not appear to be at major ecological risk at the present time is the marine environment, which was defined as deep ocean. However, the Accidental Release problem area is critical to the marine environment, particularly since the region includes Georges Bank, an important spawning area that could be threatened by oil drilling operations.

The work group analyzed and ranked the risk evaluation information in two ways: (1) For each problem area, we identified the ecosystems exhibiting the most significant adverse effects and the stressors causing those effects. We grouped the problem areas into categories 5 through 3. Problem areas not evaluated because they were assumed to pose low ecological risks were placed in Category 2/1 (Table III-2). (2) For each ecosystem, we identified the problem areas causing the most significant impacts and the stressors associated with those impacts (Table III-3).

The ranking matrix included both ground water and air as "ecosystems." As the work group developed issue papers based on each problem and tried to rank the problems using the matrix system, we realized that it was difficult to rank air pollution within the air ecosystem category and have any real meaning. Therefore, we decided not to discuss air as a receptor or a resource. On the other hand, six of the problems rated ground water as the most significantly stressed receptor. Based on the premise that the problem list is representative of important environmental issues in New England, and that one-quarter of the most significant ecological impact from those problems was to ground water, the work group chose to discuss it as a separate issue. Ground water is obviously a unique and critical natural resource in Region I. As previously mentioned, it was initially incorporated as an ecosystem but could not effectively be ranked accordingly (Table III-4).

We separated the problem areas into groupings of high, medium, and low residual ecological risk based on the level of stress to the ecosystem. Some of our major conclusions are as follows:

High Residual Ecological Risk

Seven problem areas clearly pose significant ecological risks in Region I:

- Ozone, a Criteria Air Pollutant, has adverse impacts on forests and may affect crop yields.
- Acid Deposition has adverse impacts on lakes in New England and also contributes to forest decline.
- All discharges to surface waters have adverse impacts on aquatic life in steams, lakes, ponds, impoundments, and estuaries. This includes three problem areas: Industrial Point Source Discharges, POTW Discharges (including combined sewer overflows and stormwater discharges), and Nonpoint Source Discharges.
- Habitat loss--significant loss of uplands and wetlands that are important areas for spawning and breeding--is occurring in New England.
- Catastrophic accidental releases are not common, but this problem area was highlighted as significant because major oil spills in the estuarine, tidal wetlands, and/or marine ecosystems would be likely to have drastic environmental impacts.

Medium Residual Ecological Risks

The environmental problem areas that primarily affect the ground-water resource appear to pose medium to medium-high residual ecologic risks. These problems areas include Superfund Waste Sites, RCRA Waste Sites, Municipal Waste Sites, Industrial Waste Sites, Releases from Storage Tanks, Other Ground-Water Contamination, and Pesticide Application.

Generally, contaminants from sources related to these problem areas are in highest concentrations in ground water and may be discharging or running off into surface waters and wetlands, threatening those ecosystems. An ecological risk evaluation, which looks strictly at ecological receptors, will find that these problems have less ecological impact relative to the sources directly discharging pollutants to water and air. The Ecological Risk Work Group included ground water as an "ecosystem" category precisely so that the serious problem of ground-water contamination would not get lost in the overall analysis. In many ways, the contamination of ground water poses primarily a welfare risk, because it affects present and future drinking water supplies. The work group agreed that ground-water quality in New England is seriously threatened by the problem areas listed above.

Low Ecological Risks

All of the problem areas not evaluated were considered to pose low ecological risks. These problem areas include Radon, Indoor Air Pollutants Other than Radon, Drinking Water, Lead (ecological impacts covered under discharges to surface waters), Asbestos, and Radiation from Sources Other than Radon.

Unknown

Impacts from Hazardous/Toxic Air Pollutants were ranked as unknown, because there were very little data available to evaluate this problem. However, there is concern regarding potential environmental impacts.

Table III-1

Assessment of Problems By Ecosystems and Environmental Resources

		Marine	Estuaries	Tidal Wetlands	Streams	Lakes	Wetlands (fresh water)	Terres-trial	Agri-culture	Ground-water
#1.	Criteria Air Pollutants	1	1	u	1	1	u	5	5	-
#2.	Acid Deposition and Visibility	1	1	1	3	5	1	4	2	1
#3.	Hazardous/Toxic Air Pollutants	1	2	2	2	u	u	u	u	1
#7.	Industrial Point Source Discharges to Surface Waters	2	3	2	5	1	3	1	1	1
#8.	POTW Discharges to Surface Waters	3	5	3	5	3	3	1	1	1
#9.	Nonpoint Source Discharges to Surface Waters	1	2	2	4	5	3	1	1	1
#11.	Wetlands/Habitat Loss	1	2	2	4	2	4	5	4	1
#13.	RCRA Waste Sites	1	1	1	3	1	3	1	1	4
#14.	Superfund Waste Sites	1	2	2	4	1	4	1	1	5
#15.	Municipal Waste Sites	1	2	2	3	1	4	1	1	5
#16.	Industrial Waste Sites	1	2	2	3	1	4	1	1	5
#17.	Accidental Releases	4	5	5	3	3	3	1	1	2
#18.	Releases from Storage Tanks	1	2	2	2	2	3	1	1	5
#19.	Other Ground-Water Contamination	1	3	2	3	4	3	1	1	5
#20.	Pesticide Residues on Food/									
#21.	Pesticide Application	1	3	2	3	4	4	4	x	5

Notes: 1 = low ecological risk, 5 = high risk, u = unknown, x = unranked.

Indoor Air Pollutants Other than Radon (problem area #5) and Radiation from Sources Other than Radon (#6) were not ranked.

Table III-2

Ecological Problem Area Ranking
(unranked within categories)

Environmental Problem	Sources and Stresses	Ecosystems Most Significantly Affected
Category 5		
1. Criteria Air Pollutants	Ozone is the most significant stressor	Terrestrial--Ozone is considered to cause the decline of forests, especially at higher elevations. Agriculture--Several crops have shown decreases in yield due to ozone.
2. Acid Deposition and Visibility	Lowering of pH and buffering capacity	Lakes--New England lakes are experiencing significant acidification due to acid deposition, which affects aquatic distribution. Terrestrial--Acid deposition contributes to decline of forests, particularly at higher elevations.
7. Industrial Point Source Discharges to Surface Waters	Discharge of toxics, especially in water with low dilution ratios	Streams--Toxic plants affect sediments and aquatic life.
8. POTW Discharges to Surface Waters (includes combined sewer overflows (CSOs) and stormwater discharges)	Discharge from CSOs and stormwater of nutrients and toxics; POTW discharge of chlorine, nutrients, and industrial waste to water quality limited streams	Estuaries--Toxics and nutrients affect plants, sediments, and aquatic life. Streams--These discharges are toxic to aquatic organisms. Lakes, Ponds, Impoundments--Nutrients and toxics build up in impoundment sediments.
9. Nonpoint Source Discharges to Surface Waters	Runoff of nutrients and toxic chemicals into lakes and streams	Lakes--Nonpoint source runoff causes eutrophication. Streams--Runoff of toxics, including pesticides, has significant impact on aquatic life.
11. Habitat Loss	Conversion of undeveloped land to residential and commercial property	Terrestrial--Significant loss of land to development affects the habitat environment and breeding areas. Wetlands (freshwater)--Significant loss of land as a habitat breeding and spawning area occurs. Agriculture--Significant loss of habitat environment and breeding area occurs.
17. Accidental Releases	Oil spills from shipping and drilling	Estuaries and tidal wetlands--Major oil spill could destroy habitat and spawning area and other uses. Marine--The drilling at Georges Bank could destroy habitat spawning.
Category 4		
14. Superfund Waste Sites	Discharges of toxics from leachate	Wetlands (freshwater)--Approximately 50% of the sites are adjacent to streams or freshwater wetlands. Toxics affect plants, sediments, and aquatic life.
15, 16. Municipal and Industrial Waste Sites	Discharges of toxics from leachate	Wetlands (freshwater)--similar to 9.
19. Other Ground-Water Contamination	Septic tank discharges of nutrients	Lakes--Nutrients contribute to eutrophication of New England lakes.
20, 21. Pesticide Residues on Food/ Application	Residual runoff from application	Lakes--Pesticide use has significant impacts on aquatic life, particularly when directly applied. Wetlands--Use in mosquito control can affect aquatic life and vegetation. Terrestrial--Spraying can affect habitat.
Category 3		
13. RCRA Waste Sites	Discharge of toxics from leachate	Streams and wetlands (freshwater): Toxics affects plants and sediments.
18. Releases from Storage Tanks	Discharges of toxics from leachate	Streams and wetlands (freshwater): Toxics affect plants and sediments.
Unknown		
3. Hazardous/Toxic Air Pollutants		Unknown.

Note: Toxics includes organic chemicals, metals, and pesticides.

Problem areas considered to pose low ecological risk (Category 2/1) were not evaluated by the work group, and were not included in this table.

Table III-3

Problem Areas Affecting Ecosystems

Ecosystem	Problem Area	Stressor	Impact(s)
Marine	#17. Accidental Releases	Oil spills from drilling	Habitat spawning at Georges Bank
Estuaries	#8. POTW Discharges to Surface Waters (includes CSOs and stormwater discharges)	Nutrients and Toxics	Toxics affect plants, sediments, and all aquatic life
	#17. Accidental Releases	Oil spills from tankers	Significant long-term impact to aquatic and plant life
Streams	#7. Industrial Discharges to Surface Waters	Toxics	Impact on plants, sediments, and aquatic life; potential threat to water supply
	#8. POTW Discharges to Surface Waters	Toxics, nutrients	Same as #7
	#9. Nonpoint Source Discharges to Surface Waters	Toxics, nutrients	Same as #7
	#11. Habitat Loss	Stream alteration	Eliminates spawning and breeding areas
	#14. Superfund Waste Sites	Toxics	Impact on plants, sediments, and aquatic life
Lakes	#2. Acid Deposition	Sulfur dioxide	Lowers pH that affects aquatic and plant life
	#8. POTW Discharges to Surface Waters (CSO and stormwater)	Nutrients and toxics	Impact to plants and aquatic life
	#9. Nonpoint Source Discharges to Surface Waters	Nutrients and toxics	Nutrients cause eutrophication, which impacts plants and aquatic life
	#19. Other Ground-Water Contamination	Nutrients from septic systems	Cause eutrophication
	#20,21. Pesticides	Toxics	Affect plants, sediments, and aquatic life

Note: Toxics include organic chemicals, metals, and pesticides.

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(continued)

Table III-3 (continued)

Ecosystem	Problem Area	Stressor	Impact(s)
Wetlands (freshwater)	#11. Habitat Loss	Development	Eliminates breeding, spawning, and feeding areas
	#14. Superfund Waste Sites	Toxics	Affect plants, sediments, and aquatic life
	#13,15,16. Other Waste Sites	Toxics	Affect plants, sediments, and aquatic life
Terrestrial	#1. Criteria Air Pollutants	Ozone	Causes forest decline, especially at high altitudes
	#2. Acid Deposition	pH	Causes forest decline, especially at high altitudes
	#11. Habitat Loss	Development	Eliminates breeding and habitat areas
	#20,21. Pesticides	Toxics	Accidental secondary impact on animals and birds
Agriculture	#1. Criteria Air Pollutants	Ozone	Decreases crop yield
	#11. Habitat Loss	Development	Eliminates breeding and habitat areas

Note: Toxics include organic chemicals, metals, and pesticides.

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Table III-4

Problem Areas Affecting Ground Water

Problem Area	Stressor	Impact
#13. RCRA Waste Sites	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters
#14. Superfund Waste Sites	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters
#15. Municipal Waste Sites	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters
#16. Industrial Waste Sites	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters
#18. Releases from Storage Tanks	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters
#19. Other Ground-Water Contamination	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters
#20. #21. Pesticides Application and Residues on Food	Organic chemicals, metals, pesticides	Lose as a water supply resource plus impacts to wetlands and surface waters

Appendix

Problem Area Papers

1. Criteria Air Pollutants

Problem Area Definition

This category covers outdoor exposure to airborne criteria pollutants. Six criteria pollutants have been designated under Sections 108 and 109 of the Clean Air Act (CAA):

- Ozone (O_3)
- Carbon monoxide (CO)
- Total suspended particulate (TSP) and/or PM_{10}
- Sulfur dioxide (SO_2)
- Nitrogen oxides (NO_x)
- Lead

An exposure problem arises when a criteria pollutant is present in concentrations that exceed National Ambient Air Quality Standards (NAAQS). Primary standards are set to protect human health, while secondary standards are set to protect welfare or to prevent damage to crops, vegetation, buildings, and visibility. In some cases, a single standard may protect health and welfare.

Lead will be covered in a separate category.

Summary/Abstract

The criteria air pollutant of concern in New England is ground-level ozone. Currently in New England, 45 out of 67 counties are not in attainment for ozone, meaning that the standard has recently been violated. Ozone is a strong oxidant, and has significant ecological effects on plants and animals. This study ranked ozone as having a high impact on terrestrial (i.e., trees) and on agricultural resources (i.e., reduced crop yield and other vegetation damage). Ozone probably also has an impact on the vegetation found in freshwater and coastal wetlands, but the extent of the damage has not been quantified. Coastal wetlands may be especially vulnerable in New England since the highest ozone levels in Connecticut, Rhode Island, New Hampshire, and Maine all occur near the seacoast; however, because actual studies of damage to wetland vegetation have not been conducted, the risks have been rated as uncertain.

Sources

An assessment of air quality levels in New England shows that SO_2 and NO_x levels are below their respective NAAQS throughout the area. The PM_{10} standard, which is now *the* standard for particulates, is a new standard, and data collection has just recently begun in New England. The limited PM_{10} data show that the only areas thought to be not in attainment in New England are small areas in northern Maine. Because these three pollutants (SO_2, NO_x, and PM_{10}) are either not problems at all or are problems in only small areas of the region, they were not considered in this risk evaluation.

Although some urban areas in New England are nonattainment areas for carbon monoxide, CO also was not considered in this ecological risk evaluation because CO is primarily an urban human health problem connected with heavy traffic and street canyon areas. The habitat in these urban areas is already greatly perturbed.

This leaves ozone as the only criteria pollutant considered by the Ecological Risk Work Group in this risk analysis. Ozone is a major air pollution problem in New England. Forty-five out of 67 counties are not in attainment for ozone, even though the attainment deadline was December 31, 1987.

Ozone is a secondary pollutant. It is not emitted directly into the atmosphere; it is formed by a series of atmospheric reactions between precursor emissions (e.g., hydrocarbons and nitrogen oxides) in the presence of sunlight. Ozone precursors are not emitted from a few large or conveniently concentrated sources, but from numerous sources, large and small, in diverse locations. These sources include motor vehicles, petroleum refineries, oil storage tanks, household products, petroleum marketing, chemical manufacturing, surface coating, and printing industries. Precursor emissions usually are transported many miles before ozone is formed. The chemical structure of individual precursor emissions may quickly be altered, making it difficult to assess the impact that emissions from any one source have on the amount of ozone created. Air temperature and stagnating air masses during the summer months can also substantially affect ozone formation.

Because the chemical reactions that form ozone are driven by the sun, ground-level ozone concentrations are higher during the daytime than they are at night, and they are at their highest during the summer. The absolute highest ozone in New England occurs under conditions of strong sunshine, light winds (<10 mph), and high temperatures (>86° F). The sunlight drives the reaction, the light winds create stagnant conditions, and the warm temperatures aid in VOC evaporation and/or volatilization. For these reasons, warm, sunny summers are much more conducive to ozone production than cool, cloudy summers. Figure 1-1 shows the number of ozone exceedance days in New England from 1980 to 1987 versus the number of days the temperature in Hartford, CT, reached or exceeded 86° and 90° F, respectively. The figure shows how ozone exceedances vary from year to year.

Ecological Hazard Assessment

Effects of Ozone on Animals

Animal studies show that ozone interferes with the functioning of many components of the immune system, a phenomenon observed in several studies using the ozone levels frequently encountered in the ambient air. In one series of studies, 0.08 ppm (66 percent of the federal standard) ozone for three hours resulted in increased susceptibility to acute respiratory infection. Animal toxicological studies also show that ozone initiates damage to sensitive lung tissue, and that damage continues for some time after ozone exposure has ended. If the exposure is not repeated, the damaged tissue repairs itself, leaving a small amount of scar tissue. If the exposure is repeated or continued for long periods of time, scar tissue can become extensive enough to cause permanent lung damage. Scar tissue reduces pulmonary elasticity, a process that is tantamount to premature aging of the lung. Thus far, permanent damage has been observed only in studies lasting from weeks to months where ozone exposures of 0.20 ppm or greater were used. However, some recent animal studies indicate that short-term exposures to ozone at or near 0.12 ppm cause inflammation. Some believe that this inflammation is the first step toward more permanent injury.

Effects of Ozone on Agriculture

In the late 1970s, EPA initiated the National Crop Loss Assessment Network (NCLAN) study to develop pollutant-specific, dose-response information for important crop species. Evidence from the NCLAN studies indicates that several major cash crops such as soybeans, peanuts, corn, and wheat experience 10 percent or higher yield losses when the average seven-hour daylight ozone concentration during the growing season exceeds 0.04 to 0.05 ppm. Controlled studies in greenhouses strengthen the evidence of demonstrated field effects. In addition, ambient air exposure studies demonstrate that ambient ozone in many regions of the country (outside California) can reduce plant yield in tomatoes by 33 percent, in beans by 26 percent, in soybeans by 20 percent, and in snapbeans by up to 22 percent. The ozone levels in Connecticut are so high that certain types of tobacco can no longer be grown in that state.

Effects of Ozone on Forests

Repeated ozone peaks equal to or greater than 0.08 ppm (66 percent of the standard) have been implicated in damage observed in white pine in the eastern United States and Canada. Recent reports indicate that growth rates of red spruce at numerous high-elevation sites throughout the Appalachian Mountains may have been dropping for 20 to 25 years. Conclusive determination of the role of air pollution, particularly of ozone, in these most recent declines is not possible at present because data are limited. Many scientists, however, think ozone is a major contributor to this decline in growth.

Effects of Ozone on Wetlands

Since ozone causes damage and reduces growth rates of some trees and plants, it probably also affects the vegetation found in both freshwater and coastal wetlands. The exact nature of damage to vegetation in wetlands has not been quantified.

Impact Assessment

The only known pathway of exposure to ozone is through the atmosphere. The current ozone standard (both primary(health) and secondary(welfare)) is 0.12 ppm, not to be exceeded more than three times during any three-year period (expected exceedance < 1.0). Studies have shown that the 0.12 ppm standard may have no margin of error with regards to health effects. Other studies have shown plant damage and reduced crop yield at lower concentrations (0.08 ppm) for longer periods of time (e.g., eight hours). An EPA study has shown a strong correlation between the current 0.12 ppm standard and a proposed or hypothetical 0.08 ppm eight-hour standard, and an even longer-term, three-month standard (growing season average). The study implies that if a site exceeds the 0.12 ppm one-hour standard, it probably will exceed a 0.08 ppm eight-hour standard and the longer three-month standard.

The eight-hour and the three-month standards might be especially important on mountain top locations, because the ozone levels at mountain top locations are not as influenced by 'ground-level scavenging' as are valley locations. Thus, ozone levels on mountain tops are higher at night than the levels in the surrounding valley locations.

Currently in New England, 45 out of 67 counties are not in attainment for ozone. These nonattainment areas include the entire states of Connecticut, Massachusetts, and Rhode Island. In the past six years (1982-1987), ozone concentrations in excess of 0.24 ppm (twice the standard) have been measured in Connecticut, Rhode Island, and Massachusetts. Exceedances of the standard have been measured as far north as Acadia National Park in Maine. Some vegetation studies show reduced plant yield at values above 0.04 to 0.05 ppm (40 to 50 ppb). Figure 1-2 shows the number of days ozone levels exceeded 0.12 ppm at monitoring sites in the greater Northeast in 1985.

Risk Characterization

Ambient levels of ozone in New England frequently exceed the federal standards and pose risks to animals and vegetation. The known effects in animals include acute respiratory infection and potential lung-tissue damage. Impacts on vegetation include reduced agricultural crop yields and reduced growth rates in trees and plants. The Ecological Risk Work Group ranked ozone as having a high impact on terrestrial and agricultural resources. Coastal wetlands may be especially vulnerable because average one-hour concentrations of ozone are higher in those areas than in inland areas. Mountain tops in New England also are deemed especially vulnerable. Risk to humans and wildlife from high ground-level ozone concentrations also is high.

The work group rates overall risk as low for marine ecosystems, estuaries, streams, and lakes. Impacts on tidal wetlands and freshwater wetlands also may be high, but actual studies have not been conducted, so the risks are rated as uncertain.

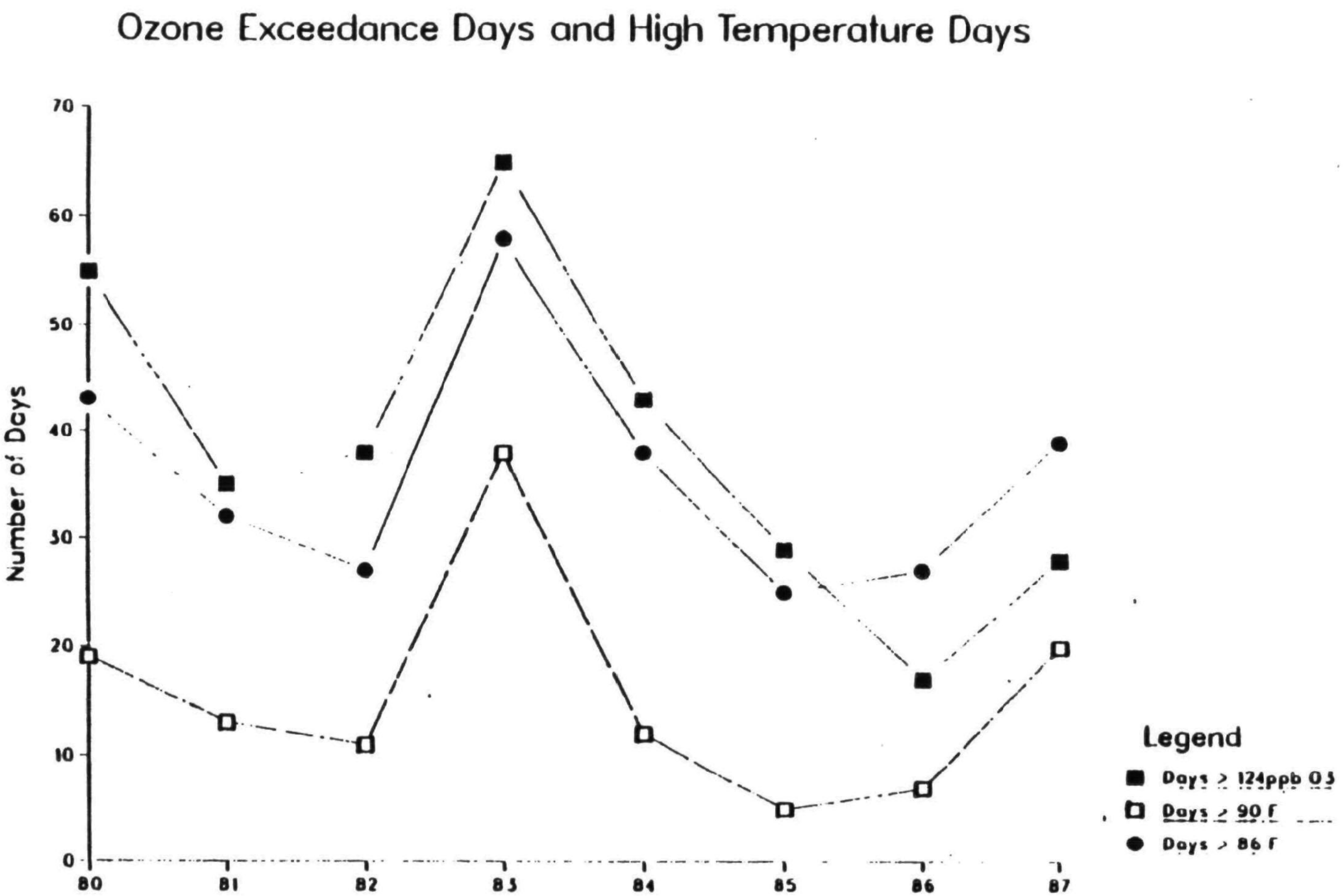
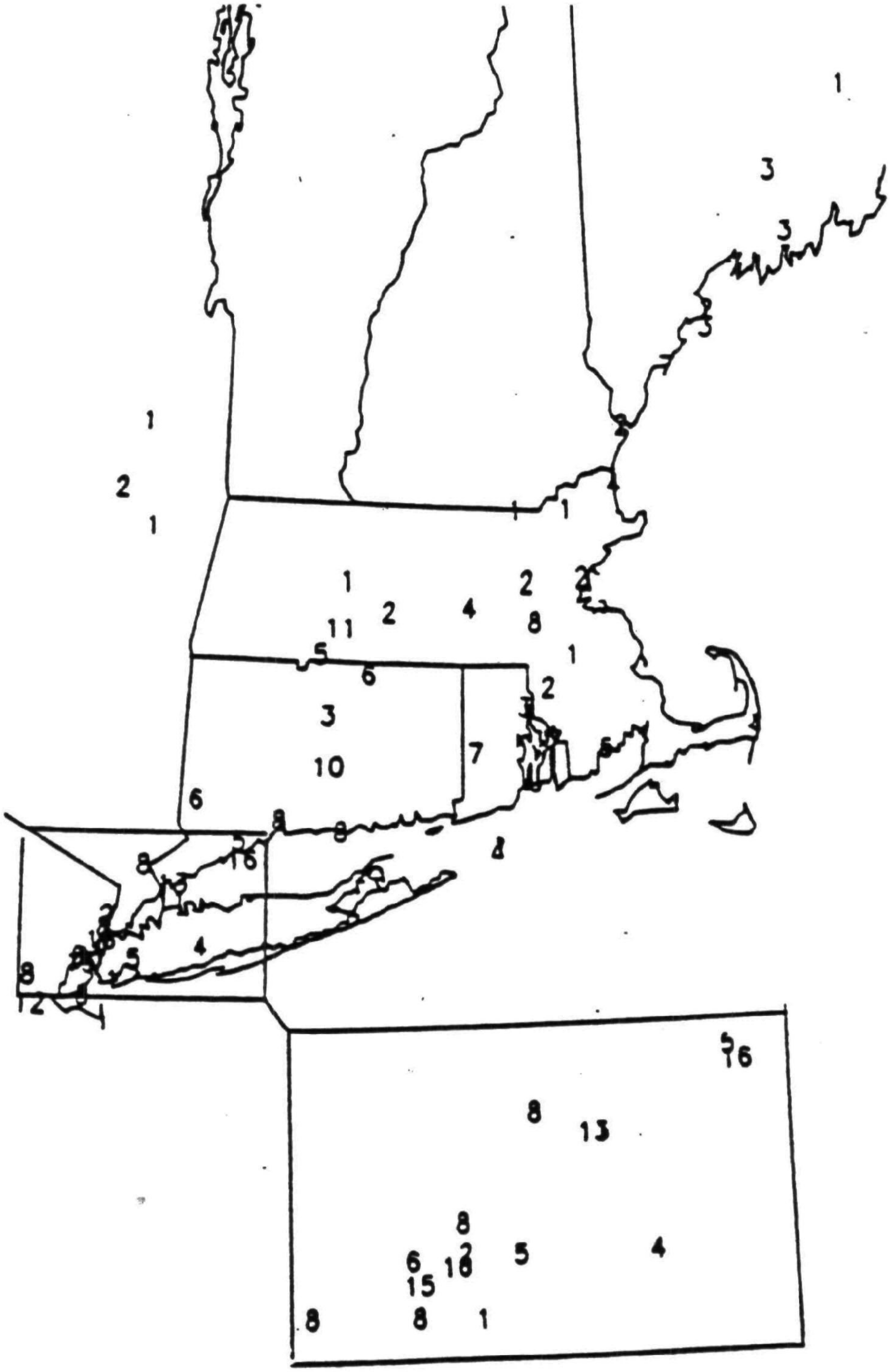


Figure 1-1

Data show the number of days that levels exceeded standards from 1980 to 1987 in New England, and the number of days that high temperature in Hartford, CT, exceeded 86°F and 90°F.

Figure 1-2



At each location, the data show how many days the ozone levels in 1985 exceeded 0.12 ppm.

2. Acid Deposition and Visibility

Problem Area Definition

This problem area applies to damages caused by wet or dry deposition of acidic compounds from the atmosphere. Some gases emitted into the atmosphere interact with sunlight, water vapor, and oxygen to form acidic compounds. Wet deposition then occurs when the acidic compounds fall as acid rain or snow. These acidic compounds may also combine with dust or other dry particles and fall as dry deposition. The pollutants that contribute to acid deposition are already regulated under the Clean Air Act; however, deposition can occur even when emissions of these compounds meet EPA standards. Visibility was also included in the definition, although that issue was not explicitly addressed by all work groups.

Summary/Abstract

Acid deposition affects all of New England. The most pronounced ecological effects occur in ponds and forests. Some leaching of toxicants and minerals from soils may occur. More than 100 lakes greater than 10 acres in size are estimated to be acidic. More than 700 are estimated to be threatened, and more than 2,000 are estimated to be sensitive to acid deposition. Acid deposition may be a major contributor to the decline of red spruce, balsam fir, and white ash in northern New England and Massachusetts. It may also contribute to damage to the sugar maple.

Sources

Naturally occurring wet deposition (rainfall) is already mildly acidic (pH 5.0 - 5.6) as a result of moisture combining with carbon dioxide in the atmosphere to form a weak carbonic acid.

Massachusetts reported that the average annual pH of precipitation in the state is approximately 4.2. Maine reported the average annual pH as 4.35 in the western part of the state (Bridgeton) and 4.5 in the northeastern part (Caribou). Vermont reported pH 4.4 as the weighted average from four stations during 1980-1983.

The sources causing acid precipitation may lie within or outside Region I. While regional sources are responsible for local or near field effects, the regionwide extent of the problem is attributed to sources in the Midwest and Southeast as well as to Canadian influences.

The sources of concern are industries that burn fossil fuels (coal, oil, and gasoline) and discharge the precursors of acid deposition (SO_2, NO_x, and volatile organic compounds (VOCs)) to the atmosphere. Such sources include electric utilities, industrial boilers and processors, smelters, chemical processors, residential and commercial fuel burning, and mobile sources.

Ecological Hazard Assessment

Acid deposition is the result of chemical reactions and interactions that may occur in the atmosphere in the case of wet deposition or on the surface with dry deposition. The transformation in the atmosphere occurs when the precursors, primarily sulfur dioxide (SO_2), nitrous oxides (NO_x), and VOCs, interact with moisture, ozone, hydrogen peroxide, and other oxidants to transform the SO_2 and NO_x into acids. Particulate matter (sulfates and nitrates) may be captured by water vapor in clouds to eventually fall to the earth as wet deposition, or the heavier particulates may drop to earth as wind velocities decrease or air density diminishes.

While the focus has been mainly on SO_2 and NO_x, organic acids may also contribute to the acidity of precipitation. The organic acids may be the result of both natural and man-made VOCs.

Acid deposition's ecological impact is aquatic and terrestrial. The aquatic effect is to lower the pH of surface waters to a point where fish can no longer survive and only a limited number of aquatic organisms can exist.

The terrestrial effects may be the destroying of the forest canopy, destruction of flora, disruption of life cycle processes, interference with humus production on the forest floor, leaching of toxic metals from the soil, and destruction of the acid neutralizing capacity (ANC) of soils.

While evidence suggests that some of the impacts may be reversible in stressed environments, it is doubtful if water bodies that have become acidified can regain a healthy aquatic community. Similarly, soils that have lost most of their ANC will not neutralize naturally occurring rainfall and will continue to get worse. One concern of researchers is that even if most of the pollution sources could be controlled, many waterbodies will continue to become more acidic because of the lost ANC of soil and the natural acidity of rainfall.

In areas where the forest canopy has been severely damaged, pollution-tolerant species dominate the new growth.

Impact Assessment

The stressors were evaluated only as they affect freshwater impoundments and forests. Although recent hypotheses indicate a potential for harm to the marine environment, the preponderance of research has examined effects upon freshwater ecosystems and terrestrial effects. The major exposure route to these two systems has been long-range atmospheric transport. Reportedly, visibility in rural New England has declined 50 percent since the 1950s because of sulfate particulates.

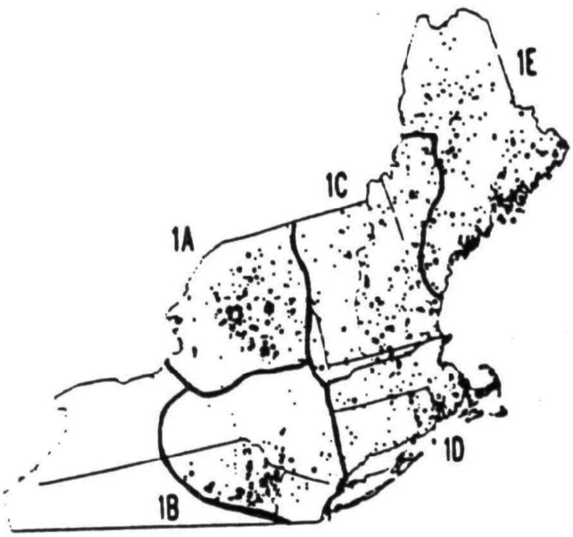
Admittedly wide variations in the acidity of wet deposition exist within New England, some of this caused by local pollution sources. The entire northeast area (upstate New York and New England) has been identified as having lower pH rainfalls than the rest of the country. Long-range transport of pollutants from the Southeast and Midwest appear to be creating acidification problems in New England.

Acid deposition impacts all of New England. Sulfate precipitation in the Northeast is estimated to be 8 to 12 times background levels. Researchers indicate that high-elevation lakes and forests seem to be most affected and also seepage ponds. The most sensitive areas in Region I are western Maine and the far eastern portion of Maine, the western areas of Massachusetts (Berkshire County), and Cape Cod. Central and northern Maine do not appear to be seriously affected.

Aquatic Exposure

For our purposes, acidic lakes will be defined as those having an acid neutralizing capacity (ANC) $\leq$0 equivalents per liter, threatened lakes having ANC $\leq$50, and sensitive lakes with ANC $\leq$200.

Using EPA's Eastern Lake Survey (ELS) database and its subregion characterization as shown in the map below, the following observations were made:



- The Northeast, including New York and Pennsylvania, contains more threatened and low pH (≤6.0) lakes than any other region studied. It also had the highest median sulfate concentration.

- No lakes in Vermont were estimated to have ANC ≤0. (Vermont has recently reported two lakes devoid of fish.) Seventeen lakes in New Hampshire were estimated to be acidic. (In recent conversations with New Hampshire, of 479 lakes studied, 10 have ANC ≤0, 103 have ANC ≤50, and 293 have ANC ≤200.)

- Sixty-six lakes in southern New England (subregion ID) had ANC ≤0, and researchers estimate that 284 lakes have ANC ≤50 and 755 have ANC ≤200. (Massachusetts recently reported a 0.83 correlation for ELS projected pH values and a 0.98 correlation for alkalinity projections, based on a Massachusetts survey of 2,500 surface waters.)

- Maine (subregion 1E) had the fewest acidic or low pH lakes in the Northeast; only 0.5 percent had ANC ≤0, 11 percent had ANC ≤50, and 67 percent had ANC ≤200. Lakes with the lowest ANC concentration appeared to be influenced by organic acids, not sulfate deposition.

The Eastern Lake Survey looked at lakes 4 hectares (approximately 10 acres) or larger in size. Smaller lakes are generally more susceptible to acidification. The Maine DEP estimates that of its 6,000 lakes 1 acre or larger, 58 are fishless, 75 to 100 lakes have ANC ≤0, and another 75 to 100 have ANC ≤50. One-half of these may be the result of organic acidity.

Terrestrial Exposure

Selected tree species in the forests of northern New England (Maine, New Hampshire, and Vermont) and Massachusetts have been reported as being affected. The most affected species are red spruce and balsam fir, which are exhibiting declining growth rates.

The sugar maple is also being damaged. A Massachusetts survey of 440 sugar maples at 22 sites in the state reported that 60 percent were in relatively poor health. Sugar maple groves in Vermont were also reported to be damaged.

Massachusetts surveyed the state in 1984 and 1985. It reported that 24,287 acres of forest showed signs of stress and decline. The most affected areas were Bristol, Plymouth, Worcester, and Berkshire counties; however, only 2,500 acres of red spruce and sugar maple are believed to be affected by acid deposition.

The USDA Forest Survey studied approximately 1,900 eastern white pine, 600 eastern hemlock, 800 northern red oak, 700 red maple, 571 sugar maple, 300 white ash, 2,800 red spruce, and 1,300 balsam fir trees from several thousand plots. These species represent approximately 78 percent of the growing stock in New England. Red spruce has had a declining growth rate since 1960; the balsam fir rate began declining in 1970 as did the white ash's rate.

Researchers cannot state that acid deposition is the principal causative agent for forest decline. Ozone, parasites, loss of nutrients, soil damage, climate change--all may be contributing factors. Researchers do believe that acid deposition plays a significant role in the health of forests.

Risk Characterization

Acid deposition is a region-wide problem. Our lakes and ponds are being affected, and acid deposition is, quite likely, a major influence on forest decline and damage. As a result, the work group ranked the impact of acid deposition on lakes as a 5 and the impact on terrestrial areas a 4. Streams were ranked as a 3 because of the vulnerability of some high-altitude lakes. All other ecosystem impacts were ranked as a 1 due to the buffering capacity of soils in the region and the dilution capabilities of the ocean and tidal waters.

The uncertainty we have is with the processes causing the decline in these resources and the rate at which changes will occur. This discussion did not address the chemical changes that will occur as a result of acidification, the leaching of toxicants from the soils, or the effects on pollen and reproduction cycles of aquatic organisms. Most of the research focused upon sulfate acidification. More recent works are looking at intraregional effects of NO_x from mobile sources.

The paper looked only at the major issues, probably 80 percent of the problem. It has not examined direct effects upon flora and resultant effects upon fauna.

The impacts are significant. Entire water bodies may be lost to recreational uses. The forests may change. Habitats can be lost. But documentation of the problem has only begun, and understanding of its mechanism is in its infancy. The cumulative effect of acid deposition on the animal reproduction and the food chain may be far-reaching.

Welfare

Visibility impacts and agricultural effects are the primary source welfare effects from acid deposition. As reported by the Massachusetts Executive Office of Environmental Affairs in a 1988 study, *Interim Report on the Findings of the Massachusetts Acid Rain Research Program*, visibility in rural New England has declined 50 percent since the 1950s because of sulfate particulates. That same report notes that acid deposition "could be affecting" agriculture in New England. Indeed, in the Midwest, studies have linked spotting on corn and the staining of leaf vegetables with acid deposition; no such documentation of effects has shown in New England, however. As a result, agricultural ecosystem impacts were ranked as a 2.

3. Hazardous/Toxic Air Pollutants

Problem Area Definition

This category covers outdoor exposure to airborne toxic and hazardous pollutants from routine or continuous emissions from outdoor point and nonpoint sources. Hazardous pollutants are designated under Section 112 of the Clean Air Act (CAA) as pollutants that may "cause or contribute to air pollution, which may reasonably be anticipated to result in serious, irreversible, or incapacitating reversible illness." Toxic air pollutants encompass any chemical substance, particulate or gaseous, that can become airborne and be inhaled in sufficient concentrations to threaten human health.

Major pollutant categories are the following:

- Volatile organic compounds
- Dioxins/furans
- Products of incomplete combustion
- PCBs
- Metals
- Pesticides
- Indoor air pollution (e.g., radon and formaldehyde)
- Asbestos

Summary/Abstract

This paper addresses the toxic air pollutants thought to have some negative effect on ecological systems. The toxic/hazardous air pollutants of concern are metals, dioxins/furans, PCBs, and wood smoke. Unfortunately, any information available on these pollutants and their effects has been limited to their effects on human health. A study on ecological effects of a resource recovery facility in Vermont is beginning to collect some data, but final results are not available. The entire issue of airborne toxins and their effects on the environment is still in its infancy.

Because of the data limitations, the risks have all been rated as uncertain. The ranking of uncertain, however, does not mean that toxins are not important from an ecological point of view. It only means that more research on the effects of toxins on the environment needs to be performed.

Sources

Of the toxic pollutant categories cited in the problem area definition, pesticides are covered in a separate category; asbestos and indoor air pollutants do not have significant ecological effects and will not be considered further; VOCs, although very important with respect to the formation of ozone, are not thought to pose significant ecological risks by themselves. The VOCs are a potential health risk through inhalation (e.g., the inhalation of gasoline fumes by service station attendants), but such effects are "close-in" effects and do not cause widespread ecological damage.

This paper therefore concentrates on metals, dioxins/furans, PCBs, and wood smoke. Routine releases for the four areas of concern include the following:

- Point Sources
  - Chemical plants
  - Refineries
  - Steel mills
  - Chemical processing
  - Industrial boilers
  - Metallurgical processing
  - Fossil-fired power plants
  - Space heating (oil, coal and wood)
  - Municipal waste incinerators
- Nonpoint
  - RCRA and Superfund waste sites
  - Industrial and municipal solid waste sites
  - Accidental releases

(All of the nonpoint sources--RCRA and Superfund waste sites, industrial and municipal solid waste sites, and accidental releases--are covered in separate papers.)

Ecological Hazard Assessment

As stated in the Headquarters document *Unfinished Business*:

- The principal stress agents for ecological effects (from toxic air pollutants) have not been identified.
- Most of the studies to date on toxins have focused on human health effects, especially carcinogenic effects.
- Persistent compounds such as metals, PCBs, and TCDD may be of special importance ecologically because of food chain effects.

Unfinished Business also lists specific pollutants and their sources:

Pollutant	*Source*
Arsenic	Combustion sources such as waste oil burning, coal-fired utility boilers, wood smoke, smelters, glass manufacturing
Chromium	Waste oil burning, steel manufacturing, refractory manufacturing, metals manufacturing, combustion
Products of Incomplete Combustion (PICs)	Burning of wood and coal in small combustion units, coke operations, internal combustion engines

Impact Assessment

The category Hazardous/Toxic Air Pollutants requires the pathway from source to receptor to be via the air. But the ecological effects do not necessarily come through direct inhalation. The deposition of toxins on the ground or in the water may have large ecological effects. As noted in the EPA Headquarters report, atmospheric loading of toxic pollutants to the Great Lakes appears to be a major pathway, but details are unknown.

In some instances, such as the damage caused by large smelters in this country and abroad, the pathways are known. In general, concentrations of toxins will be greatest near major sources (which include urban areas), but ambient and deposition data are scarce.

Risk Characterization

Ecological impacts from the deposition, absorption, or inhalation of toxic air pollutants is possible for all ecological systems, except ground water, although even ground water may be threatened by toxic air emissions. Again, most of the work done to date regarding toxic air pollutants has been in the health effects area. Little has been done as far as the ecological risks of air toxins.

Unfinished Business states the uncertainties succinctly:

> Major weaknesses and gaps characterize the base of information on toxic air pollutants. Generally, the few air toxins emission inventories that are available show inconsistencies and anomalies, the air quality data that exist are inadequate to develop ecosystem exposure estimates, and few compounds have been tested for ecotoxicological effects. The data limitations preclude performing any type of comprehensive assessment of ecological risks.

7. Industrial Point Source Discharges to Surface Waters

Problem Area Definition

Point sources are sources of pollution that discharge effluents into surface waters through discrete conveyances such as pipes or outfalls. Discharges may result in contamination of surface water and subsequent injury or harm to aquatic organisms, wildlife, and humans. For this project, point sources have been divided into industrial (this category) and Publicly Owned Treatment Works (POTWs) (problem area #8). Pollutants of concern include total suspended solids, biological oxygen demand (BOD), toxic organics (e.g., PCBs and phenols), toxic inorganics such as metals, and thermal pollution. Typical sources of discharge include chemical manufacturing, metal finishing, pulp and paper processing, iron and steel production.

Summary/Abstract

The New England region of the United States has enjoyed strong industrial growth from the beginning of the industrial revolution through the ongoing development of the high technology industry. With this industrial growth has come significant industrial discharge of wastes. The three most significant industries in this regard are metal finishers, which discharge a variety of toxic heavy metals; pulp and paper mills, which discharge oxygen-depleting organics plus color and odor and possibly dioxin; and the textile industry, including tanneries that discharge heavy metals, toxic organics, and inorganics. New England is a small geographic area with an abundance of rivers and streams that serve as the receptors of these industrial wastes. The major impact of the industrial discharges is on fish and other aquatic organisms that live in small streams or rivers where natural dilution is insufficient to overcome the toxic concentrations. Numerous rivers and harbors hold posted fish advisories because of high levels of PCBs, dioxin, and other contaminants. In addition, some streams have no aquatic life due to continued discharges of metal plating wastes.

Sources

The EPA Region I office and the six New England states regulate more than 2,100 direct discharges of industrial waste to this region's surface waters. Of this total, 270 industrial dischargers are considered to be *major* dischargers by virtue of their waste volume, the strength or hazard of the contaminants, or their location with respect to sensitive water uses. The other 1,800 industrial facilities are labeled *minor* dischargers because of their size or the size of the receiving stream. These discharges include non-contact cooling water, small process waste volumes, and laundromat waste water. Only the major dischargers are considered to pose a significant hazard to the ecological resources in Region I.

Representative industrial categories in Region I include electroplating, metal finishing, jewelry making, pulp and paper, tanning, textile fabrication and dying, plastics and pharmaceuticals. These industries discharge a wide variety of contaminants, ranging from conventional oxygen-demanding substances to toxic metals to exotic chemicals with sometimes unknown impacts.

Connecticut and Massachusetts have the greatest number of industrial dischargers. On a per-square-mile basis, Rhode Island and Massachusetts have the same industrial discharge density (Figure 7-1).

In Connecticut, Massachusetts, and Rhode Island, the primary categories of industrial dischargers are electroplating/metal finishing, chemical industries, and pharmaceutical companies. In the less-developed northern states, the industrial discharges from pulp and paper, tanning, and textile industries predominate, with a small but increasing number of industries that discharge toxic metals.

Ecological Hazard Assessment

Industrial point sources discharge toxics, BOD, solids, and nutrients. Common pollutants include heavy metals such as mercury, copper, cadmium and cyanide; organic chemicals, including PCBs and PAHs; nutrients of nitrogen and phosphorus; and BOD. These compounds affect aquatic communities by differentially reducing or eliminating populations of certain species. Productivity is reduced and alteration in the structure of the aquatic community is likely to occur.

The oxygen-demanding materials and nutrients will lead to losses of dissolved oxygen in streams and to subsequent loss of production or even loss of life in the aquatic community. At depressed oxygen levels, organisms are less tolerant of toxicants and may succumb to toxicant concentrations that are ordinarily sublethal.

Suspended solids can settle in the receiving water, resulting in loss of habitat for benthic organisms, loss of valuable spawning area for fish, and loss of breeding/growth area for shellfish. Additionally, sediments contaminated with metals or organic chemicals may cause loss of life in benthic organisms or lead to the buildup of chemicals in the food chain, with impacts on finfish, shellfish, and wildlife consumers of this aquatic life. The impact is most severe in the local area of the discharge and can include a buildup in the sediment that will lead to long-term irreversible impacts. Also, certain persistent compounds such as PCBs can be transported considerable distances before they are deposited.

The Environmental Research Center (ERC) at Cornell University considered industrial discharges as having a high potential impact on all freshwater ecosystems. It is difficult to quantify the severity of the impact because it depends on many factors, including the dilution of the pollutant, the type of pollutant, and the mixing zone of the receiving stream.

Impact Assessment

The direct discharge of industrial waste to water bodies is the pathway of exposure. It is continual and immediate, with dilution or treatment prior to discharge being the only means of reducing the impact.

The volume of the industrial flow will lead to adverse chemical impacts where the receiving water flow is low compared with the discharge. Most of Region I is industrially developed in small watershed areas where the industrial waste flow in the warmer months represents a majority of the total flow. This presents an obvious problem since industrial wastewater, even highly treated for contaminant reduction, bears little resemblance to natural waters in terms of habitat value.

In New England, more than 50 percent of the major industrial dischargers are on streams where the normal level of conventional treatment and dilution are not adequate, and therefore the discharge will have a potentially long-term ecological impact unless additional treatment is applied. As a result, of the 270 major industrial dischargers, 140 require water quality based permits. Historically, in southern New England, these dischargers are geographically clustered, which may heighten local impacts. A recent extensive study of the Ten Mile River examined the long-term effects of toxic metal discharges to a slow flowing stream and its sediments. The stream, located in an area with geographically clustered industries, provided an opportunity to evaluate the cumulative impact to the ecosystem. The metal plating wastes have destroyed most of the aquatic life in the interstate water.

The overall actual amount of resources lost to industrial contamination in New England is difficult to estimate. Every two years the states must perform water quality analyses and report on the quality of their water bodies (the 305(b) report). However, since many factors, including industrial discharges, affect water uses, it is difficult to assess what percentage of ecological damage is caused by the industrial waste. New England states in the 1986 305(b) report estimated that between 0 percent and 42 percent of use impairment was caused by industry. In comparison, the national range is 0 percent to 85 percent, with a weighted average of 9 percent. It is reasonable to assume that most of the ecological impact is due to industrial dischargers, with lesser amounts due to habitat loss. As of October 1987, Region I has completed one cycle of permit issuance with attention focused on eliminating toxicity. Many facilities have permits with so-called safe limits on toxicants, many are proceeding with construction of necessary treatment works, and the remainder are conducting toxicity evaluations.

Of those facilities with permits in effect, a significant portion of discharges in any reporting period will not be in compliance with the limits. Further, until the completion of field surveys to verify the correctness of the permit limits, it will be impossible to assess the levels of protection provided.

Because of the uncertainty of the protection granted by the permits and the fact that a certain level of noncompliance will continue, it is impossible to accurately estimate the amount and locations of surface waters with fish, shellfish, and wildlife at risk.

There are sufficient data on the types of industrial discharges and their location. Good data on the locations and sizes of the streams in New England also are available. The Permit Compliance System (PCS), as part of the National Pollution Discharge Elimination System, has complete discharge data on all 270 dischargers. The Storet system, a national computer database, has some data on the water quality of numerous streams.

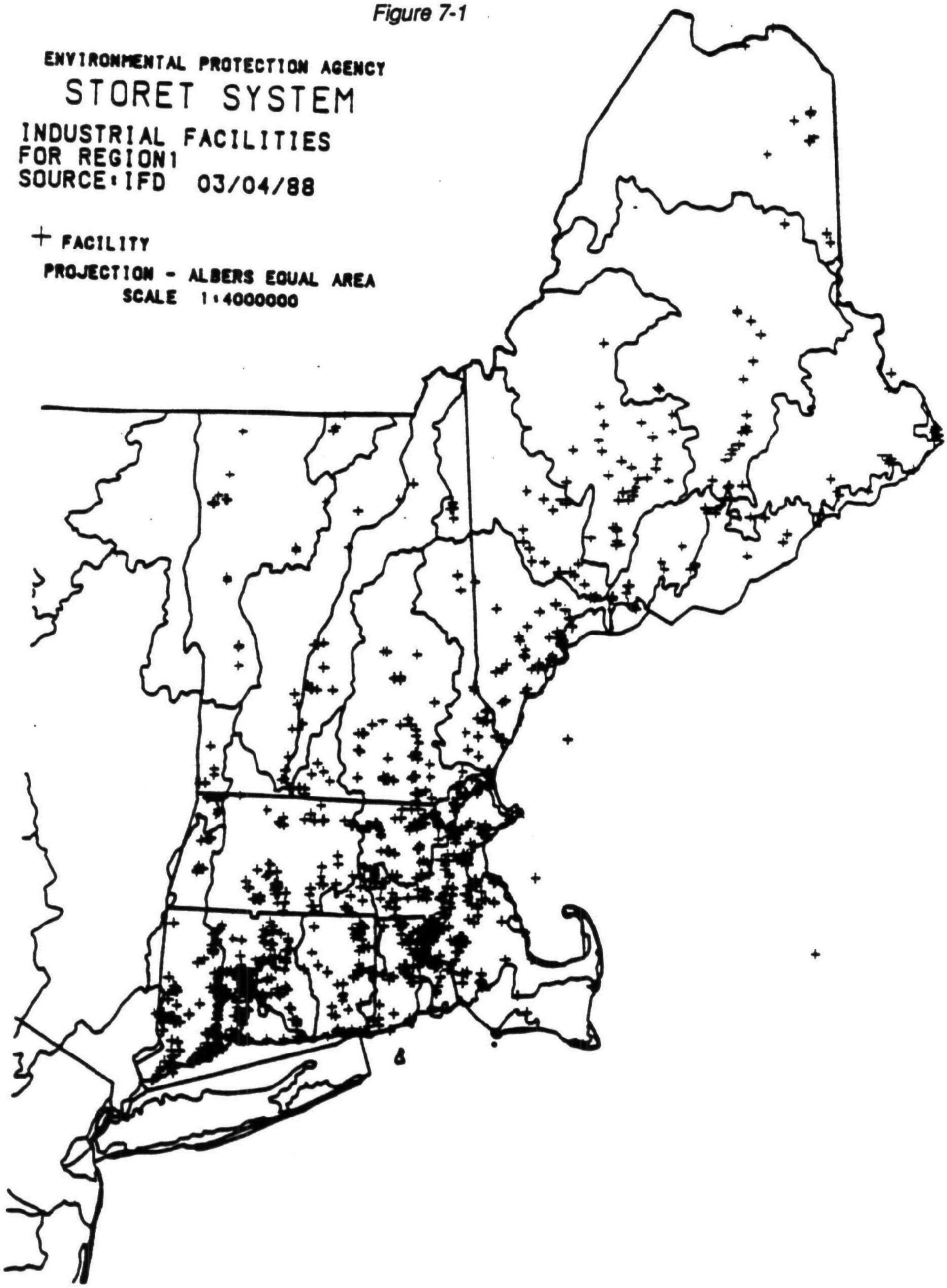
Risk Characterization

In New England, the majority of direct industrial dischargers are located on freshwater, streams, and rivers, and more than 50 percent of these need permits to control water quality. We ranked the impact of industrial discharges to streams as relatively high (5). The number of direct discharges to estuaries and wetlands is very limited; however, where they exist there is the potential for significant, irreversible, long-term impacts. The PCB contamination problem in the Acushet River and in New Bedford Harbor is an example. Impacts on these two ecosystems were therefore rated as medium (3). Based on very reliable state and EPA data in PCS, there are virtually no major direct industrial discharges to the marine ecosystem or into lakes; therefore, risks for these ecosystems received a low rating (2/1). The other ecosystems--terrestrial, agricultural, and ground water--are not directly affected by this problem and were considered to be minimally impacted.

Welfare

Industrial discharges have caused a loss of both recreational and commercial fishing and shellfishing. There are miles of stream reaches that post fish consumption advisories as well as numerous clamming flats that have been closed due to industrial pollution.

Figure 7-1


ENVIRONMENTAL PROTECTION AGENCY
STORET SYSTEM
INDUSTRIAL FACILITIES
FOR REGION1
SOURCE: IFD 03/04/88
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PROJECTION - ALBERS EQUAL AREA
SCALE 1:4000000

8. POTW Discharges to Surface Waters

Problem Area Definition

The discharges from Publicly Owned Treatment Works (POTWs), including industrial indirect dischargers connected to POTWs, travel to surface water. Indirect dischargers include all industrial facilities that are tied into a municipal sewer and do not have a direct outfall pipe. Discharges may result in contamination of surface waters and subsequent injury or harm to aquatic organisms, wildlife, and humans. Combined sewer overflows (CSOs) and stormwater discharges are included in this problem area. POTWs are also a major source of ammonia, chlorination products, pathogens, and nutrients, as well as metals and organic compounds commonly found in industrial discharges.

Summary/Abstract

New England has a population concentrated most densely along the coast. The region comprises cities and towns with old sewer systems and a large number of combined sewer overflows (CSO) and stormwater discharges. These relatively uncontrolled discharges cause a variety of short- and long-term problems in surface waters and are not easily controlled. The discharges are responsible for beach closings in the summer months, because of high bacteria counts from these sources, and closed shellfish areas because of either bacterial or toxic pollutants.

Region I is the only region in the country with four major estuaries of national significance: Boston Harbor, Buzzards Bay, Narragansett Bay, and Long Island Sound. These estuaries are under tremendous ecological stress because of municipal discharges, particularly CSOs and stormwater. Each estuary, as part of the National Marine Estuary Program, is being studied to identify the major sources of pollution and to develop a plan for cleanup.

New England has achieved a high level of POTW compliance with the requirements of the Clean Water Act. Approximately 95 percent of all major POTW dischargers are in compliance with their National Pollution Discharge Elimination System (NPDES) permits for secondary treatment or are on a judicial enforcement schedule. The remaining problems are due primarily to indirect industrial dischargers, nutrient loadings of phosphorous and nitrogen from all sources, and toxicity from chlorine and ammonia. These discharges, in combination with the CSO and stormwater discharges, greatly stress aquatic life and shellfish in surface waters and also create adverse welfare impacts by limiting recreational use of this water.

Sources

An estimated 748 publicly owned treatment works (POTWs) in Region I discharge to surface waters. Based on volume of discharge and location with respect to sensitive water uses, these POTWs are broken into major and minor categories, with 321 being major and 427 being minor. All municipal discharges greater than one million gallons a day (mgd) are considered to be major discharges. In addition to these known POTWs, there are countless CSOs and municipal stormwater discharges to surface waters that are untreated and not monitored.

Major dischargers vary in size from 1 mgd to the proposed 500 mgd secondary plant for the Boston area. Minor dischargers, because of their sizes and locations, are not considered to have as significant an impact on surface waters. However, any direct untreated discharge improperly located can close shellfish areas or beaches. Table 8-1 provides a breakdown by state of the total number of dischargers as well as the number of major and minor dischargers.

Table 8-1

POTW Dischargers In Region I

	Number of POTWs	Number of Major POTWS	Major POTWs as a Percentage of the Regional Total	Number of Major POTWs per 1,000 Square Miles
Connecticut	133	67	21	13
Maine	178	64	20	2
Massachusetts	208	101	32	12
New Hampshire	99	39	12	4
Rhode Island	33	20	6	16
Vermont	97	30	9	3
Total	748	321		

The older, larger New England cities usually have the most significant CSO and stormwater discharges. The city of Boston, for example, has 53 CSO discharges into Boston Harbor and its tributaries.

There are many more industrial dischargers tied into municipal sewer systems than those that discharge directly to surface waters. Within the MWRA sewer system, there are an estimated 2,000 major dischargers and 5,000 minor dischargers. This number is representative of all the major cities in New England (i.e., Providence, Springfield, Hartford). All these cities have developed pretreatment programs recently. These programs are managed by each city and rely on industrial self-compliance and monitoring. The limited monitoring creates a high potential for toxic discharges to POTWs.

Ecological Hazard Assessment

Municipal point source discharges from POTWs include conventional pollutants, biological oxygen demand (BOD), suspended solids, nutrients (ammonia, nitrogen, and phosphorous), organic and inorganic toxics from indirect dischargers, chlorine as a byproduct of disinfection, and pathogenic organisms. CSOs can discharge any combination of these pollutants. Stormwater discharges do not include indirect industrial sources but may include some toxic compounds in the urban runoff.

These different pollutants affect the aquatic community in different ways. Discharges of conventional pollutants, particularly nutrients, will typically cause a shift in community structure from a diverse biotic assemblage with higher level species to one dominated by less-desirable, pollution-tolerant forms. This shift is particularly serious in lakes and estuaries where nutrients may build up because of insufficient flushing action. Organic and inorganic toxics from indirect dischargers have the same effect as those from direct industrial dischargers. They disturb the aquatic community by differentially reducing or eliminating populations of certain species. Productivity is reduced and alterations in the structure of the aquatic community are likely to occur.

Suspended solids can settle in the receiving water, resulting in loss of habitat for benthic organisms, loss of valuable spawning area for fish, and loss of breeding/growth area for shellfish. Additionally, sediments contaminated with metals or organic chemicals may cause loss of life in benthic organisms or lead to the buildup of chemicals in the food chain, with impacts on finfish, shellfish, and wildlife consumers of this aquatic life.

Historically, chlorine has been used by all municipal dischargers as a means of disinfection. Recently, studies have shown that chlorine at low concentrations and without proper dilution can cause long-term toxic effects. A significant number of Region I's inland cities and towns where chlorine disinfection is used are located on small streams with inadequate dilution.

The Environmental Research Center (ERC) at Cornell University considered municipal pollution as having a high potential impact on all freshwater and estuarine ecosystems. It is difficult to quantify the severity of the impact because it depends on many factors, including the dilution and location of the discharge, the type of pollutants in the discharge, and the mixing zone of the receiving stream.

Impact Assessment

Direct discharge from POTWs to water bodies is the pathway of exposure. This discharge is continual, with dilution or treatment prior to discharge being the only means of reducing the impact. CSOs and stormwater discharges are intermittent, and their impact is related to factors such as the size of a rainstorm, the frequency between storms, and the time of the year.

All of New England is subject to impacts from municipal discharges. While there is greater risk in southern New England because of its concentrated population along the coastline, significant aquatic and wildlife damage occurs throughout the region.

The actual amount of ecological resources lost to municipal contamination is difficult to estimate, because water quality is affected by a variety of factors. Region I states say in the 1986 Report to Congress, *National Water Quality Inventory*, that 22 percent to 100 percent of the impairment stems from municipal discharges.

Table 8-2

Ecological Impairment from Municipal Wastes

State	Percentage of Impairment Due to Municipal Pollution
Connecticut	40
Maine	100
Massachusetts	26
New Hampshire	64
Rhode Island	24
Vermont	22
National Average	*17*

Because of the large impact of CSOs and stormwater, all of the New England states reported figures above the national average in terms of impairment caused by municipal contamination. Many of these discharges flow into important resource areas and cause significant ecological damage. Examples include Quincy Bay, where a recent study found aquatic organisms with toxic levels above standards for human consumption, the acres of clam flats closed in Narragansett Bay as a result of the Providence overflows, and the high metal level in sediments in Salem Harbor. It is extremely difficult to correct CSOs and stormwater discharges because of the high costs and the technological considerations involved in treating large intermittent flows effectively. Chicago and Milwaukee have built enormous underground tunnel systems to store, pump, and treat their CSOs.

A good computer data system on POTW discharges and their locations is available, as well as a good computer data system on the locations and sizes of streams in New England. The Permit Compliance System (PCS), as part of the NPDES, has complete discharge data on all 321 major dischargers. Also, the Storet system, a national computer database, has data on the water quality of numerous streams.

Numerous studies, both ongoing and proposed, aim to determine which sources are having the greatest impact on water quality and to identify control methods for these sources. For example, Vermont is planning a major interstate study of Lake Champlain to determine the impact of nutrient loadings and their sources. The estuary studies described previously are designed to determine the synergistic impacts of municipal discharges, CSOs, stormwater discharges, and nonpoint sources on the marine environment. Until these studies are complete, we can only estimate the relative impacts from the different sources. Evidence to date suggests that municipal pollution as a whole is having severe long-term effects on estuaries and on freshwater ecosystems.

Risk Characterization

In New England, the majority of municipal dischargers are located along the seacoast and inland waterways. Their potential impacts to estuaries and streams were ranked high (5). Restrictions on fishing and swimming provide evidence of these impacts. Boston Harbor is a prime example of the impacts to an estuary from municipal discharges. Most lakes do not have major municipal discharges that affect their ecological balance. However, there are exceptions where a major city has been built on a lake, such as the city of Burlington on Lake Champlain. There are even fewer true ocean discharges from POTWs in New England that affect the marine ecosystem. Discharges to wetlands are also rare and for this reason do not pose as high a risk as discharges to other surface waters. Impacts on all these ecosystems were ranked medium (3). There are very few direct discharges from municipalities to either agricultural or terrestrial ecosystems, and none where any impact has been shown; they were ranked low (1).

Welfare

Numerous welfare issues are related to municipal discharges. POTW contamination of surface waters leads to decreased value or loss of aquatic life resources. Fish and shellfish body burdens of toxicants may render them unfit for human consumption or less desirable if tainted with unpleasant tastes and odors. Additionally, all surface waters have the potential to be used as drinking-water supplies. The presence of POTW discharges may eliminate or reduce the value of receiving waters as potential water supplies. There have been increased incidences of beach closings due to high bacteria counts from POTW, CSO, and stormwater discharges. Beach closings in estuaries are all directly related to POTW pollution.

9. Nonpoint Source Discharges to Surface Waters

Problem Area Definition

Nonpoint sources (NPS) of water pollution are diffuse in nature and can derive from virtually any land use. They are generally considered to include any discharge to surface water through means other than a discrete conveyance or pipe. Nonpoint source pollutants may be transported to surface waters by runoff following rainfall or snowmelt, by mine drainage, or by suspension and dissolution of contaminated sediments.

Summary/Abstract

For New England, NPS pollutants come from five categories: agriculture, development, urban runoff, on-site treatment systems, and hydro-modifications. Runoff from rainfall or snowmelt is the pollutant pathway for agriculture, development, and urban areas. The discharge from these events is intermittent and of relatively short duration.

Nutrients and sediments are the greatest pollutant stressors. Nutrients cause eutrophication in impoundments, and sediments destroy benthic organisms.

The states have generally rated NPS impacts as moderate, with land or urban development the most widespread concern. Impacts from nutrients associated with agricultural runoff pose problems in all the farming areas of New England.

Sources

Nonpoint source pollutants may include runoff, on-site disposal systems (septage systems) atmospheric deposition, landfill operations, and hydro-modifications. The major concerns in Region I are runoff from agriculture, urban areas, and land development (including construction activities); on-site disposal systems; and hydro-modifications. On-site disposal systems are addressed in "Other Ground-Water Contamination" (problem area #19) and hydro-modifications are touched upon in problem area #11 (Wetlands/Habitat Loss).

Runoff is the largest contributor to NPS pollution in surface waters. Urban runoff, as the name implies, occurs near any urban area. It contains the droppings of animals, oily residues and washings from automobiles, organics, pesticides, lawn fertilizers, and similar substances. It may discharge as a bank load to the water body or be transported through storm sewers. The most extensive problems occur in the metropolitan areas of southern New England.

Runoff from development occurs throughout New England. With the healthy economy in Region I, the suburbs in southern New England have experienced a housing boom and industrial development. Concurrently, rapid development of recreational areas and second homes has occurred in ski areas and on shorefront properties. While the development stage may be short-lived, the immediate stress it places on water bodies may be long lasting. Typically, the resultant development generates an urban runoff problem.

Agricultural activities contribute to NPS throughout New England. Poor land management practices increase erosion and accelerate the flushing of fertilizers, manure, pesticides, and herbicides to adjacent waterways. Educational programs have helped eliminate some historical land use practices such as improper storage and spreading of animal wastes. The elimination of persistent pesticides and herbicides has greatly reduced the threat of those toxicants. Erosion and resultant sedimentation with nutrient additions continues to be problematic.

Hydro-modification activities include stream channelization, bridge building, bank stabilization, and dam building. The first three activities occur throughout Region I and are mostly associated with highway construction. Dam building for small hydropower development or recreational impoundments is an increasing activity in the upland streams. Vermont in particular is experiencing this pressure on its streams. During the construction stage, these activities cause siltation and choking of the stream beds.

Based upon the states' evaluations of their NPS problems, the following problems were the most significant:

- Connecticut--on-site disposal systems, landfills, habitat modification, and land development
- Maine--development impacting lakes and agriculture
- Massachusetts--on-site disposal systems, land development near lakes
- New Hampshire--landfills, construction related to land development
- Rhode Island--construction, land development, on-site disposal systems
- Vermont--agriculture, land development, hydro-habitat modification

Ecological Hazard Assessment

A detailed list of specific contaminants could be produced, but for the purposes of this paper a more generic list of problems such as sited atmospheric deposition, mining activities and silvaculture will not be considered, nor will in-place contaminants (sediments) and naturally occurring pollutants.

The principal ecological stressors considered are as follows:

Sediments	Toxic organics (pesticides, VOCs)
Nutrients	Oxygen-demanding wastes
Heavy metals	Highly variable stream flows or water levels

Sediments and nutrients have the most widespread impacts, disrupting or destroying aquatic habitats. Sediments cause a "blanketing" of stream benthos. They coat the bottom of streams and impoundments. Spawning beds are covered, which removes a hatching area from production and interrupts the life cycle of the species. In addition, the habitat of macrophytes is smothered, and food supplies for the aquatic community are destroyed. High spring flows flush most New England streams, and they may recover their "habitat." But the species population and food supply may take years to recover. The spring flushing does not improve impoundments, on the other hand, because the impoundment will be blanketed and filled as the sediment moves downstream and settles in the quiet waters.

Nutrients have the greatest impact in impounded or quiescent areas where they promote the growth of algae and rooted plants. Algal blooms may clog a water body, preventing boating and swimming, and create nuisance conditions. During the night, the blooms may deplete the dissolved oxygen in the water, killing other living organisms and themselves. At this point, the bloom area may become a decaying, stinking, biological slime. The entire effect is to accelerate eutrophication of the water body: Dissolved oxygen is reduced, light penetration diminishes, species are displaced, their diversity diminishes, and the water body dies. Eutrophication may be slowed but reversal is difficult. If the nutrients are dissolved in the incoming water and not bound up in the sediments, the problem may be remediated.

Heavy metals and toxicants also may stress aquatic organisms or "snuff out" their lives. Even a pulse of a toxicant, an acute dose, may destroy life for miles. The habitat has not changed, but life in the stream portion is unbalanced and can take years to be restored. Chronic exposure will cause the toxicant to accumulate in the organism, where it may stress or eventually kill the organism. Such bioaccumulation may be even more destructive to higher life forms that devour the contaminated species. Fortunately, such situations may be reversible once the toxicant is removed.

Impact Assessment

The stressors reach the environment primarily as a result of human activities. Hydro-modification is the only activity where the NPS impact results from in-stream activities. The other pollutants of concern are transported via rainfall and snow melt.

Nonpoint source pollution is a problem throughout New England and is highly localized. Even the locales are subject to change from year to year as development areas change.

Agricultural runoff, especially sedimentation, is a problem in Maine's Aroostook County. Nutrients associated with the agricultural runoff come from manure and fertilizer. Most of the farm areas in Region I are affected by the nutrients. The most noticeable impacts are within small, shallow impoundments with a low water-exchange rate.

Other agricultural runoff may include toxicants such as herbicides and pesticides. Isolated cases of spills or cleaning of equipment have caused fish kills but the impact does not appear to be as significant as those from agricultural runoff. Toxic pollutants, however, may be more significant in urban runoff. Lack of regional data about bioaccumulation of toxics in fish tissue makes assessment of the magnitude of exposure difficult, but the potential is great.

The states in their NPS assessment reports rated land or urban development as the most widespread NPS concern. These activities will have the greatest continuing impact on water bodies.

Urban runoff causes some concern in southern New England, but impacts may not be long lasting. Primary concern is bacterial loading (oxygen-demanding loads), which has negligible ecological importance. Also of concern are sediments, road salts, street droppings, and toxicants. These may have a significant impact for several days, but in most cases do not have long lasting significance. The evaluation does not include combined sewers as an NPS problem. Storm sewers, which are part of large collection systems, also are not considered an NPS problem and are included in problem area #15 (Municipal Waste Sites).

Dam construction (hydro-modification) causes concern in Vermont and in Maine. These projects have high visibility but tend to have primarily local effects.

Not all states used the same format for defining the extent of problems with nonpoint source discharges to surface waters. Some used river miles and acreage, while others used number of basins impacted and percentage of waters. The reported information is based upon qualitative judgement after review of the reports and discussions with Region I staff.

Risk Characterization

More than 100 miles of streams in New England are reported as moderately impacted by agricultural runoff. Urban runoff moderately affects a similar number of stream miles but significantly affects 60 miles of Rhode Island streams.

Lakes seem to be the most sensitive to NPS pollution. Because impoundments are the settling basins for rivers and streams, much of the NPS loadings sink in those locations. Because lakes and ponds do not purge themselves during high flow conditions, their problems are long lasting. The work group ranked NPS impacts on lakes as a 5.

The largest problem with nonpoint source discharges stems from nutrients and their resultant algal blooms. The growth leads to eutrophication--the loss of recreational use, the development of noxious conditions, the loss of habitat, and the death of a resource. Lakes are an important recreational resource to Region I. The high use of this resource attracts attention to the lakes, so that maintaining a healthy aquatic community and an aesthetically pleasing environment is important.

Sedimentation is the other significant stressor having the potential for far-reaching effects. The biological ecosystems of interdependent organisms needed to nurture life are being threatened by sedimentation. Soil eroding from land development and farmland blankets benthic communities and stream beds used for fish reproduction. Several hundred miles of streams in New England are affected. How many of those miles are in highly productive areas is unknown. The impacts on streams were ranked a 4.

Not included in this risk evaluation were damages to the marine environment. Estuaries are a valuable marine resource. They are the nursery and reproductive areas for much of marine life. Urban runoff would have a significant impact on these resources, especially if storm sewers were included as a nonpoint source discharge.

11. Habitat Loss

Problem Area Definition

This problem area includes risks from pollutants reaching wetlands, risks from physical alteration of wetlands and uplands, and impacts from physical alteration of wetlands and uplands. Activities that contribute to the problem include agricultural modification; flood control channelization; filling for highways, housing, and landfills; dredging for navigation channels, harbors and marinas; mining and resources extraction; discharges from point sources, nonpoint sources, and others, including contamination from hazardous waste sites. Such activities alter the salinity and water level while contributing turbidity, sedimentation, and numerous pollutants. The more significant overriding impact is the continued loss of habitat through the elimination of both wetlands and the adjacent uplands.

Summary/Abstract

The upland and aquatic habitats of New England have suffered major losses and disruption and continue to be destroyed at an alarming rate. Habitat is often sacrificed for short-term, seemingly persuasive reasons without consideration or appreciation of the long-term, unintended consequences. The seriousness or "risk" associated with habitat loss varies according to location in the region, nature of the threat, and the type of habitat affected. We believe the highest risk in Region I is concentrated in rapidly growing areas (e.g., central Connecticut, southern Maine, and New Hampshire). When historical losses are considered as well, risk increases north to south and closer to the coast. Some ecosystems, such as the tidal wetlands, are very sensitive to habitat disruption but are generally well protected; others (most upland types), while less sensitive, experience wholesale losses. Direct, reliable data are unavailable to assess the problem. The data that do exist are generally uncollated and difficult to retrieve. We assume that habitat loss correlates with growth and development. On that basis, we subjectively rank risk from habitat loss across eight ecosystem types and conclude that risk is high for upland, freshwater wetlands, and streams; moderate for lakes and agricultural lands; and low for marine systems, estuaries, and tidal wetlands.

Sources

This report focuses on the ecological risks of physical destruction or alteration of habitat and does not analyze other risks to habitat. The other risks, primarily those caused by the discharge of pollutants to the water, air, and land, are evaluated in separate reports prepared by the ecological work group. Moreover, from an ecological standpoint, the physical destruction (and in some cases alteration) of habitat overshadows the impacts caused by other factors.

The causes of habitat loss vary widely. Alteration of habitat ranges from outright destruction to the conversion of the habitat to less valuable types. Habitats differ in the values they provide and in their susceptibility to degradation. Likewise, the magnitude and frequency of habitat losses are not constant, but vary according to location within New England. In assessing risk, we must therefore be mindful of three main variables: the nature of the threat, the habitat in jeopardy, and the location within the region. In addition, we must consider the extent of adverse effects in both space and time. Far-reaching and permanent impacts pose greater risk than local and temporary ones.

Construction of roads, houses, factories, shopping malls, and other facilities destroys habitat. Other activities, such as industrial discharges, dam construction, pesticide applications, and stream channelization, alter or pollute a habitat. Some types of projects generate all three types of impacts. With highways, for example, the road construction directly destroys habitat, alters the hydrology and biology of the surrounding landscape, and pollutes nearby waterways.

While the sources of habitat destruction vary, the effect does not. Loss of the habitat means a total and permanent loss of natural resource values. Both the causes and effects of habitat alteration and pollution vary, ranging from beneficial (e.g., wildlife management actions) to adverse (e.g., channelizing streams) to severe (e.g., toxic discharges).

The major sources or "stressors" physically destroying or altering upland and aquatic habitat in New England are the following:

- Residential developments
- Industrial and commercial developments
- Dam construction
- Transportation projects, especially interstate highway or expressway construction
- Drainage and alteration of aquatic habitats for agriculture
- Logging/silviculture
- Solid waste disposal
- Peat mining

Often, one type of activity creates and reinforces the "need" for another. Industrial development along Route 128, for example, contributed to a housing boom in nearby communities. This, in turn, increased traffic and aggravated solid waste disposal problems. The solution for each problem accelerated the destruction of habitat (or, in the current jargon, "loss of open space").

We continue to lose habitat in New England, with the central and southern sections suffering the greatest impacts. It is also in these areas, especially near the coast, where the most significant historical losses have occurred. In recent years, habitat loss has been most pronounced in certain "hotspots" in the region--southern Maine and New Hampshire; Burlington, Vermont, and vicinity; southeastern Massachusetts; and central Connecticut. In some areas (e.g., certain counties), habitat is shrinking at an alarming rate; in other parts of the region only small-scale losses are occurring. Some habitat types (e.g., ocean, saltmarsh) either experience little development pressure or are now well protected. Ongoing rapid destruction characterizes other habitats (interior deciduous uplands, coastal uplands).

Ecological Hazard Assessment

Our densely populated landscape and long history of settlement underscore the special concerns the loss of habitat issue holds for us in New England. Although local and state authorities control development more tightly in New England than elsewhere, we must view current habitat losses in a historical context. By the end of the eighteenth century, settlers and farmers had cleared much of the land for agriculture. In the ensuing 50 years, New England became a much more industrial society. Factories were built, rivers were dammed, the coastline developed--all at the expense of the extant natural habitats. (A number of authors have examined this issue; see, for example, *The Changing Face of New England*, by Betty Flanders Thomson.) Although heavy industry eventually declined in New England, much natural habitat was forever lost.

Habitat loss can be analyzed on several different geographical and biological scales. Impacts may be viewed in the immediate (i.e., within project boundaries) or local (e.g., watershed) area, or in a broader context (e.g., ecotype, political boundaries). Biological effects can be measured at the individual, population, species, or community level. As a rule, adverse effects become more difficult to quantify and analyze at the higher and more complex levels. A single episode of habitat loss, such as construction of an industrial park, may be devastating to individuals, detrimental (but difficult to quantify) to populations, and scarcely noticeable at the species and community levels.

It is beyond the scope of this paper to discuss in detail the direct ecological effects of habitat loss. The national study did summarize in general terms the main threats facing aquatic habitats but did not address upland habitat losses. The subject received some attention in the literature and, while much research remains to be done, a considerable body of knowledge has been amassed. Some key ecological impacts that result from habitat loss or alteration are:

- *The extirpation of local populations of a given species*--Loss of particular features of a habitat critical to a given species can occur (e.g., loss of tree cavities for nesting birds when mature woodland is replaced with a pine plantation). Loss of critical habitat could result in complete extinction for endangered or threatened species.

- *Disruption of normal movement patterns of species*--Physical barriers such as dams and highways block normal migratory routes. Many organisms cannot cross areas of inhospitable habitat to reach the favorable habitats, fragmenting species into small, isolated populations more vulnerable to extinction.

- *Proliferation of common nuisance species of plants and animals*--As these species prosper, the overall productivity and diversity of ecological communities decrease.

- *Physical habitat alteration that indirectly kills or impairs organisms*--For example, dredging sediments may release toxic substances into the water column, resulting in death or damage to aquatic organisms.

- *Sublethal effects to animals*--Animals will alter their behavior, competitive interactions, predator-prey relationships, or reproductive success.

- *Degradation or disturbance of natural hydrological functions*--Habitat loss correlates directly with increased pollution of surface and ground water, disruption of ground-water discharge and recharge, and alteration of natural patterns of stormwater flow, storage, and release.

- *Increase in turbidity/suspended solids*--In some cases, toxic organic and inorganic chemicals also increase.

- *Alteration of energy flow and nutrient cycling (nitrogen, sulfur, and carbon cycles)*

- *Adverse effects on local weather and global climate*

These impacts weaken or degrade the physical or chemical environment needed by ecological communities for survival. Moreover, most if not all of these effects become far more alarming when viewed cumulatively or interactively. For example, beyond the obvious impact of habitat destruction we must also consider the deleterious effects of habitat alteration and fragmentation. Altered habitat (e.g., after impoundment) is usually depauperate compared with the natural system that once existed. Not only do direct physical assaults modify or destroy habitat, they also make natural communities more susceptible to other environmental stresses, some of which we consider elsewhere in the regional study.

While the direct impacts of large projects are readily identifiable, cumulative losses continue to be a major concern. Many proposals to alter habitat appear reasonable (and may, in fact, be reasonable) when viewed alone, but taken together produce an unacceptable result. This reflects the difficulty of evaluating the effect of piecemeal habitat losses in a large spatial or temporal context. Cumulative impacts manifest themselves in different guises--as additive, exponential, positively or negatively synergistic, or as thresholds. The sudden outbreak of waterfowl cholera in the Dakotas illustrates the threshold effect: The decline of prairie pothole habitat created overcrowded conditions under which the disease could infect a large number of birds. Except for such anecdotal studies, few data exist upon which to predict the long-term or indirect effects of habitat loss.

Impact Assessment

We have located few data that directly bear on the issue of habitat loss and alteration. Insofar as data do exist, they are scattered, uncollated for the most part, and distributed among many government agencies at different levels, academic institutions, private groups, and individuals. Simply trying to assemble the information would be a daunting task beyond the resources of the regional study. Moreover, the objectives, methods, geographical coverage, and quality control undoubtedly differ markedly among studies. Had we restricted our analysis to a specific habitat (e.g., peat bogs) or area (e.g., Cape Cod) we could have assembled more reliable data,[1] but it would not have been representative of the overall situation in Region I.

An ideal assessment would allow us to judge the severity of risk to each habitat type from each type of stress. A more realistic approach, given our constraints, would be to locate areas of high growth and development in the region and identify (or infer) the resulting habitat losses (i.e., trends). State and regional planning or environmental review agencies may keep records of major development activities or trends. Moreover, documents produced by project proponents often disclose the types of habitat impacts expected to occur. We provided a list of contacts to the regional risk study contractor and asked them to assemble data along these lines. The effort generally did not uncover any good data that systematically address the issue. Anecdotal evidence, however, suggests that the natural landscape of New England is rapidly being despoiled.

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[1]While information on this limited scale would not be predictive for purposes of regional risk evaluation, it would be useful in evaluating and controlling ecological losses in high-risk areas.

- By the year 2000, 80 percent of the U.S. population will live within 50 miles of the coast. The impacts of this seaward migration and ribbon of development along the coast will be particularly heavy in a coastal region like New England.

- From 1982 to 1987 construction contract awards (commercial, industrial, residential, public works, and utilities) increased by 63 percent in the United States. During the same period in New England, the award rate jumped by 158 percent--2.5 times the national increase.

- Housing starts in New England doubled from 1982 (42,300 units) to 1985 (92,300 units).

- *The Boston Globe* (April 10, 1988) reports that "construction devours 600 acres each week of Massachusetts farmland, forests, and other open space. . . ." The population on Cape Cod has grown 27 percent and its housing stock 43 percent in the last decade.

- Federal permit requests for dredge and fill work, ocean disposal, and placement of structures have risen from roughly 1,600 in 1983 to the more than 5,500 projected for 1988.

- In Massachusetts, notices of intent filed with conservation commissions increased from 2,393 in 1981 to 7,226 in 1987, a 159 percent increase in activity. The state expects 10,000 notices to be filed in 1990.

- Although comparative historical data were not available, New Hampshire reports processing approximately 2,300 dredge and fill permits in 1987 alone.

These data do not show the total extent of habitat loss nor partition it by habitat type, but they do demonstrate the unprecedented building explosion in New England in recent years. Without exact figures, it seems reasonable to assume that the rapid rate of development translates directly into loss or alteration of habitat. While some of the development work involves renovation or replacement of existing structures, much of it undoubtedly occurs at undeveloped sites. Since state and federal laws strongly discourage destruction of wetlands and other aquatic habitats, the majority of impacts probably occur in upland areas.

The information discussed above led us to qualitatively describe the impact of habitat loss on each of the eight ecosystems as shown below:

Marine

Little destruction of the habitat except along the immediate coastline for erosion control, causeway construction, and marina development. Widespread alteration of habitat from dredging occurs but adverse effects are neither permanent nor severe on a broad scale. Some work (e.g., dredging in eelgrass beds) causes substantial impacts.

Estuaries

Impacts occur from marina development and the straightening and filling of shorelines. Dredging of intertidal areas (e.g., mudflats) destroys shellfish habitat. While direct loss of this habitat type is uncommon, estuaries are sensitive to perturbation (e.g., changes in salinity).

Tidal Wetlands

Very little destruction has been allowed since state and federal regulatory actions began. The resource has suffered major historical losses, however. This sensitive ecotype is now well protected.

Streams

Channelization and culverting are the main threats. Few large-scale projects are mounted but a multitude of smaller ones occurs. Outright habitat loss is less of a problem than alteration by eliminating meanders, backwater areas, and riffle/pool complexes. Data are available on streams but uncollated.

Lakes

Most physical alteration occurs at the shoreline. Some "landgrabs" also occur. Drawdown and dredging cause adverse but not usually permanent impacts. Uncollated data are available for only some stressors.

Freshwater Wetlands

Highways, dams, and residential construction, especially in southern Maine and New Hampshire and central Connecticut, threaten this ecosystem. Peat mining is a growing concern in Maine. The largest single threat is from the Big River Dam in Rhode Island, which would destroy more than 600 acres of productive inland wetlands. Conversion of freshwater wetlands for agricultural use (e.g., cranberry production) is a problem in southeastern Massachusetts. Data on the ecosystem are better for major projects than for minor areas (<1 acre in impact).

Upland

Hard data are virtually nonexistent because this habitat is poorly protected by state and federal laws, but the ecosystem is under siege from development of all types. These habitats are generally considered less valuable than aquatic systems, but the magnitude of the losses is significant.

Agriculture

The adverse impacts mainly affect health and welfare. However, New England loses large farmland acreages to residential and other types of development. As an ecosystem, agricultural lands are monotypic, disturbed areas of less value than natural areas. Nevertheless, they do provide some natural resource values (food, cover, etc.), especially when juxtaposed with other habitat types.

Risk Characterization

The Ecologocal Risk Work Group ranked the impact of habitat loss on upland (terrestrial) areas as 5 and the impacts on streams and freshwater wetlands as 4. Lakes, tidal wetlands, and estuaries received a 2 ranking due to protection afforded those areas and the limited opportunity for additional perterbations. The marine ecosystem was ranked in the lowest category because of the small area of effects and the generally non-permanent nature of effects. (Ground water and air do not suffer habitat loss in the standard sense and are not applicable to this analysis.)

The National Comparative Risk Project ranked the ecological risk of habitat loss second only to global warming. It concluded, "Physical habitat alteration is the stress that has the greatest adverse impacts on ecosystems," and further commented, "Perhaps the single most important stress, which tends to eclipse most of the others for most ecosystems, is the alteration--including outright destruction-- of habitat."

Welfare

Habitat loss causes serious human-use impacts as well. Destruction or degradation of fish or shellfish habitats adversely affects both sport and commercial interests. Upland habitat losses similarly affect commercial and sport hunters and trappers. Recreational opportunities (e.g., hiking, boating) suffer when natural habitats are destroyed. Loss of habitat is often costly too. Floods become more frequent and damaging; shorelines erode; drinking water becomes more polluted. Having lost the "free work of nature," we often have to engineer expensive and only partially effective solutions that otherwise might not have been necessary. We did not evaluate these and other welfare impacts of habitat loss. However, the national study did treat the issue in detail.

13. RCRA Waste Sites

Problem Area Definition

This category includes the risks posed by hazardous waste sites regulated under the Resource Conservation and Recovery Act (RCRA). More specifically, it includes operating and inactive RCRA landfills and surface impoundments, hazardous waste storage tanks, hazardous waste burned in boilers and furnaces, hazardous waste incinerators, and associated solid waste management units. Seepage and routine releases from these sources contaminate soil, surface water, and ground water, and pollute the air.

Summary/Abstract

The RCRA waste sites problem area ranks low in the overall ecological damage to the receptors. The major significant concern is the welfare impact caused by the degradation of ground water, which may cause a need to obtain alternative water supplies and potential loss of property value. The exposure route is primarily from releases from land disposal units such as surface impoundments and landfills. Contaminants mostly consist of volatile organic compounds and heavy metals. However, the impact is generally localized and can be detected with adequate ground-water monitoring systems.

The potential effects of the SWMUs pose the uncertainty in this problem area. The SWMUs can pose a greater impact on ground water than RCRA units because most of the solid waste units do not have proper lining or any ground-water monitoring systems in place. However, at this time, Region I lacks sufficient data on the universe of SWMUs.

Sources

According to the regional database, New England has about 350 RCRA treatment, storage, or disposal facilities. Table 13-1 indicates the types of facilities and locations within Region I; data on SWMUs are not included due to insufficient information.

Table 13-1

Distribution of RCRA Waste Facilities in New England

Location	Storage	Land Disposal	Incinerator	Total
Connecticut	128	74	2	204
Massachusetts	71	20	1	92
Maine	22	5	0	27
New Hampshire	5	4	0	9
Rhode Island	13	0	1	14
Vermont	4	0	0	4
Total	243	103	4	350

Table 13-2 shows the quantities of wastes generated annually in Region I and the amount of wastes handled on-site and shipped off-site. The information is based on draft 1985 state data and has been edited by Temple, Barker & Sloane, Inc. (TBS).

Table 13-2

Waste Generated Annually in New England

Location	Waste Generated (metric tons)	Waste Handled On-Site (metric tons)	Waste Shipped Off-Site (metric tons)	Waste Shipped Within Region (metric tons)
Connecticut	157,042	57,953	97,089	49,265
Massachusetts				
Maine	7,876	1,766	6,110	5,049
New Hampshire	19,495	2,919	16,575	10,951
Rhode Island	11,455	207	11,248	8,280
Vermont	13,981	1,976	12,005	4,618

*Massachusetts data were not available for analysis.

Ecological Hazard Assessment

More than 100 compounds may be found at RCRA sites across Region I. The common stressors of concern include compounds such as 1-1-1 trichloroethylene, toluene, benzene, heavy metals, and synthetic organics.

The potential impacts on the ecosystem caused by the RCRA waste sites consist of direct and indirect impacts that result in the degradation of ecosystems. Releases could increase the concentration of contaminants in surface water or air such that the productivity of vulnerable ecosystems is increased.

Impact Assessment

The major pathways of exposure from the RCRA waste sites are releases of contaminants into the ground water and into the surrounding soil. Other potential pathways of exposure include the discharge of pollutants into the surface water from the contaminated ground water, the release of contaminants in air from the hazardous waste incinerators, and the volatilization of the organic compounds from the storage and land disposal units.

The magnitude of exposure from the RCRA waste sites is highly site specific and variable. Overall, the impact is generally localized and the severity of effects low on the ecosystem.

Federal regulations impose strict requirements for both operating and inactive RCRA waste sites. For the operating RCRA land disposal facilities, the federal regulations require installation of liners and leachate collection systems. In addition, the owner/operator is required to install ground-water monitoring systems to detect any releases from the units. If release is detected, the owner/operator must conduct a ground-water assessment monitoring program to determine the rate and extent of the release and implement corrective action. For the inactive RCRA land disposal facilities, the federal regulations require the closure of the units within 180 days from the last receipt of waste. The owner/operator could either clean-close the unit or close as a landfill. The regulation for clean closure requires removal of all the contaminants to health-based standards. For closure as a landfill, the regulation requires an RCRA cap consisting of an impermeable membrane and leachate collection. In addition, post-closure care and ground-water monitoring are required for 30 years.

Risk was assessed using the Regional Hazardous Waste Planning Model previously developed by TBS for EPA. The model was designed to assess the relative costs and risks associated with various hazardous waste management strategies. To estimate risk, the model uses generator-specific data on quantities of waste handled, how it is handled, and where it is handled, along with average releases algorithms and data on exposure parameters. The waste data come from validated annual reports filed with each state. The waste constituent data and releases algorithms were developed by EPA's Office of Solid Waste. The exposure parameters (hydrogeologic setting, temperatures, population, locations, drinking-water source type) were developed by TBS for each geographic area in Region I where waste handling takes place. These characterizations are rough in some cases, with each location being forced into one of several possible characterizations for each exposure parameter.

Based on estimates of typical constituents of the hazardous wastes generated in Region I, more than 100 compounds could be expected to be found in RCRA sites across New England. The model is based on estimates of the ambient concentrations in the air, surface water, and ground water for these compounds, which include arsenic, benzene, cadium, carbon tetrachloride, chloroform, chromium, dichloromethane, ethylene dibromide, lead, mercury, perchloroethylene, PCBs, toluene, vinyl chloride, and xylene. The ambient concentrations for 17 of the compounds were compared with water quality criteria to determine the potential impact to ecosystems. In no instances were water quality criteria estimated to be exceeded.

Risk Characterization

Impacts on wetlands and streams were ranked as medium (3) by the work group. Even though the modeling results did not show any exceedances of water quality criteria, the work group felt that those results were based on overly conservative assumptions (e.g., stream measurement point distance). The other ecosystem impacts were all ranked in the lowest category due to a lack of pathways and exposure and the localized impact of RCRA sites (e.g., marine and lakes). Overall, the problem area was ranked in the lowest risk category by the Ecological Risk Work Group.

As discussed previously, one of the uncertainties is the lack of data on SWMUs. Since most of the SWMUs are unlined and have no ground-water monitoring provision, this could have a greater impact than RCRA units. Based on an examination of RFAs for nine facilities in Region I, more than 200 SWMUs were found, or an average of more than 20 SWMUs per site. These SWMUs were generally of two types: tanks and drums, or unlined landfills and lagoons. Further investigation found that the materials in these SWMUs were generally consistent with current activities and wastes at the site.

The percentage of problem covered is estimated to be medium. Region I has reliable data on the RCRA universe. Data on SWMUs, however, is lacking and therefore reduced our estimate of the percentage of the problem covered.

Assuming that the waste types and annual volumes are roughly equivalent to the present activities at the sites, the model can develop a very rough estimate of the impact of the SWMUs. The drums and tanks currently regulated pose very minimal risk as estimated by the model; we would estimate that the SWMU drums and tanks probably pose a higher but still minimal risk. The unlined landfills and lagoons, however, may pose higher risks than those posed by currently regulated RCRA units. Due to the uncertainty in this area, however, we did not alter the risk ranking of the problem area.

The Region I study ranking is consistent with that of the national study. The national study ranks active hazardous waste sites "low" in the overall impact on the ecosystem. The study concluded that the reasons for the low ranking are due to adequate control of spills and releases, localized impact, and the unlikelihood of a catastrophic event. However, the national study does not take into account the effect of the SWMUs.

Welfare

The RCRA Waste Sites problem area ranks medium (4) in impacts to ground water. The potential impacts could be categorized as follows:

- Leakage of pollutants from hazardous waste sites into ground water, which may cause a need to obtain alternative water supplies
- Loss in property value due to soil contamination
- Loss in value of the affected property due to contamination of ground water

14. Superfund Waste Sites

Problem Area Definition

This category includes hazardous waste disposal sites that are regulated by Superfund. Generally, they are inactive and abandoned sites. They include sites on the National Priorities List (NPL), those deleted from the NPL, those that are candidates for the NPL, and any additional sites that states may be addressing. Releases from these sites may contaminate ground water, surface water, sediments, and soil, and pollute the air. Pollutants include many toxic and hazardous chemicals.

Summary/Abstract

The ecological impacts from Superfund sites in Region I have been qualitatively evaluated. The most likely ecological effects of approximately one-half of these sites will result from contamination of streams and/or freshwater wetlands. Many Superfund sites are close to these ecosystems, and the chemicals typically found at many of these sites have acute and/or chronic effects on aquatic organisms.

The welfare impacts from these sites are a major concern. Ground water is a vital resource in New England, and many Superfund sites have contaminated this resource within the site boundaries and, in some cases, beyond the site boundaries, affecting municipal water supplies or nearby residential wells. Many of these sites are near residential areas and may affect local property values.

Sources

The ecological risk evaluation focused on the 59 proposed and final NPL sites (as of early June 1988) located in EPA Region I. At present, no sites in Region I have been deleted from the NPL.

The distribution of the 59 NPL sites in the New England states is as follows:

State	Number of NPL Sites	Percentage
Connecticut	8	13.6
Massachusetts	21	35.6
Maine	7	11.9
New Hampshire	13	22.0
Rhode Island	8	13.6
Vermont	2	3.3
Total	59	100.0

This analysis will use the definition of "natural resources" found in Section 101(16) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986:

> Land, fish, wildlife, biota, air, water, ground water, drinking-water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Fishery Conservation and Management Act of 1976), and State or local government, any foreign government, an Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe.

Limited information is available on the approximately 1,650 hazardous waste sites presently being evaluated within Region I for possible inclusion onto the NPL. One hundred twenty-nine sites have undergone a removal action to abate an imminent or substantial threat (primarily threats to public health) from the release of hazardous substances from these sites. Approximately 25 percent have undergone a complete preliminary assessment and site inspection (PA/SI) under the Pre-Remedial Superfund Program. Only 132 (5 percent) of these sites have been determined not to warrant any further action within Region I to date.

It should be noted that for those sites with completed PA/SIs, evaluations were made using the old Hazard Ranking System (HRS) methodology. This methodology placed little emphasis on ecological impacts.

Ecological Hazard Assessment

Each Superfund hazardous waste site typically contains a hodgepodge of pollutants that occur in all media. Most, if not all, of these pollutants have short-term and/or long-term effects on aquatic and/or terrestrial organisms.

The National Comparative Risk Project (NCRP) presented a list of the 30 most frequently observed chemicals, and their respective percentages, based on a preliminary national survey of 540 hazardous waste sites. The compounds listed are typical of those found at NPL sites in Region I. They include trichloroethylene (55 percent), lead (57 percent), toluene (43 percent), PCBs (29 percent), methyl ethyl ketone (7 percent).

The NCRP also provided results from a 1985 survey of 277 NPL sites. The results indicated, "Approximately 6 percent of the 277 NPL sites reviewed are likely to have significant natural resource injuries--commercial effects (primarily to fisheries) or recreational effects large enough to bring upon damage suits. Another 16 percent may have some possibility of injury to natural resources."

The frequency of potential ecological injuries mentioned for these sites was as follows:

Surface	90%
Wetland	37%
Fisheries	55%
Other (land, forests, endangered species, marine mammals, biota, and wilderness)	32%

Non-NPL sites also have the potential for natural resource injury.

The NCRP identified three anthropogenic ecological stressors of greatest importance--acid, toxic organics and inorganics, and ground-water contamination--and attempted to prioritize the potential ecological effects from these environmental stressors on a biosphere, regional, and ecosystem basis. The results indicated that for the Superfund problem area, toxics in water are of medium ecological importance on a regional scale and ground-water contamination is of unknown, but potentially very significant, importance on an ecosystem scale.

The two Superfund trustees--the Department of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA)--have studied Superfund sites. Their focus is principally on chemicals that are highly persistent and/or severely toxic. Chemicals typically characterized by these parameters are metals (e.g., lead and chromium), polycyclic compounds (i.e., PCBs and dioxins), and/or pesticides in surface water/sediments and ground water.

Impact Assessment

Based on sources presented above, the pathways of exposure were identified as surface waters and ground water. The work group focused primarily on surface-water exposure via runoff and/or ground-water discharge to surface waters.

The ecological impacts from the air exposure route at Superfund sites, while a "natural resource" as defined previously, is very difficult to quantify or qualify from an ecological perspective. Further, it primarily involves human health and welfare effects. Local air impacts to terrestrial and/or agricultural ecosystems in the vicinity of Superfund sites have not been investigated to the degree that would allow even a qualitative assessment.

Most of the information for this analysis comes from NOAA and DOI. Substantial quantitative information on ecological damage is available from only a few of the 59 Region I NPL sites. However, there is a national coordination program, established by EPA (with DOI and NOAA), to conduct "Preliminary Natural Resource Surveys" (PNRSs). The objective of the PNRSs is to assess available site-specific information and determine the need for a complete damage assessment or to provide a release from ecological damages from a particular site.

In lieu of having these completed surveys, NOAA (in 1983) initiated a systematic review of the potential for Superfund sites to cause injury to their resources, e.g., marine fisheries, anadromous fisheries, marine mammal habitats, and endangered marine species. The DOI, the trustee for migratory birds, endangered species, and DOI land and waters, undertook a similar but less intense review process of selective NPL sites by conducting preliminary PNRSs. The Region I NPL sites covered by DOI or NOAA to date can be summarized as follows:

- NOAA--All 59 sites have been reviewed; four sites have been issued a "release"; one site has a release pending; and one site is in litigation (New Bedford Harbor).

- DOI--A preliminary PNRS has been completed for 16 sites; 10 sites have been issued a release; and one site has a potential for litigation (New Bedford Harbor).

The assumptions used by NOAA and DOI are considered accurate and representative for this analysis. These data will be extrapolated to non-NPL sites in Region I. This approach is consistent with the model used in the NCRP for this problem area.

Risk Characterization

The results from NOAA's site evaluation process (1983 to 1987) of the 59 NPL sites in Region I showed the following *potential* impact distribution:

State	Number of NPL Sites	Number of Impacts	Percentage
Connecticut	8	3	38
Massachusetts	21	12	57
Maine	7	6	86
New Hampshire	13	5	38
Rhode Island	8	5	61
Vermont	2	1	50
Totals	59	32	54

Data from 24 of the 32 sites identified for their potential NOAA trustee impacts reveal that virtually all Superfund sites have possible injury to recreational and/or marine fisheries (shad, trout, salmon, etc.) via surface-water contamination. Four sites (approximately 7 percent) have potential impacts to estuaries due to their close proximity to the Atlantic Ocean. One site--New Bedford Harbor--has shown significant contamination in marine species. As a result, New Bedford harbor is closed to the harvesting of all finfish, shellfish, and lobster. (Note: NOAA considers potential impacts to occur even if no known [but potential future] installations of fish ladders in streams are or will be present).

The results from the 16 sites for which DOI has conducted a preliminary PNRS were not yet available for review. However, based upon the information cited previously, 6 percent (1/16) of these sites had sufficiently serious injuries to warrant a potential damage claim on impacted DOI trustee resources (approximately 30 percent--five sites--are currently being evaluated further). No sites to date have had any formal damage claim made by DOI.

Assuming that 33 percent of the current non-NPL sites in Region I will become NPL sites and that approximately 50 percent of these sites have a potential for natural resource injuries, roughly 250 new Superfund sites in Region I could have potential ecological effects. Based upon similar assumptions, approximately 30 sites could have significant natural resource injuries in the future.

The Region I results are similar to the results of the NCRP, i.e., 2 percent to 6 percent of NPL sites are likely to have sufficient ecological impacts to natural resources, commercial or recreational, to bring upon a damage claim. However, the NOAA information projects a 38 percent increase in the potential for ecological injury in Region I. NOAA's identification of the potentially affected ecological receptors in Region I was generally consistent with those of the NCRP. Due to the locations of Superfund sites, the work group ranked the impacts on streams and wetlands a 4; all other ecosystem impacts were ranked as a 2 or a 1. Ground-water impacts were ranked a 5.

The uncertainty in these results is significant. Large-scale biological sampling efforts have not been undertaken at many of the 59 NPL sites in Region I. The upcoming PNRSs to be conducted by NOAA and DOI over the next two years should significantly increase the amount of quantifiable ecological information on the impacts from Superfund sites in Region I.

Based upon the 59 NPL sites for which some limited, qualitative information is currently available, it is difficult to quantify the percentage of the problem area addressed. Assuming that approximately 250 additional hazardous waste sites could indicate a potential for ecological impacts now or in the future, this analysis addresses only 25 percent of the problem area.

Welfare

Ground water is a vital natural resource in Region I. Contaminated ground water has a significant welfare impact at almost all of the Region's 59 NPL sites. Alternative drinking-water supplies have been developed at five sites where the entire municipal water supply is contaminated.

The loss of property values of residences around Superfund sites can be very significant. No Region I-specific data is available to better qualify this statement.

15. & 16. Municipal Waste Sites Industrial Waste Sites

Problem Area Definition

The municipal waste sites category includes exposures to releases from open and closed municipal landfills, municipal sludge and waste incinerators, municipal surface impoundments, land application units, and land treatment units. Impacts from the management (disposal, treatment, reuse) of all household, municipal, and other solid waste not regulated by RCRA are included here. Routine and non-routine releases, soil migration, and runoff can contribute particulates, toxics, biological oxygen demand (BOD), PCB, and nutrients to air, soil, and surface and ground water.

The industrial waste sites category consists of industrial waste, including sludges handled in nonhazardous industrial landfills, industrial surface impoundments, land application units, and land treatment units subject to Subtitle D, along with numerous incinerators. Routine and non-routine releases, soil migration, and runoff may contribute particulates, toxics, BOD, PCBs, and nutrients to air, surface water, ground water, and soil.

Many municipal landfills receive wastes other than household wastes, such as sludge or incinerator ash. We consider only those landfills that receive at least 50 percent of their waste from household and commercial sources to be municipal landfills. Landfills receiving less than 50 percent household and commercial waste (i.e., ash, small quantity generator waste, sludge, mining) would be classified as industrial landfills.

Due to a lack of information on industrial landfills in the Region (e.g., their number and location), we were only able to evaluate these facilities relative to the municipal facilities. That is, we based our judgment of the risk of industrial waste sites on our estimate of the risk associated with municipal waste sites (specifically active municipal landfills).

Note that risks from these two problem areas (municipal and industrial waste sites) may be double-counted with Other Ground-water Contamination (problem area #19), Hazardous/Toxic Air Pollutants (problem area #3), and Surface Water Discharges (problem areas #7, #8, and #9).

Summary/Abstract

There are 739 active municipal solid waste landfills in Region I. An estimated 1,700 municipal solid waste landfills have closed since 1978. An undetermined number of other municipal waste sites also exist in New England. The major modes of ecological damage are from runoff and ground-water infiltration into surface water; the major welfare impact is the loss of the use of ground water as a drinking-water source due to contamination by landfill leachate.

The risks associated with municipal sites were estimated by examining the risks associated with open municipal solid waste landfills (MSWLFs). MSWLFs (largely due to their propensity to be located in wetlands and floodplains) were judged to pose a medium ecological risk due to effects on freshwater wetlands and streams through runoff and infiltration. We did not directly characterize the impacts of municipal waste combusters, municipal surface impoundments, land application, or treatment units due to the lack of available data in these areas to perform risk assessment.

Due to a lack of data, industrial waste sites were evaluated solely by qualitatively ranking the problem area relative to the evaluation of municipal waste sites. Using this approach, industrial waste sites were judged by the work group to be slightly more risky than municipal waste sites. This was due to their probable greater number and perhaps more hazardous constituents.

Sources

Since 1978, 14,000 municipal landfills have closed nationwide, an estimated 1,700 of them in Region I. This paper focuses on active municipal landfills and attempts to also determine the risk posed by closed municipal landfills where there are insufficient data to perform risk assessment.

There are more than 739 active municipal landfills in Region I. These landfills are scattered throughout the six states in the region (Table 15/16-1).

Table 15/16-1

Active Municipal Landfills/Region I

State	Number of Landfills
Connecticut	91
Massachusetts	203
Maine	294
New Hampshire	70
Rhode Island	11
Vermont	70
Total	739

EPA Headquarter's Subtitle D survey developed extensive survey data for 58 of these landfills. These data formed the basis for our analysis of the risk associated with MSWLFs.

The 58 surveyed facilities range in physical size from 1 to 256 acres and receive between 1 to 962 tons of waste per day. There is no apparent correlation between physical size and the amount of waste received at each landfill per day. Using the amount of waste received per day to categorize landfills, 75 percent of the landfills in Region I can be categorized as small, receiving less than 30 tons of waste per day. Twenty-three percent fall into the medium category, receiving between 30 and 500 tons of waste per day, while the remaining 2 percent fall into the large category, receiving more than 500 tons of waste per day.

The landfills in Region I tend to be smaller than those of the nation as a whole. Nationally, approximately 67 percent of all landfills receive less than 50 tons of waste per day compared with 75 percent in Region I.

Ecological Hazard Assessment

The major pollutants or stressors are included in Tables 15/16-2 and 15/16-3. While these are the constituents found in landfill leachates, we must assume that some of these may also be found in surface water. There are no useful data on the concentrations of these constituents in surface water that can be associated with MSWLFs. We also could not find any useful data on gas releases at landfills in Region I. It is generally believed, however, that landfill gas releases involve methane gas.

Table 15/16-2

Landfill Pollutants and Stressors

Pollutants	Ground-Water Resource Damage Threshold (mg/l)	Note	Surface-Water Aquatic Toxicity Damage Threshold (mg/l)
Vinyl Chloride	0.0020	D	
Arsenic	0.0500	D	0.1900
Tetrachloroethane	0.3000	E	0.8400
Dichloromethane	3.2000	E	0.0000
Carbon Tetrachloride	0.0050	D	
Antimony	0.0000		1.6000
Phenol	0.0001	E	2.5600
Iron	0.3000	D	1.0000
TDS	500.0000	D	0.0000

Notes: D=MCLs; E=taste and odor.

Table 15/16-3

Characteristics of Landfill Contaminants

Pollutants	Median Concentration (mg/l)
Vinyl Chloride	0.100
Arsenic	0.010
Tetrachloroethane	0.020
Dichloromethane	0.230
Carbon Tetrachloride	0.010
Antimony	0.470
Phenol	0.260

The major ecosystem risks associated with MSWLFs are impacts to surface water (through runoff and infiltration), to habitat due to landfill location, and gas releases to the atmosphere. The greatest risk landfills pose, however, is contamination of ground water by their leachate. This risk is considered a welfare effect. We will discuss the loss of ground water as a resource, as a welfare effect, later in this paper.

Impact Assessment

Although ground-water infiltration into surface water is an important area of potential ecosystem risk, the determination of concentrations of pollutants as they infiltrate from ground water to surface water is site-specific and difficult to analyze. Since the majority of active landfills are unlined, infiltration of landfill leachate through ground water to surface water is assumed to be the chief transport route to surface water. Toxics found in landfill leachate thus may be expected in surface water, although no specific levels could be characterized by us based on our literature search and interviews. Methane gas release at landfills is difficult to measure because most MSWLFs do not currently perform gas monitoring. Region I's higher annual average net precipitation may contribute to leachate generation and surface-water runoff and infiltration. The location of landfills in floodplains and wetlands also creates potential risk to surface water (through runoff and infiltration) and to habitat.

MSWLFs have historically been located on "low-value" real estate; these areas were often wetlands or floodplains. Of the surveyed landfills for which we have detailed data, 9 percent are located in floodplains and 16 percent are located in wetlands. Nationally, 13 percent of all MSWLFs are located, at least in part, within the 100-year floodplain, while only 6 percent are located within wetlands. These locations and the lack of controls at the typical landfill may result in impacts on surface water. The loss or alteration of wetland habitat due to an MSWLF is another ecosystem risk associated with landfills.

There are insufficient data available to quantitatively characterize surface-water runoff or infiltration or gas-release risks at landfills. However, information about other variables that may impact surface-water runoff and infiltration and gas release allows us to qualitatively discuss these areas. These variables include regional net precipitation and the remaining capacity at landfills.

Annual average net precipitation (precipitation minus evapotranspiration) in Region I, at 20 inches per year, is higher than many other regions in the nation. The national average, including states with very high (Alaska) and very low (Arizona) net precipitation, is an estimated 4 inches per year. While the higher precipitation in New England has potential to increase the volume of surface-water runoff and leachate generated at landfills, other variables, such as the hydrogeological setting at any given landfill, may mitigate the higher annual average net precipitation.

EPA's Subtitle D survey shows that there is a short remaining life at landfills in Region I. Within 15 years, almost three-quarters of all MSWLFs currently in operation nationwide expect to close. In Massachusetts and New Hampshire, the survey data indicate that all landfills may be closed within 10 years. Because a majority of these landfills are nearing capacity, the leachate generation, the surface-water runoff and the infiltration and gas release may be reaching maximum levels.

In the early 1970s, roughly 300 to 400 new landfills opened nationwide. During the past 10 years, the number has dropped to between 50 and 200 landfills per year. With fewer new landfills opening and older landfills reaching capacity, older landfills may be forced to remain open and accept unsafe levels of waste for their size and location. Since many older landfills were poorly located to begin with, they are already in higher risk locations. In addition, there will be pressure to transport wastes to landfills not yet at capacity, decreasing their remaining lives. The potential for illegal dumping may increase, which could create problems in unaffected ecosystems.

All data for Region I were taken from EPA Headquarter's national municipal solid waste landfill (MSWLF) survey. A subset of 56 surveyed landfills was used to characterize risk in New England because we only had landfill size and regional precipitation numbers for these facilities. There are few data available to quantitatively characterize ecosystem risk. Data needed include the locations of the landfills, surface-water runoff, and gas release to the atmosphere. The best data available were on landfill location; time and budget constraints disallowed actual mapping of the 739 landfills in Region I. Therefore, we relied on the survey sample of 58 to characterize the Region I location risk.

Risk Characterization

Ecosystem risk at Region I landfills is difficult to rank because of insufficient data for assessing ecosystem variables. For this reason, a qualitative decision is necessary. Approximately 27 percent of active landfills are located in sensitive areas and pose a potential threat to wetlands and surface waters. Moreover, we assume that the 1,700 closed landfills are at least as risky as the active landfills. Therefore, the work group ranked the impacts on freshwater wetlands and surface water as medium (4 and 3, respectively). Tidal wetlands and estuaries were ranked slightly lower (2) due to the smaller number of facilities located in these areas. All other ecosystems were ranked in the lowest impact category due primarily to the locational pattern of landfills and the lack of pathways of exposure. This ranking is similar to the ranking determined in *Unfinished Business.*

The Ecological Risk Work Group judged the risk associated with Subtitle D industrial landfills to be probably greater than risk from municipal landfills. The primary reasons for this determination were the probable larger numbers of Subtitle D facilities and the judgment that the compounds in the landfills might be slightly more toxic than those in municipal landfills. Overall, however, the work group did not feel that the increase in risk would be significant enough to rank this problem area higher than the municipal Subtitle D sites (e.g., industrial Subtitle D sites were not judged to be as risky to the environment as Superfund sites). As a result, it was decided to rank these two areas the same across all ecosystems.

We have not characterized the impacts of municipal waste combusters, surface impoundments, land application, or treatment units. We feel the portion of the problem characterized in this analysis is medium. The uncertainty due to lack of data in the landfill areas is also medium.

Welfare

The loss of ground water due to contamination from landfill leachate is the primary welfare concern associated with this problem area. We examined this issue by using model results and data on the landfills in Region I to determine the portion of landfills that might lead to the loss of ground water as a potential drinking-water source (either through violation of MCLs or exceedance of taste and odor thresholds).

The major stressors reviewed in our welfare analysis were taken from the risk segments of EPA Headquarter's recent Subtitle D Regulatory Impact Analysis (RIA). These include vinyl chloride, arsenic, tetrachloroethane, dichloromethane, carbon tetrachloride, and phenol (see Table 15/16-2). These pollutants were selected from an initial set of 212 pollutants as the chief constituents of concern, or those with the highest potential for causing human health risk or resource damage.

Antimony was also considered in the RIA analysis for health risk. We have excluded it here because we could not locate data on MCLs or taste and odor thresholds.

Using the same modeling result used to support EPA's Subtitle D landfill regulations, the ratio between the level of the stressors in ground water 60 meters from a landfill was compared with the benchmarks described above for the constituents of concern.

- Vinyl Chloride: 77 percent exceed MCLs
- Arsenic: 0 percent exceed MCLs
- Tetrachloroethylene: 0 percent exceed taste and odor standards
- Dichloromethane: 0 percent exceed taste and odor standards
- Carbon Tetrachloride: 11 percent exceed MCLs
- Phenol: 100 percent exceed taste and odor standards

Eleven percent of the landfills were estimated to exceed threshold levels for vinyl chloride, carbon tetrachloride, and phenols.

17. Accidental Releases

Problem Area Definition

The accidental releases problem area as defined by Region I includes catastrophic events with acute impacts, often requiring emergency response. Contaminants are accidentally released into the environment in a variety of ways during storage, transport, or production. For example, an industrial unit may explode and emit toxics into the air, or a railroad tank car may turn over and spill toxics into surface water or onto soil and roads. Damages to industrial property and personnel and releases to sewers, oceans, air, soil, and waterways may occur from short-term releases of a variety of chemicals, some highly toxic or flammable. Acids, PCBs, ammonia, and sodium hydroxide are examples of past releases, with PCB accidents being the most frequent. Releases from oil spills are also included in this category, with a focus on water releases where the impacts of oil spills are often the most severe. Spilled products may include pesticides, crude oil, gasoline, solvents, diesel oil, fuel oil, and other distillates. Spills from tanks are discussed in problem area #18 (Releases from Storage Tanks).

Summary/Abstract

Accidental releases may affect freshwater, marine, or terrestrial ecosystems. Sources include transportation accidents and industrial releases. Data on such releases, however, are available only for the past few years and are not sufficient for determining the probability or nature of various infrequent accidents. The data used for this analysis--developed by the National Response Center (NRC)--show that most releases of toxic chemicals and petroleum products are small (less than 1,000 pounds for toxic chemicals or 1,000 gallons for petroleum products). However, a small number of very large spills accounts for a high percentage of the total quantity released and causes the greatest ecological damage.

The impacts of releases of toxic chemicals to terrestrial ecosystems are generally not significant. However, the local impacts of releases to freshwater, wetland, marine, and estuarine ecosystems can be very significant. This is especially true for the rare releases of large quantities of toxic substances to marine ecosystems.

Sources

Accidental releases of oil occur during the transport of oil in vessels, tanker trucks, and pipelines; from marine- and land-based transfer facilities; and from refinery, bulk storage, and both onshore and offshore production facilities. Releases of oil range from crude petroleum to gasoline and other distallates. Releases can occur to all media, but the focus here is on releases to water because data are available to characterize releases to that medium and because the ecological effects would be on a larger scale and more severe for aquatic than for terrestrial ecosystems.

Marine releases are predominantly the result of small leaks and spills of petroleum products from a large number of individual vessels. Large, individual marine releases are rare. Three of the largest in recent history in Region I were (1) a spill from the barge Florida in 1969 in West Falmouth, Buzzards Bay, (2) the open ocean spill from the Argo Merchant in 1976, and (3) the barge Bouchard No. 65 in Buzzards Bay in 1977.

The Florida accident released 650,000 to 700,000 liters of Number 2 fuel oil into Buzzards Bay. The oil spread over more than 1,000 acres, including at least four miles of coastline. The Argo Merchant carried 7.6 million gallons of Number 6 industrial fuel oil, which spilled into Nantucket Shoals. The barge Bouchard No. 65 spilled 100,000 gallons of Number 2 fuel oil onto ice-covered Buzzards Bay.

Coastal releases typically occur at marine terminals. A Connecticut source estimated that petroleum spills on the order of 50,000 gallons occur two or three times per year. While these spills have the potential to damage critical estuaries, they have not resulted in significant, long-term effects in the last 10 years. Cleanup efforts are undertaken to remove the oil and generally succeed. Smaller spills (2 to 100 gallons) are common. A Rhode Island official estimated that up to 95 percent of the material released in these smaller events is recovered.

Inland spills that result in ecological damages in Region I may be caused by (1) transportation accidents, (2) industrial releases to surface water, or (3) in-plant releases that are improperly drained through municipal sewer systems. The industrial releases to municipal sewer systems can interfere with proper functioning of water treatment plants, thereby allowing harmful substances to enter surface water. Rapid response by state and local authorities to roadway spills greatly reduces the risk of ecological damages from transportation-accident events. Each state responds to hundreds of small events each year. The inland releases probably cause short-term terrestrial damages. Response and cleanup efforts at the roadway spills generally include the removal of any contaminated soil or vegetation. These removals have temporary damaging effects. In addition, a major goal of these response efforts is to prevent contamination of water bodies.

The National Comparative Risk Project relied on accidental release data from the NRC in its analysis. The NRC collects reports of *releases of hazardous materials* that exceed the threshhold level of reportable quantity. Underreporting to NRC may be as high as 40 to 50 percent. Most of the releases of toxic chemicals and petroleum products are small (less than 1,000 pounds for toxic chemicals or 1,000 gallons for petroleum products). However, a small number of very large spills account for a high percentage of the total quantity released and cause the greatest ecological damage.

A major source of national information on *accidental releases of toxic chemicals* is the Acute Hazardous Events Database (AHEDB). The AHEDB was assembled by Industrial Economics, Inc. (IEc) to support the EPA Headquarters review of the public health dangers associated with accidental releases of acutely toxic chemicals. The AHEDB currently represents 11,097 accidental events. Accident records were collected primarily from the National Response Center (70 percent) and augmented by data from Region VII, state governments, other consulting firms, and newspapers. The database focuses on events involving toxic chemicals, so it contains very few reports of events involving oil or other fuels. Most events in the AHEDB have occurred since 1980, but data are provided for some serious events as early as 1964. Of the 122 accidental events reported for Region I, 24 are transportation-related and 98 are associated with plant facilities. The major chemicals involved were chlorine, several acids, and polychlorinated biphenyls. After adjusting for the undersampling of non-injury, non-death, and non-air-release NRC events and the estimated underreporting to the NRC database, we estimate that from 1982 to 1986 there were approximately 890 release events in Region I involving chemicals listed as hazardous under CERCLA (the Comprehensive Environmental Response, Compensation, and Liability Act of 1980).[1]

A recent analysis of the data collected by NRC on releases of non-CERCLA chemicals (primarily petroleum products) in Region I showed that 732 events occurred from 1982 to 1984: 304 releases in Massachusetts, 152 releases in Connecticut, 115 releases in Maine, 74 releases in Vermont, 61 releases in New Hampshire, and 26 in Rhode Island. The NRC collects information on oil releases to surface water and does not collect information on releases on the land.

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[1] We estimate the total number of CERCLA chemical releases in Region I as follows. The number of events in the sample AHEDB (which focuses on non-death, non-injury, and non-air accidental releases) is multipled by a factor of 10 to account for underreporting of those events. The number of estimated sample events then is added to the number of events listed in the main AHEDB, which contains data on accidental releases that involve death or injury. That sum gives the estimate for total NRC CERCLA events.

The NRC staff also summarized information on the frequency of releases of hazardous substances and the media (land, air, water) that are affected by these releases. These data are presented in Exhibit 17-A. On a national basis, land is the media most commonly affected by releases of CERCLA substances (53.2 percent).

Ecological Hazard Assessment

The most common substances involved in accidental releases are petroleum products. Other organic and inorganic substances also may be released during industrial or transportation accidents. The AHEDB and NRC data were used to identify non-petroleum products frequently involved in accidental releases. These substances include PCBs, sulfuric acid, anhydrous ammonia, chlorine, and hydrochloric acid. Acids, although potentially hazardous in the short term, are not likely to cause long-term ecological damage.

The effects of accidental releases on ecosystems have been studied most extensively for major marine or coastal oil spills. Petroleum in the marine environment can elicit a broad range of toxic responses at low concentration (less than 1 mg/1) to many marine organisms, both plant and animal.

A study of the ecological effects of the fuel oil spill from the barge Florida near West Falmouth, Massachusetts, has shown (1) high mortality of plants, crustaceans, fish, and birds immediately after the spill, (2) short-term physiological and behavioral abnormalities in these populations found in areas with high concentrations of fuel oil, and (3) detectable changes in the biota and presence of partly degraded fuel oil from the spill in the sediments of the harbor and estuary five years after the spill. In studies of sediments and the water column to date, there is no compelling evidence indicating permanent damage to the world's ocean resources or even to a particular part of it. There is also no evidence of a permanent increase in pathological abnormalities due to petroleum hydrocarbons alone in marine biota.

Short-term effects of petroleum releases are documented. Typically, the range of effects will depend on the degree of vertical mixing that occurs within the water column. Fish kills can result from surface contamination alone, whereas food-chain effects will be observed when the benthic environment is contaminated.

In general, water column communities respond more quickly than do benthic communities. Phytoplankton populations can recover within weeks after an accident; microfauna and macrofauna recover within months and years, respectively.

Impact Assessment

The ecological impacts of oil spills vary depending on a number of factors, including the size of the spill, the type of oil, the location of the spill, and the ability to manage the spill. According to *Unfinished Business*, the spills with the most severe impacts are those in confined, shallow bodies of water in which the volume of the spill is large relative to the size of the water body, the oil is light, refined oil, and there is a high load of fine sediment in the water column. Spills occurring under these conditions are rare. When they do occur, they damage populations of benthic communities for many years.

Most oil spills occur in inland areas (70 percent by quantity) as compared with coastal areas. The inland areas most affected by spills are rivers, beaches, and non-navigable water bodies. In coastal areas, the spills are primarily in ports, harbors, and river channels connecting terminal facilities to harbors.

Of the four major pathways of exposure, only one was evaluated by the Ecological Risk Work Group for this report: the direct contamination of surface water bodies and marine and estuarine environments. Not evaluated in the report are the following exposure pathways: direct exposure of wildlife from air releases, direct exposure to vegetation from air releases and contaminated soil, and indirect exposure to wildlife from ingestion of food contaminated by air or soil.

NRC and AHEDB do not identify the type or extent of ecological damages resulting from the releases of hazardous events. In order to obtain information on these damages in Region I, officials in the region were contacted and asked to recall the ecological damages of releases and the extent and reversibility of the damages. The information obtained from these offices and from several literature sources is summarized. The literature sources are cited in the bibliography.

On average, approximately 11,000 oil spills occur each year, resulting in releases of about 9 million gallons of oil (Table 17-1).[2] Most reported spills are fairly small--more than 90 percent of spills for which the release volumes are reported are less than 1,000 gallons. On the other hand, the relatively small number of spills greater than 10,000 gallons, about 1.3 percent of reported spills, account for more than 80 percent of the volume of spills (Table 17-2). The data indicate that the infrequent, large-release event dominates releases to the environment. Most releases are of crude oil and diesel and fuel oils, and most occur in inland areas where rivers, beaches, and non-navigable waterways receive the impacts.

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[2] Some small spills may not be reported. Many reported spills are from an unknown source, are of unknown quantity, or are sheens that have been observed.

Table 17-1

Oil Spills by Number and Quantity

1979-1983

Year	Quantity (thousands of gallons)	Number
1979	10,990	10,500
1980	9,194	10,171
1981	8,820	17,800
1982	8,612	9,188
1983	9,208	8,270
Average	9,365	11,186

Table 17-2

Distribution of the Number and Quantity of Spills, by Spill Size

1982 and 1983[a]

Spill Size (gallons)	Percentage of Total Spills	Percentage of Total Volume Spilled
<10	39.5%	0.1%
10 - 99	36.5	0.9
100 - 999	16.8	3.6
1,000 - 10,000	5.8	13.3
10,000 - 100,000	1.1	21.3
100,000 - 1,000,000	0.2	35.9
>1,000,000	<0.1	25.0

[a]About 28 percent of reported spills either are of unknown quantity or are sheens. Such spills are not included in the above calculations.

Although oil spills to water are frequent events, generally the amounts spilled or left unrecovered after cleanup activities are small enough so that natural systems are not significantly threatened. The very infrequent large-size spill in confined waters can cause significant short-term localized damage. However, even in such cases the combination of cleansing processes of natural systems, weathering of oil, and cleanup efforts have resulted in ecosystems recovering relatively quickly.

Accidental releases of toxic chemicals occur in all media and involve a wide range of chemicals. Most involve relatively small quantities of material. But it is the infrequent, large quantity (only 2.4 percent of the number of releases) that accounts for more than 90 percent of the quantity of material releases. The types of chemicals released in greatest quantities and highest frequencies are acids, bases, and non-persistent organics (PCB releases are mostly to land).

Accidental releases of toxic substances are unlikely to substantially affect terrestrial ecosystems, but they may create significant localized effects of short duration to freshwater ecosystems. Releases to marine, estuarine, and wetland ecosystems are infrequent but could result in significant localized effects. There always exists the potential that low probability events involving releases of large volumes of highly toxic and persistent compounds could result in significant and persistent local and regional effects to marine environments.

Available data (which are acknowledged to understate releases) indicate that about 2,000 accidental releases of CERCLA listed chemicals occur each year, resulting in an average of about 40 million pounds of releases per year (Table 17-3). (The number of releases is relatively similar from year to year, but the quantity of releases varies considerably.) About 12 percent of the releases are to water. Of this, about 3.5 percent are to sewers (and may have subsequent effects if POTWs cannot adequately treat the released material), about 1.5 percent are to the oceans, and about 8 percent are to inland waterways.

Table 17-3

NRC Notifications of Releases of CERCLA Chemicals

Year	Number	Quantity (million lb)
1982	1,664	10.7
1983	2,014	93.6
1984	1,991	11.1
1985	2,523	-
Average	2,048	38.5

The types of toxic chemicals released in largest quantities generally are common production chemicals. Spills of PCBs are reported with the greatest frequency. About 90 percent of these spills involve power companies and occur primarily as a result of equipment failure and of maintenance activities. Most PCB releases, thus, would be confined to land. They are expected to decline as phase-out of PCBs continues. Releases of anhydrous ammonia, chlorine, methyl chloride, and vinyl chloride are reported frequently but do not account for a large volume of releases because the reportable quantities for these chemicals are set very low--100 pounds, 10 pounds, 1 pound, and 1 pound, respectively.[3]

The consequent effects of the residual release on the aquatic environment will depend on the characteristics of the chemical (persistence, bioaccumulative properties, and toxicity). We do not have information to characterize the short-term and long-term effects of releases already experienced. It would appear that most ecological impacts would be localized and of short duration. This observation, of course, does not rule out the potential for a natural disaster at a regional level from an accidental release of large volumes of highly toxic persistent chemicals.

Risk Characterization

Terrestrial ecosystems are unlikely to be substantially affected by accidental releases. Freshwater ecosystems are likely to have significant localized effects, but they are likely to be of short duration. Wetland ecosystems also could have significant localized effects (probably of short duration), but releases to such systems occur infrequently.

Marine and estuarine systems are infrequently affected by releases. However, the potential always exists for highly significant and persistent local and regional effects to marine environments from low probability events involving releases of large volumes of highly toxic and persistent compounds. The work group ranked impacts to marine ecosystems as a 4; impacts on estuaries and tidal wetlands are ranked as a 5.

Releases of oil to water are frequent events but generally are in amounts small enough, in combination with cleanup activities, not to significantly threaten natural systems. The very infrequent event of a large-size spill in confined waters can cause significant localized damage.

The regional results are based primarily upon the data gathered for the National Comparative Risk Reduction Project and its report, *Unfinished Business.* Accidental releases rank relatively higher in the region than they rank nationally. *Unfinished Business* assigned the same rank to the ecological impacts of oil spills but placed oil spills below accidental releases of toxics. The low rank assigned to both types of accidental releases reflects the

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[3] If a release exceeds the "reportable quantity," the responsible party is required to notify the NRC and report the release.

conclusion that most of the events involve small releases and that their impacts are short term and of moderate severity.

A recent study showed that there is significant underreporting to the NRC of accidents. Based on the results of this study, we adjusted the estimate of the total number of accidental events involving toxic chemicals occurring in Region I. However, this adjustment is based on the assumption that the underreporting of events, determined for 1987 by the study, has been consistent since 1980.

The AHEDB has been designed to supplement the information from the NRC on accidents involving air releases, deaths, and injuries. However, no special effort has been made to supplement the AHEDB with information on ecological damages available directly from states in Region I, and the database seriously underreports accidents causing ecological damage only. The focus of the AHEDB also has been on releases from fixed facilities. The database underreports transportation accidents, but we have not analyzed the magnitude of this problem.

This brief analysis provides only limited insight into the probability and nature of an accidental release of more severe consequence than is reported in the available databases. Data are available for only the past few years and are not sufficient to determine the probability or nature of infrequent accidents. Due to the limited data available, it is not possible to determine the percentage of problem covered.

Welfare

Oil spills from offshore drilling accidents or ruptures in storage tanks or tanker vessels can damage coastal and ocean sealife. Generally, responses to oil spills in the region are rapid, quickly limiting the size of the damage area. However, although the damage area may be small, the economic impact may be devastating. An analysis of an oil spill impact in 1969 at West Falmouth, Massachusetts, shows that the spill of 650,000 liters resulted in an immediate, massive kill of crabs, lobsters, and other crustaceans, mollusks, fish, and polychaete worms. Mortality in affected areas was 95 percent. The spread of contaminated sediments compounded the problem, causing continued, extensive mortality. The high (41 percent) aromatic content of this spill resulted in a greater environmental impact by killing virtually all of the benthic community. This caused destabilization of sediments, which were then mechanically transported. Seven years later, the sediments at Wild Harbor still carry oil from the spill.

In discussing welfare impacts of accidental releases in Region I, the Draft EIS, Proposed North Atlantic Outer Continental Shelf Oil and Gas Lease Offering (Lease Sale #96) also must be discussed. Region I's comments to Headquarters on the Draft EIS detail the conclusion that the risks associated with outer Continental Shelf oil and gas activities in the North Atlantic are unreasonable and unnecessary in light of the exceptionally valuable biological resources within the proposed area of sale:

- Georges Bank supports a $180 million per year fishing industry, which accounts for 20 percent of the total dollar value of U.S. landings.
- Tourism is an important industry in Region I. An accidental release of oil resulting in closed beaches during the summer would have a severe impact on the region's economy.

The welfare effects of toxic releases are difficult to assess because few data have been gathered to measure the impacts on the ecosystems. Based on the limited data available, however, accidental releases have a high potential welfare impact in Region I.

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Attachment 17-A

Media Affected by Accidental Releases Reported in the NRC Database

(percentage of events)

Media	1982	1983	1984	First Half 1985	Cumulative Average
Non-CERCLA Releases:					
Air	10.7%	9.9%	7.8%	4.9%	8.3%
Land	18.7	22.5	28.0	27.5	24.2
Water	50.2	49.4	48.2	54.2	50.5
Unknown	20.3	18.3	16.1	13.3	17.0
CERCLA Releases:					
Air	15.8	14.0	15.0	17.8	15.7
Land	50.2	54.6	57.6	50.4	53.2
Water	12.8	12.5	9.8	14.5	12.4
Unknown	21.3	18.9	17.7	19.8	19.4

Source: *A Statistical Analysis of Hazardous Material Releases Reported to the National Response Center.*

18. Releases from Storage Tanks

Problem Area Definition

An underground storage tank (UST) system consists of a storage vessel with at least 10 percent of its volume below ground and the underground piping connected to the tank. The substances stored in USTs can be divided into four product categories: petroleum motor fuels, heating oil fuels, chemical compounds, and miscellaneous substances (stormwater runoff, waste water, etc.)

Currently, EPA only has regulatory authority over 35 percent of the UST population of tanks. The vast majority of exempt tanks are utilized for storing heating oil for use on-site. Approximately 2 million tanks are estimated to be in current use in the northeastern United States (Region I, New York, Pennsylvania, and New Jersey). Precise data on volumes of gasoline and heating oil stored in those tanks are not available. However, an assumption that 50 percent store gasoline and 50 percent store heating oil would seem to be an acceptable range. Statistical analysis of existing databases can then be applied to both regulated and exempt tanks. By a conservative estimate, 10 percent of the tanks at the nation's gasoline service stations have leaked or are leaking. This percentage extrapolated to the Northeast would represent a staggering 200,000 leaking USTs, ranging in size from 250-gallon residential USTs to the 50,000-gallon bulk storage facility.

Summary/Abstract

Underground storage tanks are the ubiquitous depositories of gasoline, heating fuels, and hazardous substances. Gasoline and heating oil hydrocarbons that have been released in ground water represent the most widespread form of aquifer contamination by organic chemicals within Region I. EPA has estimated that approximately 60 percent of existing regulated USTs are constructed of unprotected bare steel. The 500,000 exempt USTs in Region I are all bare steel and unprotected against corrosion, which is the leading cause of leaks to the environment. It has been estimated that 10 percent of the regulated USTs at gasoline service stations are currently leaking into the ground water. If this percentage is applied to all USTs in Region I, both regulated and exempt, then there are more than 70,000 leaking USTs in Region I.

Region I may be facing a pervasive threat to its underground resources from USTs and a lesser but also important ecological risk. Transport of the released product, with regard to its mobility and velocity in the terrestrial environment, is slow and usually confined to a limit of several thousand feet from the source in worst-case conditions. This factor, combined with the typical urban or residential locations of USTs (in disturbed settings), tends to mitigate and lessen the potential impact on the natural ecosystem. Therefore, even though the total number of suspected leaking USTs is extremely large in Region I, the adverse ecological impact is low because previous activities to install the tanks already have altered natural environment and because migration of released product is limited.

Releases from underground storage tanks will have greatest impact on the ground-water ecosystem. Management of all USTs is imperative to minimize the threat to underground drinking water systems. Potential impacts on wetlands, streams, and lakes are moderate. Continued collection of data on releases from storage tanks will be required to improve the reliability of assessing impacts.

Sources

The national population of all USTs is estimated to be 4.8 million tanks. An important distinction to remember when discussing USTs is the fact that only 1.7 million tanks are currently being regulated by EPA under Subtitle I of the Resource Conservation and Recovery Act (RCRA). The basis on which USTs are regulated is determined by the substance and use of the product being stored. Essentially all motor fuels, most hazardous substances, and heating oils that are not used for consumption on the premises where they are stored are considered regulated substances for UST purposes. Therefore, it can be confidently stated that 3.1 million USTs nationwide are exempt from federal notification and technical standards.

Most of the statistical data on USTs presented in this report will be on a national, geographical, and regional basis. Due to gaps and limitations of the reference material, extrapolation and assumptions will be based on regional totals.

The population size of exempt and regulated USTs is listed in Table 18-1.

Table 18-1

Population Size of Exempt and Regulated USTs

(in thousands)

National	Northeast	Region I	Type of UST
880	225*	75	Retail motor oil, regulated
820	195*	65	Non-retail motor fuel, regulated
60	-	3.5	Chemical UST, regulated
1,760	*420*	*143.5*	*Total, regulated*
1,900	1,215	500*	Residential heating oil, exempt
800	345	15*	Non-residential heating oil, exempt
340	47	15*	Farm heating/motor fuel, exempt
3,040	*1,607*	*530*	*Total, exempt*

*Estimated total based on correlation.

Ecological Hazard Assessment

The heating oil sector of the UST population in the Northeast is nearly equal to the national total of the regulated USTs. This factor is significant when looking at the impacts of all USTs within Region I. We assumed that total consumption of motor fuel and of heating oil is almost equal in the Northeast. Therefore, the regulated USTs in Region I distribute approximately the same product volume as the exempt USTs, despite representing a smaller fraction of the total population. This fact should not give a false sense of assurance about regulation and control, however. The vast majority of the heating oil USTs, unlike the regulated systems, are located in suburban and rural areas and are closer to ecosystems where disturbances to the natural state have been minimal. Potential for greater ecological damage in those areas, therefore, is high.

The chemical USTs (the smallest percentage of the total population) are located primarily in urban and industrialized areas. These UST sources, although more toxic because of their hazardous contents, pose much less of a threat to the environment than the heating oil USTs that are distributed more uniformly throughout Region I.

Lighter fuels are more likely to contaminate a larger area than heavier fuels that are retained in the subsurface pore space. Yet the lighter fuels will disperse and dilute at faster rates than the heavier fuels, which have a tendency to be retained in the soil, to build to greater concentrations, and to contaminate the environment longer.

When a released product eventually reaches a water table, it will spread out and float on top of the water table. Previously absorbed material can become mobile and enter the migrating plume when rainfall percolates through the soil. As the water table surfaces and flows to a stream or a lake, the released products contained in the flow become toxic to the aquatic ecosystem, threatening fish, water fowl, and wetland vegetation. Biodegradation may reduce the contaminant levels; lighter, more aromatic fuels will degrade more readily than the heavier oils, which have a larger molecular size and low solubility.

Another pathway for ecological damage results from the potential introduction of a released product into surface waters through runoff from contaminated soils. During corrective and cleanup activities, excavation of soil may leach released product to surface water unless adequate containment is provided. This inadvertent secondary contamination can be eliminated through good management practices.

Contamination of the air through evaporation of a released product also is possible. Differences in vapor pressures will tend to volatilize the aromatic fraction of a fuel that has been released to the environment.

Impact Assessment

Residential and farm tanks pose the greatest threat from released products in Region I. Impact would be on a small and localized scale, however. Potential contamination of the air through product evaporation poses only minimal ecological impacts, and those impacts would be very localized. Location of the storage tanks below ground minimizes risk to many ecosystems.

Releases from underground storage tanks will have the most significant impact on groundwater. The potential impacts on wetlands, streams, and lakes would be moderately affected by a petroleum release. The data reliability associated with this analysis is low based on a lack of any comprehensive database. Only within the past two years has there been any systemized data collection on releases. It will be several more years before there will be sufficient consistency in data collection so that qualitative assessments can be made with a high level of reliability.

Risk Characterization

Underground storage tanks are usually installed in areas that have already been significantly disturbed from a natural state. Also, releases from USTs do not migrate great distances from their points of discharge. There are exceptional situations where the insult to the ecosystem can be extreme. As a result, the work group ranked the impacts to wetlands as medium (a 3) and impacts to all other ecosystems as a 2 or a 1.

Ground-water contamination by a UST release is extremely expensive to clean up and treat, and the resource is never restored to its original water quality. Dilution and dispersion mechanisms do not adequately treat UST-contaminated ground water. Cleanup will always require sophisticated treatment.

19. Other Ground-Water Contamination

Problem Area Definition

Ground water can be contaminated by an extensive variety of point and nonpoint sources of pollution not addressed in other problem areas for the Region I Comparative Risk Project. For the purposes of this project, only septic systems, road de-icing salts, Class V underground injection wells, and the leaching of agricultural pesticides and fertilizers will be assessed due to limited resources and time. The impacts from underground storage tanks, hazardous waste sites, and landfills are covered in other problem areas.

The list of possible contaminants is even more extensive than that of possible sources and includes nitrates, microbes, sodium, chloride, pesticides, and, due to the inclusion of Class V underground injection wells, potentially any waste fluid produced by various industries, utilities, and commercial ventures, including toxic organic and inorganic chemicals, heavy metals, and oil and petroleum products.

Summary/Abstract

The New England region has very high septic system densities (as many as 200+ per square mile in places) and high rates of road de-icing salts applications (as much as 300 pounds per square mile per storm in some states). Region I also has a projected agricultural pesticide application rate, for 12 pesticides, of more than 1,000 tons per year and a large potential for ground-water contamination from Class V underground injection wells. The pollutants represented by the sources in this problem area, as ground-water contaminants, present their greatest environmental risk upon discharge to surface waters. Where ground water is a major source of water to an aquatic system, the ecological threat from these pollutants is the greatest but that threat is largely unstudied, undocumented, and unknown. The major environmental impacts from "other ground-water contamination" are thought to be on our lakes, streams, freshwater wetlands, and estuaries. The primary concern about these pollution sources, however, is for ground water as a regional resource and its route of exposure to humans.

Sources

Obtaining data on the types, numbers, sizes, and locations of the major sources in this problem area requires documented inventory by the states and their local communities. Whereas a town might have one landfill, it could have hundreds of septic systems, many miles of roads that are salted in the winter, numerous unrecognized Class V underground injection wells discharging hazardous and nonhazardous wastes, and some areal extent of agricultural fields where pesticides and fertilizers are applied. The most readily available statistics about the separate sources appear below.

Septic tanks and cesspools considered in the evaluation include individual, on-site subsurface disposal systems serving fewer than 20 people. Of all ground-water pollution sources (i.e., not just those in this problem area), septic tanks and cesspools rank the highest in volume discharged directly to soils and are the most frequently reported sources of ground-water contamination (Canter and Knox, 1985). Table 19-1 presents the estimated number of septic systems and a calculation of the statewide density of systems per square mile, based on 1980 Census of Housing data.

Table 19-1

1980 Septic Tanks and Cesspools

State	Number of Septic Systems (1980)	Systems per Square Mile
Connecticut	357,446	73.4
Maine	198,629	6.4
Massachusetts	550,629	70.4
New Hampshire	161,386	17.9
Rhode Island	112,663	106.8
Vermont	99,752	10.8

Source: USEPA, January 1987.

The total number of septic tanks and cesspools in Region I in 1980 was about 1,480,500. Recent estimates by some of the New England states show an increase since 1980: a 26 percent increase for Maine (now about 250,000 systems), an increase of more than 9 percent for Massachusetts (now more than 600,000 systems), and a 28 percent increase for Rhode Island (now about 143,900 systems). It is reasonable to assume that there are about 1.75 million septic tanks and cesspools in New England today. Table 19-2 provides some county-level statistics, also based on 1980 Census data, which were calculated assuming an even distribution of systems within the county.

Table 19-2

1980 Septic Tanks and Cesspools

County, State	Systems per Square Mile
Fairfield, Connecticut	79-158
Hartford, Connecticut	68-135
New Haven, Connecticut	82-164
Bristol, Massachusetts	90-180
Middlesex, Massachusetts	61-122
Norfolk, Massachusetts	127-254
Plymouth, Massachusetts	76-153
Worcester, Massachusetts	33-66

Source: Canter & Knox, 1985

Septic tanks and cesspools are located throughout the region in unsewered areas. An assumption that they only occur in very rural settings would be erroneous: Some of the counties listed in Table 19-2 are among the most populous in the region. With regard to ecological threats, those systems in highly vulnerable settings atop ground-water aquifers and close to ground-water discharge areas (rivers, streams, lakes, ponds, wetlands, and estuaries) are of most concern. In New England, many unsewered areas border these vulnerable and recreational surface-water areas.

The application and storage of *road de-icing salts* and sand/salt mixtures also generate ground-water contaminants. Table 19-3 provides road salt statistics available from the states and other sources. Roads generally run through lowland areas, especially the larger highways, due to engineering considerations. Therefore, we can assume that they are frequently located above ground-water aquifers in proximity to surface waters.

Table 19-3

Annual Usage of Road De-Icing Salts

State	Tons/ Year	2-Lane Roads (miles)	State and/or Local Road	Lb/Lane Mile per Storm Event	Storage Capacity	Covered ?
Connecticut	-	-	-	160	-	-
Maine	55,000	22,00	both	160	700 piles	No
Massachusetts	259,367	-	state	300	-	-
New Hampshire	139,434	8,571	-	250	123,305 tons	yes
Rhode Island	-	-	-	150-300	91 piles	-
Vermont	90,000	3,000	state	250	-	-

Class V underground injection wells provide a diverse array of source types and an alarmingly large potential for unrecognized ground-water contamination. By definition, a Class V well injects nonhazardous fluids into or above underground sources of drinking water. However, many of these wells, by nature of design and function, directly discharge an array of toxic pollution sources above or into ground water. If these wells are injecting hazardous substances, they should be classified as Class IV wells, which have been banned nationally, and thus would have to be shut down or their discharges modified and regulated by permit. Table 19-4 is the May 1987 Class V well inventory for New England as reported to Congress. The scatter and various weights of numbers in the data suggest an incomplete inventory of Class V wells in New England and illustrate the variation in targeting priorities between the states to inventory specific types of wells. More recent figures, available from a USEPA FURS database report and dated February 5, 1988, indicate a total of 449 wells, and, according to the states' files on data not yet entered into FURS, there are 729 Class V wells in New England. The discrepancies are partially due to a new system of well codes for reporting inventories and are being resolved. Table 19-5 lists wells classified as Class V wells under the new reporting system. Note that wells involving disposal of septage are for systems serving 20 persons or more.

Table 19-4

New England Class V Well Inventory

State	Total	5D2	5D3	5D4	5A7	5W11	5W12	5A19	5W20	5X28	5R21	5X26
Connecticut	84	3	-	-	12	62	-	-	6	1	-	-
Maine	15	-	-	-	-	-	-	-	15	-	-	-
Massachusetts	132	19	-	-	10	27	72	3	1	-	-	-
New Hampshire	38	-	3	16	2	-	-	3	13	-	1	-
Rhode Island	80	-	-	-	-	8	-	8	59	3	-	2
Vermont	15	-	-	-	-	-	-	-	5	10	-	-
Total	364	22	3	16	24	97	72	14	99	14	1	2

Source: USEPA, May 1987.
Note: Refer to Table 19-5 for well codes.

Table 19-5

Types of Class V Wells

Well Code	Well Description
5W9	Untreated sewage waste disposal wells
5W10	Cesspools
5W11	Septic systems (undifferentiated disposal method)
5W31	Septic systems (well-disposal method)
5W32	Septic systems (drainfield disposal method)
5W12	Domestic WWTP effluent disposal wells
5A19	Cooling water return flow wells
5W20	Industrial process water and waste disposal wells
5X28	Automobile service station disposal wells
5F1	Agricultural drainage wells
5D2	Stormwater drainage wells
5D3	Improved sinkholes
5D4	Industrial drainage wells
5G30	Special drainage wells
5A5	Electric power reinjection wells
5A6	Direct heat reinjection wells
5A7	Heat pump/air conditioning return flow wells
5A8	Ground-water aquaculture return flow wells
5R21	Aquifer recharge wells
5B22	Saline water intrusion barrier wells
5S23	Subsidence control wells
5X13	Mining, sands, or other backfill wells
5X14	Solution mining wells
5X15	In-situ fossil fuel recovery wells
5X16	Spent-brine return flow wells
5X17	Air scrubber waste disposal wells
5X18	Water softener regeneration brine disposal wells
5N24	Radioactive waste disposal wells
5X25	Experimental technology wells
5X26	Aquifer remediation wells
5X29	Abandoned drinking-water wells
5X27	Other wells

Agricultural pesticides and fertilizers are nonpoint sources of pollution that primarily pose an ecological problem as direct surface runoff. However, leaching of pesticides and fertilizers into ground water accounts for some proportion of their presence in surface waters. Potential sources of pesticide and fertilizer contamination include land application, disposal, spills, and leaks by manufacturers and formulators, dealers, and industrial, agricultural, and domestic users. For this evaluation, only agricultural applications were considered.

A study extrapolating annual applications of 12 pesticides based on 1979 and 1982 national data indicates that 2.04 million pounds per year are applied in New England, or about 1,020 tons per year. This estimate does not include homeowner use or usage in forests, rights of way, golf courses, and other non-agricultural activities (Resources for the Future, 1985).

Fertilizers are a source of nitrates and leach into ground water much more readily than pesticides. In Rhode Island, fertilizer applications totaled 22,849 tons in 1987 and only 9 percent was for agricultural use; the rest was for lawn and golf course types of applications.

Ecological Hazard Assessment

Major pollutants from septic tanks and cesspools include nitrates, microbes (e.g., coliform bacteria and viruses), chloride, methylene chloride (a.k.a. dichloromethane) and 1,1,1-trichloroethane. Major pollutants from road de-icing salts include sodium and chloride.

For Class V underground injection wells, no "priority" pollutants were assigned to the source, because of the variety of well types and the lack of data. Pollutants include potentially any waste fluid produced by various industries, utilities, and commercial ventures, as well as septic system pollutants and agricultural chemicals.

Major pollutants found in ground water as a result of agricultural pesticides and fertilizers applications include nitrates, aldicarb, EDB, alachlor, atrazine, oxyamyl, dinoseb, carbofuran, 1,2- and 1,3-dichloropropane.

The Ecosystems Research Center (ERC) at Cornell University, for the *Unfinished Business* project's national Ecological Risk Work Group, considered ground-water contamination as a stress agent category under "other environmental problems" (ERC, 1986). ERC defined the areas to include "all contaminants entering ground-water systems, such as metals, toxic organics, toxic inorganics, pesticides, herbicides, radionuclides, and microbes." This categorical placement reflects their judgement, at least on a national scale across all hydrogeological settings, that any contaminant discharging to surface waters via ground water is less of an ecological threat than its presence in surface waters due to direct introduction. They also note that "ecological effects are limited to localized areas of ground water reaching surface water systems; even then, ecological effects are highly unlikely unless ground water is the major source to the aquatic system; the primary concern is route to humans." Other information for ground-water contamination from the ERC study appears below:

Severity of effects. Any effects are probably limited to the ecosystem level; the effects are unknown for freshwater ecosystems, unknown for estuaries, unexpected for marine and terrestrial ecosystems, and unknown for wetlands.

Reversibility. This was not estimated for any ecosystems.

Types of impacts to resources. The only ecological response noted by the national work group across all ecosystems was a concern for the ecosystem as a potential route to humans for health-effects stresses.

Impact Assessment

Ground-water discharge to surface-water bodies is the exposure pathway considered in this assessment, the underlying assumption being that contaminated ground water is not an ecological threat until it discharges. New England's hydrogeology is such that ground-water flow systems are generally local, that is, flow paths tend to be short from primary recharge areas to surface-water points of discharge. This is due to the glacial origins of our aquifer deposits, consisting of relatively vulnerable, thin, and isolated "pockets" or "stringers" of stratified drift, deposited in preglacial bedrock valleys. Pollutants in ground water have the potential to be highly concentrated at the point of discharge. This is due to short flow paths and a lack of much dispersion or dilution. However, the particular fate and transport characteristics of the pollutants and the aquifer are extremely important in determining that potential. The effect of ground-water pollution on surface-water quality is greatest both during periods of low precipitation, since ground water as base flow can be as much as 70 percent of the stream flow in some areas of New England, and on the many ponds of glacial origin that are surface expressions of the water table.

The percentage of resources affected by "other ground-water contamination" is not fully known. The location of the pollutant release relative to a surface-water body is of great significance.

Potential Impacts from Septic Tanks and Cesspools

It is estimated that only 40 percent of all septic systems function properly, and areas with more than 40 systems per square mile can be considered to have potential contamination problems (Canter and Knox, 1985). Reference to Tables 19-1 and 19-2 shows that the more populous southern New England area has double and even triple that density in some counties. Massachusetts, with more than 600,000 systems and noted surface-water problems, appears to be at the greatest risk. On Cape Cod alone, an estimated 63.8 million gallons per year (mgy) of septage is generated, with only 31 percent being effectively treated, leaving about 44 mgy to discharge to a highly vulnerable environment (CCAMP, 1988). If the design life of these systems is 10 to 15 years, and many in New England were installed in the 1960s, we can expect that we are seeing the beginning signs of a problem that could only get worse as development in New England increases. If an estimated 1.75 million systems discharge 45 gallons per day (gpd) per person, and we assume three persons per system, then New England generates 86 billion gallons per year of septage, and potentially 51.6 billion gallons of partially treated sewage are discharging per year in New England.

Examination of the 1988 Water Quality Reports for the New England states gives some indication in a few states of the possible extent of septic problems on surface waters. Pollutant loadings from nonpoint sources are increasingly being recognized due to point source discharge reductions and continuing water quality problems. Failing septic systems--septic tanks and cesspools--are noted as a major contributor to the nonattainment status of 27 of 32 drainage basins in Massachusetts and as a minor contributor to two other basins. More specifically, septic systems contributed to the poor surface-water quality noted in 73 of 159 lakes and ponds and in 63 of 376 surface-water segments of nonattainment status. In 16 of the 63 water segments there were shellfish bans. In New Hampshire, on-site wastewater systems had moderate/minor impacts on 92.2 miles of rivers, and in Maine approximately 31.3 percent of the ground-water nonattainment areas (or 91.3 square miles) are estimated to be due to septic systems.

The ecological repercussions of this pollution source are probably related to nutrients (nitrates) as a primary stress agent. Since it appears likely that high concentrations of untreated septage are discharging, examination of nutrients as a "water source" stress agent (ERC study) warrants attention. Nutrients would have an ecological effect at an ecosystem scale. For freshwater ecosystems, nutrients would have highest effect on unbuffered lakes; they have a medium effect on buffered lakes and unbuffered streams and a low effect on buffered streams. For marine ecosystems, nutrients have the highest effect on estuaries and a medium effect on coastal marine waters.

Potential Impacts from Road De-Icing Salts

In Maine, an estimated 10.9 square miles (or 14.1 percent) of ground-water nonattainment areas are due to plumes from 700 uncovered salt storage piles. A Rhode Island study (FHA), 1981) showed high concentrations of sodium and chloride thousands of feet downgradient from salt storage piles, and some surface-water samples showed sodium and chloride concentrations in the hundreds of parts per million.

A special legislative committee on water supply in Massachusetts described the impacts of road salts. Note that some of the trees cited as most sensitive are frequently found in wetland areas, which are ground-water discharge areas:

Road salts have been documented as causing damage to vegetation. High sodium levels may inhibit moisture uptake. Sodium can interfere with a plant's ability to absorb necessary nutrients such as calcium, magnesium, and potassium. Vegetation up to 120 meters from a road can be severely damaged by salt sprayed from traffic and wind. Internal accumulation of sodium and chloride first results in foliage damage and may progressively cause growth depression and leaf burn, followed by reductions in new shoot growth, and, if sufficiently severe, eventual death. Depending on the particular species, plants range from highly salt sensitive to highly salt tolerant. Some of the most sensitive include the American elm, red maple, white pine, hemlock, and sugar maple.

Table 19-3 contains scattered estimates of road salt applied and stored in New England. Using the annual tonnage figures for some of the states, an estimated 750,000 tons of salt are applied annually to major New England roads. If it is assumed that almost all of this salt eventually reaches surface waters as runoff or via ground-water infiltration, then road salt has the potential to create, as a very rough estimate, approximately 12 billion gallons of salt water (of an average seawater sodium chloride concentration) annually.

To the extent that high concentrations of brine are discharging to surface waters near the point of application or storage, one can expect ecological effects to freshwater plants and organisms similar to those described in the report by the Massachusetts legislative committee, cited above. Ecological damage regionwide is probably restricted to localized roadside areas.

Potential Impacts from Pesticides and Fertilizers

The potential environmental damage from ground water contaminated by agricultural chemicals includes damage to vegetation, waterfowl, and aquatic life in discharge areas (USDA, 1987). The regional significance of pesticides as they impact ecology is best addressed as a surface-water issue. Generally, the amount of pesticide running off a field will be greater than that leaching into ground water, and both pathways will probably join at the same surface-water body nearest the point of application. This makes it difficult to assess the relative contributions. Fertilizers leaching into ground water, however, may be a large source of nitrates found in surface waters in agricultural areas because of their greater leaching potential.

The toxicity of pesticides varies, and no water quality criteria have been noted for them. Probably less than 1 percent of the estimated 1,020 tons per year of agriculturally applied pesticides leach into ground water. As noted above, it is believed that direct runoff is more of an ecological threat. No data analysis was attempted for fertilizer applications, but we can expect that high nitrate levels in agricultural areas are due to fertilizers as well as to other nonpoint sources.

The extent of ground-water contamination by pesticides and fertilizers is just coming to light. As quantification of the leaching potential and the fate and transport characteristics of these contaminants continues, the environmental damage by them as a ground-water source may be easier to assess. This source, similar to the others, depends significantly on location.

Potential Impacts from Class V Underground Injection Wells

No data were obtained to assist in an ecological impact evaluation for this source.

Where a Class V well is discharging toxic effluents near a surface-water body, localized ecological effects can be expected. Of all the sources addressed in this problem area, this one has the most unknowns.

Risk Characterization

Effects of stressors on each ecosystem were ranked on a scale of 1 to 5, with 5 the greatest effect. The potential impact ratings reflect a combination of information on the potential of the stressors both as ground-water contaminants and as water-source stress agents as discussed in the ERC study and referenced above. The potential to impact lakes was ranked medium-high. Impacts on wetlands, streams, and estuaries was ranked medium. The regional impacts for the most part are uncertain except for streams and lakes, which were addressed regarding septic systems in the state's 1988 Water Quality Assessment reports. Data reliability is largely uncertain; limited data were available and the amount of qualitative assessment required was high. The overall effect to each ecosystem is thought to be highest on our region's lakes because they are standing-water bodies sometimes receiving high amounts of ground-water discharge. The exception to the above statements is the rating of the impact on ground water itself, which will be addressed below.

The problem area "Other Ground-Water Contamination" was defined more broadly by the national Ecological Risk Work Group than by our regional team. The problem definition was narrowed for the regional study in hopes of improving data quality. Even so, a good database was not readily available for any of the four main sources covered.

The national study ranked this problem area in the fifth of six groupings, along with most waste sites, accidental releases, and oil spills. The fifth grouping was characterized by data of moderate uncertainty and by problem areas with many sources of generally low impact but with the potential for high local impacts. The group also represented sources of variable control and impacts of uncertain recovery.

The results of the regional ranking are somewhat better in that we were able to regionalize the problem area, primarily due to the high densities of septic systems and high rates of road de-icing salts applications. Still, an understanding of the specific ecological impacts of this problem area as a whole remains highly uncertain.

As noted in the section above, the uncertainty is high for this problem area because the ecological impacts of pollutants in ground water are not well studied or documented. Without data on Class V underground injection wells, which have more toxic potential than septic tanks and road salting, and due to a general lack of data for the other sources, the percentage of the problem covered in the evaluation is less than 50 percent. Thus, much of the ranking was qualitative.

Welfare

Ground water as a resource in this region is highly impacted by "other ground-water contamination." Although levels of the stressors may be reduced by the time they discharge to a surface-water body, where dispersion and dilution can occur, within the ground-water flow system the pollutants addressed above often occur at levels that prevent using the ground water as a drinking-water source. The problem is particularly risky with regards to private wells. These wells are largely unmonitored. As a result, people may be unknowingly drinking water contaminated by high sodium, nitrate, chloride, and bacterial levels. Also, an increasing number of wells are being contaminated by pesticides and toxic organic and inorganic chemicals, contaminants for which tests are costly. The sources in this problem area are widespread and have the potential to slowly degrade the natural high quality of Region I's ground waters.

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20. & 21. Pesticide Residues on Food & Pesticide Application

Problem Area Definition

This evaluation combined two problem areas to include risk associated with the direct application of pesticides to ecosystems and risk associated with the resultant pesticide residues on food consumed by wildlife. The term "pesticide" includes all insecticides, herbicides, fungicides, and rodenticides. It is further defined to include "any substances or mixture intended for preventing, destroying, repelling, or mitigating any pest." Accidental exposure to nontarget organisms and unwanted pesticide residues that bioaccumulate in the food chain can result when pesticides are applied correctly or when they are misapplied.

Summary/Abstract

New England faces a unique ecological problem from the use of pesticides. It is a small geographical area with no clear division between agricultural and nonagricultural land. The agricultural community, particularly in southern New England, is dispersed throughout forest, residential, and industrial areas. The use of many different pesticides in these relatively small agricultural zones raises the potential for pesticide contamination of the surrounding ecosystems either through direct application to wildlife habitat and freshwater systems or by runoff or aerial drift.

The agro-ecosystem (e.g., agriculture) is important not only because it produces the bulk of food used for human consumption but also because it can serve as a unique habitat for certain wildlife species. Most of the agro-ecosystem is treated with pesticides at least once per growing season.

The aquatic environment may be directly treated with pesticides to control mosquitos or algal blooms and it can indirectly receive pesticides through agricultural runoff and drift. Freshwater systems ultimately lead to estuarine and coastal systems that can, in turn, become contaminated with pesticides.

As a class of chemicals, pesticides can be both beneficial and hazardous, depending on where and how applied. Because pesticides are designed to kill living organisms, unintended exposure can be very destructive to the biotic receptors (e.g., fish and wildlife in the agro-ecosystem).

Sources

Types and amounts of pesticides applied in New England vary with the type of agriculture practiced in a given area. Apples, corn, small fruits, and vegetables are grown throughout the region and present essentially the same pesticide problems. There are also highly specialized agricultural situations in the region. In Maine, blueberries are grown extensively in Washington County and potatoes in Aroostook County, each crop requiring use of an array of different pesticides. In Vermont, feed corn and apples are the major crops. Cranberry production in southeastern Massachusetts requires direct application of pesticides to bodies of freshwater. A large number of nurseries and greenhouses throughout the region also rely heavily on pesticide use. The many small vegetable farms throughout Connecticut, Massachusetts, and Rhode Island are also a potential source of pesticides being introduced into the environment.

In Region I, the close proximity of crop land and pastures to both forest ecosystems and aquatic systems places these in immediate danger of receiving off-target drift from pesticide applications. Pesticides are used to the greatest extent on the agro-ecosystem.

Other major uses of pesticides include forest management (which includes herbicides used in rights-of-way maintenance) and large-scale abatement projects such as mosquito and aquatic weed control. Pesticides applied to forest ecosystems (e.g., the Maine Spruce Budworm Project) will result in direct application to aquatic ecosystems (streams, ponds, etc.). The Office of Pesticide Programs (OPP) estimates that approximately 10 percent of all pesticides applied by air or mist-blower ground equipment will reach adjacent aquatic ecosystems.

In reviewing the many sources of the ecological risks from pesticides, only a few major pesticides were considered. Those pesticides used in large amounts in agriculture, forest management (including herbicides used in rights-of-way maintenance), or large-scale abatement projects (mosquito control) were evaluated.

Ecological Hazard Assessment

Data from EPA's Office of Pesticide Programs indicate that at least 121 pesticide-active ingredients are registered for direct application to streams, lakes, ponds, and estuaries. Pesticides used for agriculture vary directly with the type of crop and the infestation to be controlled.

Ecological effects resulting from pesticide exposure can be quite pronounced (death) or, more likely, include long-term impacts such as decreasing population. Since reaction to pesticides can be species- and chemical-specific, this paper will not attempt to evaluate all possible combinations.

Fish and wildlife are directly exposed to pesticides through inhalation, ingestion, and dermal absorption. Residues on food and in fish and wildlife habitats result in direct exposure to pesticides. Certain pesticides bioaccumulate in and contaminate food chains. Acute poisoning of nontarget organisms can lead to direct mortality or cause an inability to resist predation. Chronic effects include an inability to function properly, such as inability to feed or to reproduce. Ultimately, a change in the number of species and in species size will have a deepening impact on the stability of the entire ecosystem.

Occasionally, adverse impacts are reversible. A case in point is the decline of the peregrine falcon and other species as a direct result of poisoning with DDT. Once the stressor was removed, the affected species recovered.

Most of the measurable data available for assessing pesticide impacts on wildlife concern obvious fish and bird kills.

Impact Assessment

The pathways of exposure include direct application of highly toxic pesticides, such as methylparathion, and highly persistent pesticides, such as atrazine. This includes multiple applications of insecticides and fungicides, particularly in one of New England's major fruit crops--apples.

Agricultural applications result in direct hazards to all terrestrial organisms and to aquatic organisms from runoff and drift. With respect to forest applications, the use of highly toxic insecticides to control defoliating insects of both hardwood and coniferous species and the use of herbicides in other forest management practices, such as "conifer release," result in the same threats to wildlife as stated above.

Direct application of aquatic herbicides to lakes, ponds, and streams is routine in Region I to control unwanted vegetation. Streams are affected by direct forest application and also from agricultural runoff. The use of larvicides to control mosquito populations results in direct applications to wetlands. These areas are also affected by runoff and drift from agricultural use. The use of antifouling paints on boats poses a threat to mollusk and fishing beds.

The magnitude of the exposure is difficult to assess. The data available for review only indicate which pesticides are likely to have an impact on an ecosystem due to volume used, not relative toxicity. The data were not helpful in estimating single-use-related responses. Each of the ecosystems is at high risk from pesticide contamination even when pesticides are applied correctly. The degree of risk will vary according to type of pesticide, the amount reaching the receptor, and the relative vulnerability of the receptor to the individual pesticide. Because of the variance, the diversity of pesticides, and their bio-effects, the problems cannot be consolidated into a single analysis. Each chemical and its possible impact on a given environment should be looked at separately.

There are data available regarding the average annual amount (pounds) of agricultural pesticides used in each state in the mid-1980s, prepared by the Resources for the Future, Inc., from the National Pesticides Inventory database on a per-county basis.

There are numerous examples of the misuse of pesticides and its impact. The use of DDT and its long-term impact on the reproduction of the peregrine falcon is an example. The recent banning of Chlordane because of its potential impact to human health is another example of a previously approved chemical that is now banned.

Risk Characterization

Direct application of pesticides to lakes, freshwater wetlands, and terrestrial sites puts these ecosystems in Region I at high overall risk. In addition, these receptors are a risk from pesticide infiltration from other locations, either through off-target drift or agricultural runoff. The risk to wildlife increases as food sources are ultimately contaminated with pesticide residues. Pesticides also may infiltrate into soils, eventually contaminating ground water and threatening present and future water supplies.

Estuaries, tidal wetlands, and streams are at moderate risk from direct application and indirect contamination from pesticides. Mollusk and fishing beds in particular are threatened by discharge of antifouling paints.

Welfare

The potential for ground-water contamination from pesticides is extremely high in certain areas of Region I. To date, agricultural chemicals have been found in ground water to some degree in all our states. The extent of the problem is yet to be determined.