Professional Environmentalism in Canadian Chemistry: The Greening of a Discipline?

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Preface

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Abstract

This research focuses on the involvement of chemists in professional Canadian environmentalism. We confront opposed research and development sector perspectives (government, industry, and university) to describe how incompatabilities between them resist cross-sectoral interaction and limit disciplinary greening. We then refer to original questionnaire and interview data to discuss the greening force of professional associations on a multisectoral discipline (chemistry). Finally, we consider plausible research avenues in the sociology of environment to address the current and future status of environmental chemistry.

Résumé

Cette recherche s'interesse à la participation professionnelle des chémistes dans les activitées environnementale au Canada. Nous confrontons certaines perspectives des secteurs de recherche et de développement (gouvernement, industrie, et université) pour suggèrer comment les incompatibilitées entre celles çi résistes l'interaction sectorale, et limites le verdisage disciplinaire. Nous référons en suite a l'information êxtrait de questionnaires et d'entrevues originalent pour discuter de l'impact verdissant sur une discipline multisectorale (la chémie) via association professionnelles. Finalement, nous considèrons quelques avenues de rechèrche plausibles dans la sociologie de l'environnement pour adresser le statut présent et future de la chémie environnementale.

Acronyms

BAT - Best Available Technology

BPT - Best Praticable Technology

CEAC - Canadian Environmental Advisory Council

CEPA - Canadian Environmental Protection Act

CIC - Chemical Institute of Canada

DOE - (Federal) Department of Environment

EPS - Environmental Protection Services

GOA - Government Organization Act

ICST - Institute of Chemical Sciences and Technology

IJC - International Joint Commission

IRAP - Industrial Research Assistance Program

MISA - Municipal Industrial Strategy for Abatement

NRC - National Research Council

NSERC - National Science and Engineering Research Council

OME - Ontario Ministry of Environment

RPP - Research Partnerships Program

SCC - Standards Council of Canada

SD - Sustainable Development

UNEP - United Nations Environmental Programme

WCED - World Commission on Environment and Development

WQA - Water Quality Agreement

WQB - Water Quality Board

<u>Introduction</u>

The environmental branches of the Canadian federal government have a twenty year history of development, of structural reorganization and alignment. A **first period** of environmental policymaking occured in the 1960's emulating the wider social-regulation agenda - when environmental standards, much like employment and human rights legislation, were a result of public opinion and collective group pressures (Conway, 1990). Despite budget cuts, and the lack of compliance procedures, there was intense Department of Environment (DOE) activity in both the **<u>domestic</u>** (and/or intramural) (**second period** 1970's) and the **<u>international</u>** (**third period** 1980's) political arenas **(<u>Appendix 1</u>)**.

Until the late 80's, incremental responses to environmental questions resulted in an uncoordinated collection of initiatives. The Canadian Environmental Protection Act (CEPA: 1988), served to integrate current environmental legislation by amending the Canadian Contaminants Act (1975) and merging it with three others. Canada's Green Plan (1990) integrated public policy by implementing its national environmental agenda through CEPA mechanisms. These constitute the basis of the (current) **<u>fourth period</u>** of environmental policymaking.

The World (Brundtland) Commission on Environment and Development (WCED: 1987) published the "Our Common Future" report espousing the tenets of "sustainable development": **(a)** reviving economic growth, **(b)** conserving and enhancing the resource base, **(c)** reorienting technology and managing risk, **(d)** merging environment and economics in decision-making, **(f)** ensuring a sustainable level of population and, **(g)** meeting essential needs for jobs (WCED:49). Canadian environmental leaders from the three research and development performimg sectors (**government, industry, and university)** were prominent in the talks producing the Brundtland report. The Canadian federal government's Green Plan announced its political commitment to sustainable development, as it also did when holding the Group of Seven Economic Summit in Toronto (1988), opening the Institute for Sustainable Development in Winnipeg (1988), and giving the theme "Our Common Future" to the first national Environment Week (1988) as well as to the Department of Environment's 1988-89 annual report. This international and federal agenda seeks to stimulate and maintain coordinated multisectoral participation in pursuit of "fourth period" environmental/economic objectives.

The research presented here is primarily interested in, 1) the politically aspired government, industry, university coordination, 2) how this pertains to the greening of a scientific discipline (chemistry), and 3) research perspectives and avenues in the sociology of environment. In the process, we will look at how emerging environmental issues and interests bear on professional chemistry in the separate sectors.

Why chemistry? Several factors explain why it is a strong candidate for greening, and thus why the discussion will focus on environmental chemistry;

1 - The first Canadian center for environmental chemistry will begin to offer graduate training in 1991-92 through the joint initiative of Carleton and Ottawa Universities, as well as federal and provincial government laboratories. The center is a response to legislation prescribing more detailed analyses and monitoring of chemicals in the environment, thus creating more academic research opportunities involving government and industry chemists (Affaires Universitaires, May 1991:8).

2 - Since the mid 1980's the Environmental Protection Services (**EPS**) branch of the DOE has held annual "Technical Seminars on Chemical Spills" producing papers by speakers from the three R&D sectors. Between 1984-87 the EPS published a series of research reports entitled "Collection Enviroguide: TIPS (technical information on problem spills)" yielding some 150 manuals dedicated to individual chemicals.

3 - CEPA consists uniquely of chemical regulation.

4 - The Green Plan relates largely to chemical pollution.

5 - Industrial pollution is significantly chemical.

6 - A **DOE** survey showed that Canadians perceive the top three environmental priority risks to be: a) pollution of drinking water by industrial and chemical wastes, b) the

storage of dangerous chemicals, and c) the chemical destruction of the ozone layer (Annual Report; 1988-89). These opinions constitute public pressure.

7 - After the mid 1980's, the number of environmentally-related chemical subspecialties has increased among graduate school researchers (**Appendix II**). Because there is, as of yet, **no** environmental chemistry subdiscipline per se in Canadian universities, (but rather one more established in government and industry sectors), environmentally-related academic subspecialties are vulnerable to umbrella organization. They may tend towards professional subdiscipline (specialty) merging, or centralization, because of: 1) specialized research areas with small memberships (Appendix II), 2) the impending demographic crisis due to the decline in professoriate via forthcoming retirement of academic chemists, low enrollment in graduate research, and an exodus of chemists to industry and government laboratories (Canadian Association of Graduate Schools, Annual; NSERC, 1990:10) and, 3) the greatly decreased funding to academic chemistry as a whole (NSERC, Ibid.) that exacerbates the historically low financial support allocated to environmental chemistry in universities. An umbrella organization (Environmental Chemistry) would constitute a new subdiscipline among the current group of traditional ones, and thus a solid indicator of disciplinary greening.

In view of their nature, these developments make chemical research a central element of professional environmentalism worthy of sociological attention.

Other reasons led us to survey the organizers and speakers of the environmental symposia at the Chemical Institute of Canada's (**CIC**) 1991 annual Canadian Chemical Conference.

1 - Compared to the several joint environmental symposia held that year (**Appendix III**), there was only one in both 1989 and 1990. Dating back to 1975, prior national CIC conferences included a few single, non-joint, environment division symposia. Before this, throughout the 1960's, no organized environmental sessions of the kind were held, much less joint ones. Of the 950 research papers presented at the 1991 conference, 150 (16%) were scheduled in environmental chemistry sessions, making this assembly a key event, perhaps a turning point, in professional chemical environmentalism.

2 - We anticipated the CIC, and its Environment Division, to be a potential example of networking among chemists, of the mobilizing of professional association members and their research ties across Canada. We wanted to study the stimulating of local network interaction across sectors, and the claiming of environmental competence and authority by a scientific discipline via the legitimate institutional use of one of its professional associations. The CIC could constitute then, an aspiring stakeholder in the greening of chemistry.

Finally, we decided to consider, more specifically, the Great Lakes environmental history because CIC conferences tend to build environmental themes around local environmental issues and networks of chemists. The 1991 conference in Hamilton promised to bring together leading environmental chemists from Ontario government, industry, and university research, many of whom currently work on Great Lakes pollution issues.

In Section I of this thesis we distinguish the three sectors with respect to their professional, environmental, and chemical perspectives.

In Section II we analyze the greening pressure of a professional association on a multisectoral chemistry.

In Section III we summarize our preliminary suspicions concerning the status of environmental chemistry via plausible research perpsectives in our own recent specialty, the sociology of environment.

Section I: Sectoral Perspectives

Given that environmental problems are naturally confounded, only the integration of knowledge could yield congruent environmental solutions. Multisectoral interaction is an avenue by which the melding of professional expertise may evolve. Below, we discuss how perspectives from each sector's environmental point of view contend, how this resistance delays the development of cross-sectoral ties and, therefore, of disciplinary greening. We relate this scenario to predominant political involvement in the sectoral social system of science.

A) Government

Through its local and international ties, the Canadian federal government has taken the role of environmental policy leader. It has given itself the authority to mandate and activate networks of professionals through which it aspires to sustain an integrated environmental initiative.

Political organization complicates these objectives. The Brundtland Report (WCED, 1988) highlighted two elements of political institutions that preclude the attainment of sustainable development objectives - sectoral and political fragmentation. They, in other words, constitute structural dilemmas adverse to multisectoral coordination.

Sectoral fragmentation results from the structural decentralization of federal powers among its independent agencies (e.g., fisheries, water resources, wildlife, atmospheric, etc.). Narrow mandates are distributed horizontally, promulgating inconsistent policy-making, loose decision-making coordination, and ignorance of ecosystem interdependencies (energy policies that contradict watershed initiatives, e.g., hydroelectric projects).

Vertical decentralization, prompted by tight budgetary constraints, and diminished federal environmental priorities, resulted in the distribution of environmental powers to the provinces, thus provoking a DOE decline during the mid 1970's (Conway, 1990). Because the British North America Act (1867) did not assign environmental responsibility to any one government level, ambiguous jurisdictions and mutual restrictions continue to promote political incompatabilities. For example, hydroelectric strategies under provincial powers may corrupt the integrity of inland waterways under federal powers, and municipal incineration projects may counter national atmospheric initiatives. These jurisdictional dilemmas have historically negated an integrated definition of, or approach to, the renewable resources problem (Donahue, 1991:66).

Vertical sectoral fragmentation results in political fragmentation (Kenneth, 1990) by which established political boundaries that overlap common resources and ecosystems produce jurisdictional "externalities", or policies that disregard environmental implications outside their instituted territory and designated realms of responsibility (e.g., transboundary transport of air-borne particulates, industrial effluents discharged into common bodies of water like the Great Lakes).

Since the mid 1980's, as political awareness of the integrated nature of environmental problems evolved, the response to these institutional dilemmas was, and still is, the seeking of intergovernmental agreements. This approach, however, complicates the emergence of cooperative problem-solving (e.g., political offices are reluctant to limit their autonomy and resource exploitation, agreements often do not bind succeeding governments, "upstream" governments are less willing to negotiate than "downstream" ones, and compliance procedures are subject to international economic agendas (e.g., the CFC Protocol) (Kenneth, 1990:36).

Given these structural inequities, political mechanisms fall short of their design. The CEPA and Green Plan reflect the federal government's traditional "command and control" regulatory approach - commanding behavior via performance standards that give firms the freedom to design and implement their own means to achieve environmental targets, and controlling compliance via the centralized enforcement of regulations (Laplante, 1990). While this approach may constitute a political aspiration, Canada's compliance objectives have historically been overshadowed by a federal reliance on negotiation (compliance agreements) and exhortation (voluntary compliance). There have only been two convictions out of 329 enforcement actions between June 1988 and March 1990 (21 months post-CEPA) (Conway, 1990). This confirms the persistence of top-down command through regulation yet bottom-up control of compliance by industry.

Again, this pattern of weak federal action is rooted in the DOE's fragmentation and decline, leaving it relatively powerless but to haggle and compromise. And, because this phenomenon exists in other federal departments with which the DOE must collaborate, the tenets of sustainable development (SD) have been subordinated to free-trade agendas with higher priority economic interests ("developing sustainability") (Franklin, 1989:6). SD, for example, is a politically secure compromise between industrial and public environmental interests. While the Green Plan, an SD product, was the result of public hearings, it was redrafted in response to industry pressure before being made public. In the process, the heavy lobbying was sufficient to elicit the transfer of the federal Conservative environment portfolio from Lucien Bouchard (currently the leader of the federal Bloc Quebecois) to Robert DeCotret.

Government then, has two basic dilemmas in its mobilizing of a wide based, cooperative environmental initiative. First, it must deal with its internal structural conflicts of interest. Secondly, it must attempt to integrate its science-based environmental knowledge with that of other professional claimsmakers (industry, university, media, public pressure groups) without compromising the objectives and design of environmental policy-making. Such problems are exacerbated by policymakers who lack the technical expertise to weigh different sources of information, and thus to formulate congruent standards and compliance procedures. And, because compromises are sought between industrial capital and electoral support, between the sustaining of economic growth and zero-emission, irreconcilable divergences emerge between the stakeholders.

B) <u>Industry</u>

Despite the government's historical lack of enforcement action, industry does have strong incentives to expand environmental production technologies: a) the consumer demand for green products, b) the high costs of environmental clean-up, and c) the freedom to develop its own environmental strategies within existing guidelines. These have encouraged the emergence of local environmental projects evolved out of industry R&D. Several of these however, face institutional and technical implementation obstacles. Two examples illustrate this:

1) The Canadian cement production industry is currently elaborating a Norwegian technology to supply energy to their kilns. While designed to recycle municipal sewage sludge and

tires, thus reducing the use of coal as heat source, the process is claimed to chemically bind the ash to a harmless final product, and to ultimately provide a means to destroy all Canadian PCBs within two years (Coles, 1991).

In this first case, the leading claimant, St-Lawrence Cement Inc. in Ontario, has not been able to operationalize the process beyond the prototype testing phase because of local public pressure. Citizens and groups protested and lobbied against the use of cement kilns to incinerate sludge and PCB's that emit air-borne chemicals. The Ontario ministry of environment responded to this public outcry by withholding the necessary industrial permits. In the case, the St-Bazil-Le-Grand PCB fire was referred to by opponents, as it has been in Quebec where projects to establish a permanent and/or mobile PCB incineration facility have failed. In response to public pressure, no municipality will agree to have it constructed in its jurisdiction.

Furthermore, incineration of sewage negates the DOE's investment in the "oil from sewage sludge" technology in development for the past eight years. This German process, thermal liquefaction, is claimed to yield eighty barrels of oil/day using 25 tons/day of sludge produced by a 150,000 population or more (Campbell, 1991). What was once considered an environmental problem (sewage sludge) is now a renewable resource (i.e., the lower quality oil would be sold to cement kilns as a cheap fuel source), integrated into <u>non-</u>

environmental projects (fossil fuel emission).

2) The Canadian steel industry is testing the use of lime to suppress silica-based foamy slag produced during the smelting process in order to control the absorption of furnace fume emissions. It is claimed that the process simultaneously recycles bath heat, reduces air particulates, partially solves industry disposal requirements by 1 kilogram per ton per plant, and improves firm competitiveness by reducing energy input requirements and liability costs.

In this second case, because the industry is left to solve its own emission compliance problems, its environmental R&D consequently limited, the Dofasco steel studies in Hamilton, Ontario, have yielded low success rates - 20% of trial bath heats fail to foam, and only 10% of furnace fume ejections are absorbed. It is estimated that the process will not be successfully implemented before 10 to 15 years (Cochiarella, 1991). Fines, liability insurance premiums, environmental program organization, and so forth, increase industry expenses which in turn become the basis for justifying decreased production and employment (Eisler, 1991).

Industry is irreconcilably opposed to specific governmental regulatory approaches. Plans to levy a carbon tax, for example, have proven unpopular in the chemical industry because of its inflationary and anti-competitive nature. It is argued that a $100/ton carbon tax would punish non-offenders by increasing coal, natural gas, propane ethelyne, methanol, and ammonia prices and, within the decade, increase oil and coal prices by 300% and 250% respectively, while only reducing total emissions by 10% - all at a cost of $8 billion to the chemical industry (Novak, 1991).

Furthermore, because the chemical industry is sensitive to international pricing, it is limited in its ability to pass on environmental costs to the consumer, and would thus be forced to discontinue product lines and diversification agendas (Mills, 1991). Technically naive courts are responsible for settling complex environmental lawsuits, liability costs restrict industry's ability to develop and finance environmental projects and, as a result, industry becomes less able to keep up with a growing body of standards (Belanger, 1991).

Similar arguments are given by private environmental laboratories employed by industry to monitor effluents and emissions (Burgerner, 1991). For each testing method a lab seeks accreditation for, the Standards Council of Canada (SCC) requires ten record-keeping parameters (e.g., control standards, calibration and round robin data, etc). Because of their prospective market, these labs maintain file systems set up for business purposes rather than government audit inspections. In addition, a lab seeking accreditation for 1200 different tests to perform contract specifications have to maintain 12,000 files - an expensive, time-consuming, and error prone administration. SCC demands allow contract bids to become a function of managerial rather than technical investment, thus reducing the competitiveness of the private environmental lab industry by weakening its market position versus cheaper government and university labs.

These structural dilemmas have urged industrialists to propose remedial changes. Many of these seek to convert the political command and control approach to more market-oriented policies. Instead of "one-size-fits-all" measures, it is urged that regulations be grounded on biological and economic considerations. Here are some of these proposals:

1) "Total emission" standards could be prescribed in delimited geographic areas, rather than for individual companies. Thus, within a prescribed regional quota, individual permits "to pollute" could be distributed, and a market of tradeable rights created (Doern, 1990). Because firms encounter different compliance costs due to varying product mixes, technology, plant age and size, etc., only a portion of firms would require emission/effluent rights. Companies then, whose costs to comply are lower than the cost to pollute (the price of the permit) could sell rights to those whose compliance costs are greater. This general standard system is said to create incentives for companies to promote environmental research and development that reduce compliance costs, and to charge companies for polluting, all

the while respecting the regional pollution quota.

2) Where the industry consists of few polluters in an area, it would be viable to regulate the source (site-specific attention) (Bonsor, 1990). In the pulp and paper industry, for example, it would be preferable to use individual rather than regional pollution limits, setting standards relative to the capacity of the receiving waters to absorb the effluent, and to the confinement of chemicals within drainage basins. Without these conditions, employing regional standards overprotects some and underprotects other waters.

3) The government should allow the price system to guide consumption reduction. For example, because the Montreal Protocol CFC sunset policy (1987) increased the price of CFCs, firms whose control or chemical substitution costs are lower were eliminated from the CFC market (Smith, 1991).

4) Limits that are set according to best-available-technology (BAT) assessments ignore the costs of implementation. It would be more equitable to base assessments on best-practicable-technology (BPT) (Laplante, 1991), that is, on technology that is technically and financially viable relative to different plant characteristics. Furthermore, the imposed level of technological innovation should be related to chemical hazard priorities - high hazard (state of the art technology),

medium hazard (BAT/BPT), low hazard (reasonably available/practicable technology) (Harper, 1990).

These proposals advocate the government's recognition of market dynamics pertaining to industry's environmental compliance cost complexities. Government initiatives are seen as unnecessarily costly, inefficient, and technically naive.

Sectoral cooperation between chemists and related institutions, to summarize, is strongly promulgated given the diametrically opposed nature of government and industry perspectives.

C) University

There are certain structural dynamics that favor university (environmental/chemical) participation. Initiatives however, given internal academic obstacles to environmental research, are primarily external, and themselves limit the scope of disciplinary greening.

External greening influences consist of government, industry, and professional association interests. To some modest degree, they seek to mediate sectoral collaboration, and to stimulate academic research. Some are discussed below.

A significant influence includes the National Science and Engineering Research Council (NSERC). In 1989-90, 61% of its research base consisted of operating grants, of which 94% went to collaborative research and development programs (Latour, 1991). NSERC's Research Partnership Program (RPP) includes the following dimensions (NSERC, 1991):

1) Matching Fund program - NSERC duplicates any industry grant to university.

2) Industry research chair program - shared NSERC/industry support of university researchers.

3) Shared equipment program - common industry/ university expenses and technical access.

4) Industry research fellowships - appointment of chemistry PhDs to a two year industrial position.

5) Postgraduate scholarships - industry sponsors employees to update skills in universities.

6) Undergraduate research awards - hiring of students in industrial position for 4 months.

7) Technical difusion program - university/industry personel exchanges (two year positions at 75% of salary).

8) Industrially Oriented Research program - NSERC matches company contributions to university research relevant to industry.

9) Faculty support program - NSERC matches company contribution to 3 year university appointments.

The NRC's Industrial Research Assistance Program (IRAP) is similar to NSERC's RPP in its strong support of industrial interests. In 1990-91, IRAP had a $42 million budget, only 26% of that was allocated to the sciences (as opposed to biotechnology and engineering) and only 9.5% to environmental chemistry for all three sectors (Cooper, 1991). Between 1980-89, NRC funding to universities fell by 40% (NRCC, 1990). And, it was not until 1990 that an NRC program included an institute of environmental chemistry. It's commission is devoted to sustainable development and the Green Plan agenda (NRC, 1991:4-7).

External initiatives also come from the CIC, its member organizations, the Institute of Chemical Science and Technology (ICST), and other professional associations. Their greening force is discussed in the introduction and forthcoming chapters.

Internal academic environmental forces are more illusive. Because external programs stimulate university resources sporadically, consist primarily of industrial problem-solving interests, resulting in a group of uncoordinated research projects, chemistry as a discipline has been fragmented into specializations. This, and the multidisciplinary nature of the environmental sciences that confounds related areas such as occupational health, pulp and paper, oceanography, and engineering, have delayed the establishment of an environmental chemistry program (Appendix II).

Other internal elements complicate the greening of chemistry. Since the elaboration of specialized subdisciplines in the 1980's, the academic and intellectual gap between the "homo chemicus" (theoretical tradition) and those espousing substantive application (industrial viability) has widened. One perspective is seen by the other as either retarding disciplinary growth or selling out to corporate interests. Given that the clear majority of Canadian chemists perceive themselves in one of the traditional subdisciplines, and that most have trained in theoretical (non-industrial) chemistry (Appendix II), it may require the recruiting of much faculty support to establish an environmental subdiscipline as important as the traditional ones. External invitations to institutional change are therefore confronted with internal ideological, political, and academic resistance. **Appendix V** illustrates how divided chemists are on the direction of academic chemistry.

Further disincentives make environmental research unattractive to both the theoretical and applied academic chemists. The lag between research and industrial application, short-term external support, sectoral and disciplinary competition, teaching limitations in a new or undeveloped field, lack of environmental funding, and chemistry's demographic crisis (Introduction p.9), all postpone the recruiting of academic chemists into environmental chemistry, and delay the mobilizing of university chemistry for environmental research.

Being countered by opposite internal (academic) forces, internal greening forces become marginal. External interests constitute a stronger pro-environmental force on academia, but tend towards disciplinary specialization/fragmentation, which in turn complicates the internal coordination of environmental research. They also exacerbate internal greening problems by 1) confronting theory and application, 2) recruiting academics into industry and government laboratories, 3) restricting the range of research problem selection, 4) diffusing the academic research network by temporarily employing its scientists to meet current needs, and 5) recruiting upcoming academic researchers into subordinate projects that impose external resource dependency (for some effects of external support on academic research see Hackett, 1990).

We have to this point established a general notion of the sectoral perspectives and their possible impacts on the greening of chemistry. We have seen how incompatible contexts, and claimsmaking positions, make professional (chemical) consensus and coordination problematic, and how they produce variations in the degree of chemical greening across the different sectors. We have also seen how chemical knowledge develops in irreconcilably different directions depending on sectoral needs and deployment of technical expertise.

On the national level, environmental chemistry has long been established in government and industry sectors, but still lags in universities. Part of the reason for this are institutional barriers to sectoral collaboration, and internal/external structures inimical to academic greening.

In the following section we discuss the greening force of professional associations on a multisectoral chemistry.

Section II: The Professional Association

We know from the previous section that environmental chemistry in universities has not flourished because academic participation in multisectoral interaction is limited. In this section, we continue to explore the interrelation between sectoral coordination and the greening of chemistry. We will look at how a professional association, like the Chemical Institute of Canada (CIC), can mediate this relationship. That is, an established academic environmental chemistry would require a sustained professional claim to environmental authority within a multisector arena. The CIC provides this possibility as a medium through which research claims may be presented to peers in all three sectors of the chemical community (Introduction p.10-11, and Appendix III).

Innovative science is shaped by scientists who exchange information concerning unpublished research ("invisible colleges"). "They know researchers by meeting them in conferences, ... and know of their work before it is accessible in journals" ... "It is these network groups that represent the growth points in science, the outgrowth of the search for specialties" (DeMey 1981:133). Several sources report the dynamics of scientific interaction; information exchange and diffusion (Hagstrom, 1965), consensus and paradigm formation - disciplinary autonomy and growth (Kuhn, 1970), publication ties (Crane, 1972), rivalry (Collins, 1975), ally recruitment, the academic credit cycle, and career advancement (Latour/Woolgar, 1979), collective problem-solving (Lynch, 1985), and theoretical/practical insight (Amann/Knorr-Cetina , 1987; Krohn, 1989). Biographical accounts also allude to similar processes (Watson, 1968; Masson, 1984; Patenoe, 1988). On the other hand, despite these many contributions, ethnographic studies of scientific networks remain sparse.

This study looks at professional associations as a locus of networking. We surveyed CIC chemists who organized or presented papers at the June 1991 national conference to observe patterns of environmental and sectoral interaction, (see Methodology). Again, our assumption here is that sectoral interaction and disciplinary greening are mutually dependent. The degree of academic participation in (multisectoral) professional associations for example, could decide the intensity of environmental (chemical) R&D in universities, and vice versa.

Thirty-five of 150 environmental session participants responded to our questionaire (Appendix VII: Survey Results). Many respondents believe that much environmental research is done in their field (On a scale 1 to 10, Mean = 7.97), however, most chemists in all sectors agree they would like to see more research done (7.3), that the process from theory to application is too slow (4.7), and that current sectoral coordination in solving environmental problems is weak

(3.86). Marginal sectoral coordination could partially explain the perceived research and application lag.

Below, we present sectoral and organizational matrices of ties among the CIC chemists in our sample, as well as the network data pertaining to them. We then summarize and interpret the results.

Sectoral Matrix of the Sample *

		Government n=15															Industry n=10										University n=10									
		1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
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	0				1										[7]									[8]			1							[9]	

* 1's = respondents on Y-axis indicating tie with respondents on X-axis. Rows = ties cited Columns = ties received. Double-lined sub-matrices represent intra-network ties. Boxed numbers = cell label.

% External Ties

Government	23 of 65 actual external ties	= 35.4%
Industry	16 of 22 actual external ties	= 72.7%
University	17 of 27 actual external ties	= 62.9%
Overall	56 of 114 actual external ties	= 49.1%

Sectoral Matrix Densities

Na = number of actual ties

N = number of cases

[(N)(N)]-(N) = number of theoretically possible ties

Density = $D = \frac{100 \times Na}{N}$ (Niemeijer, 1973:46)

= % of theoretically possible ties actualized within symetrical (reciprocal tie) matrices.

Reformulation for asymetrical (non-reciprocal) matrices:

$$D = \frac{Na}{[(N)(N)]-N} \times 100$$

Therefore;

Government: $D = \frac{42}{225 - 15} \times 100 = 20\%$

Industry: $D = \frac{6}{100 - 10} \times 100 = 6.7\%$

University: $D = \frac{10}{100 - 10} \times 100 = 11.1\%$

Overall: $D = \frac{114}{1225-35} \times 100 = 9.6\%$

Centripetal Measures of the Sectoral Matrix

Q = number of ties in two sectors compared
N = number of respondents in both sectors compared
n1 = number of respondents in industry matrix
n2 = number of respondents in university matrix
n3 = number of respondents in government matrix

Centripetal Measure = C = $\frac{Q}{n(N-n)} \times 100 = \%$

= relative number of theoretically possible ties externally actualized (inter-network ties) (Alba/Moore, 1978). Revised for aymetrical ties between sectoral actors. Therefore;

Industry/University:

Cell 6 I to U = $\frac{5}{10(20-10)} = .05 = 5\%$

Cell 8 U to I = $\frac{3}{10(20-10)} = .03 = 3\%$

Industry/Government:

Cell 4 I to G = $\frac{11}{10(25-10)} = .073 = 7.3\%$

Cell 2 G to I = $\frac{8}{15(25-15)} = .053 = 5.3\%$

University/Government:

Cell 7 U to G = $\frac{14}{10(25-10)} = .14 = 14\%$

Cell 3 G to U = $\frac{15}{15(25-10)} = .15 = 15\%$

Overall Degree: D = $\frac{2 \times Na}{N}$

= mean number of relations network members have with other members (Niemiejer, 1973:47)

= $\frac{2 \times 114}{35} = 6.5$

Organization Matrix *

CASE	1	2	3	4	5	6	7
1		4/10	4/2		4/3		
2	$\frac{300}{1.5}$			4/2			
3					X	X	
4		3/10			48/12	$\frac{260}{17}$	
5	1/10	1/1	1/1	12/15		12/12	12/10
6			12	52	52		12
7				2/1	72/5	5/10	

Cell ratios = frequency of meeting per year/number of years known = (strength of tie). For example respondent 5 has met with respondent 7 once per month over the past ten years. Single numbers = frequency. X = known tie, unknown ratio.

$N = 7$

$Na = 23$

<u>Density</u> = $\frac{Na}{(N)(N) - N} = \frac{23}{49 - 7} = \underline{54.8\%}$

<u>Degree</u> = $\frac{2 \times Na}{N} = \frac{46}{7} = \underline{6.6}$

* The matrix is uniquely comprised of environmental symposia and panel discussion organizers. Five of the seven organizers are government chemists, four of which are federal, including the Environment Division Chair. The other two include one industry and university.

Summary of Matrice Data

Government

Density	20.0%
% External Ties	35.4%
Centripetal Measures:	
With Industry	5.3%
With University	15.0%

Industry

Density	6.7%
% External Ties	72.7%
Centripetal Measures:	
With Government	7.3%
With University	5.0%

University

Density	11.1%
% External Ties	62.9%
Centripetal Measures:	
With Government	14.0%
With Industry	3.0%

Overall Sectoral Matrix

Density	9.6%
% External Ties	40.4%
Degree	6.5

Organization Matrix

Density	54.8%
Degree	6.6

Interpretation of Results

The overall sectoral matrix data (density = 9.6%, or 114 of 1089 possible ties, % external tie = 40.4, degree = 6.5), suggest a small and diffuse network. The intra-network (intra-sector or intra-matrix) information discussed below, suggest that predominant government participation may at least partially explain this seemingly low cohesion.

With a low density (20%), and the lowest proportion of external ties (35.4), the government network appears weak and closed. However, because most organizers are from government, and these know each other well (density = 54.8%), and because government has the most intersectoral ties (centripetal measures) as well as the highest sectoral density in the sample, we may infer that government participation consists of a tight and open, or self-sufficient, nucleus of organizers mobilizing chemists from all sectors.

On the other hand, the data also indicate that while government ties to industry and university sectors are relatively high, the ties between industry and university are weak (C = 3% and 5%) Furthermore, the industry and university intra-sector ties are themselves weak.

The government chemists as a group then, at least in this sample, seem to have taken the role of entrepreneur, of information node, mobilizing chemists who do not know each other. And organizers, despite knowing each other well, appear to have stronger intramural (government) than external ties. This could be consistent with the "command and control" approach previously discussed - a politicizing of the disciplinary greening process. However, given that this study is not longitudinal, and that the CIC conference it pertains to is the first relatively green one, we do not attempt to interpret our information as a feature of settled networks or cliques, or of governmental style. We do suggest that early phases of interaction are often loose knit, with few established cliques, because of loose organizational style.

Conference session topics and memberships often carry forward the mark of institutional interests. Our survey of the conference agenda indicates participation in more than one session was minimal. It may be then, that the low degree of inter-sectoral professional ties could be explained by the segration of, and the institutional interests in, symposia research. For example, of the two general topics of relevance here, the federal government chemists dominated the environmental law and standards panel discussions, and academic chemists that of collaborative research opportunities. Industrial chemists were underrepresented in each of these. Technical chemistry sessions were equally distributed among the sectors, but consisted of uncoordinated topics, again with low subdiscipline interaction. These fragment disciplinary session membership into closed specialties, while reducing the potential for cooperation, coordination, and chemical greening.

In short, the greening of academic chemistry is more likely to emerge via professional associations than from the universities themselves. The government/university tie is strongest (C = 14% and 15%). Since all government respondents have university degrees, including 10 PhD and 3 MSc, this possibly reflects a process of alma mater networking (Appendix VII, p.78).

On the other hand, since university ties to industry are very weak (C = 3% and 5%), any interaction between them would be mediated through government ties, perhaps in the form of cost-sharing programs promoting industrially applicable research in academia, as we have seen in the case of the NRC and NSERC. These direct and indirect ties to government may constitute something of a greening force but, as we have discussed in Section I, they may also open university (and industry) chemistry to external dependencies inimical to greening, especially if government remains the dominant sectoral link.

In order to detect potential network cliques, we used the STRUCTURE software program (Burt, 1987). We performed two separate hierarchical clusterings of the respondents' relationship distances. The first of these, is a conservative or diameter, and asymmetrical, clustering used to locate strong component cliques (in which any member can be tied to any other). Our results indicate three clusters of two persons related via <u>distant</u> ties, therefore not constituting established cliques per se.

The second operation is a liberal or connectedness measure. While the previous approach assumes that a lack of tie reciprocity is due to a lower prominence of the tie citer in the mind of the tie cited (asymetry), the second approach gives respondents the benefit of the doubt by assuming reciprocity (respondents may have missed the name of someone they know on the questionaire list). This clustering then, forces symetry on the data, and includes anyone tied to a clique member. This is relevant given 91.7% of all possible ties are indirect, or consist of one or more intermediaries.

Our results this time, (next page), identified three cliques. All are connected to each other within a larger network of distant ties (distance ranging between .889 and 1.0, where 0 = least distant, and 1.0 = most distant tie).

One clique has a path distance criteria ranging from .833 and .875 - a negligible distance. It is comprised of two government (one active conference organizer), one industry, and three university sector chemists. The other two cliques are also tied via more distant paths, and are multisectoral, but consist of fewer chemists (3 in each case), one of which includes a government organizer, and the other a government chemist/manager. Government is the only sector with members in all cliques. The largest clique is trisectoral, while the other two either consist of one government and two university, or one government and two industrial chemists.

Liberal Clustering of the Distances

Three clique memberships are represented by rectangled respondents. Also rectangled are two larger clusters the cliques belong to. An overall network is delimited within the [ ].

```
                                   RESPONDENTS

Values    0 0 1 2 3 1 1 1 0 1 2 3 0 3 1 1 1 1 2 3 0 3
of D      9 2 3 2 4 1 5 7 1 6 5 0 3 2 0 8 4 9 8 3 4 5

 .667     . . . . . . XXX . . . . . . . . . . . . . .
 .750     . . . . . . XXX XXX . . . . . . . . . . . .
 .833     . . . . . . XXX XXX . . . . . . . XXX . . .
 .833     . . . . . . XXX XXXXX . . . . . . XXX . . .
 .875     . . . . . . XXX XXXXX . . . . . . XXX . XXX
 .875     . . . . . . XXX XXXXX . . . . . . XXX XXXXX
 .875     . . . . . . XXX XXXXX . . . . . . XXXXXXXXX
 .875     . . . . . . XXX XXXXX . . . . . XXXXXXXXXXX
 .875     . . . . . . XXX XXXXX . XXX . . XXXXXXXXXXX
 .875     . . . . . . XXX XXXXX XXXXX . . XXXXXXXXXXX
 .875     . . . . . . XXX XXXXXXXXXXX . . XXXXXXXXXXX
 .889     . . . . . . XXX XXXXXXXXXXX . XXXXXXXXXXXXX
 .889     . . . . . . XXX XXXXXXXXXXX XXXXXXXXXXXXXXX
 .889     . . . . . . XXX XXXXXXXXXXXXXXXXXXXXXXXXXXX
 .889     . . . . . . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .889     . . . . . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .889     . . . . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .889     . . . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .889     . . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .889     . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .923     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1.000     -------------------------------------------
```

Cliques, on the other hand, do not necessarily consist of well known or influential members. Size, density, and prominence data on egocentric relations (below) indicate that the clique members are not interaction leaders or central network figures. Of all respondents, those with the most dense and prominent ties are all government, two of which are the government conference organizers in the two cliques.

Ego Matrix Indices

	1	2	3	4
1	8	.08	.849	.048
2	8	.053	.705	.031
3	13	.045	.746	.02
4	9	.041	1.00	.045

Rows = respondents selected as most prominent.

Columns = indices, where
1 = Size
2 = Density
3 and 4 = aggregate
and reflected prominence

The cluster analysis then, identifies three small, low density, and closed cliques. That they are multisectoral is therefore not significant. Also, because "prominent" government and CIC organizers are clique members, we may suggest, as we did previously in this section (the sectoral matrix interpretation), conference interaction was confined to mobilized individual and grouped chemists tied by distant paths, if at all. And, we may suggest that while the government may have tried to stimulate industry and university interaction, to date it has mobilized the two sectors independently, thus suppressing potential conference interaction and multiple clique membership. Again, a question is whether this resembles a government command and control (mobilization) approach that fails partially by design, whether it is an artifact of this early phase of CIC greening, or a combination of both.

To summarize, if the role of professional associations is to stimulate scientific interaction, the CIC has achieved its purpose - especially at the local level. If its role is to sustain environmental interaction, and strengthen cross-sectoral ties, CIC greening is reduced because of its network organization - its low intensity of trisectoral and multidisciplinary interaction (only 6 respondents were in disciplines other than chemistry).

We should remember again that, in this case, a diffused network may reflect the status of a relatively new environmental CIC agenda, which may constitute a basis for future collaborative research. If and when this relatively wide and thin (but open) web of chemists "crystallizes", or as inter-network ties grow exponentially and settle within the larger network, they should become increasingly cross-sectoral, and intensify collaborative environmental research opportunities in chemistry. A longitudinal analysis would specify our picture of the CIC network.

Furthermore, the question remains, is a tight network of dense cliques more favorable to sectoral coordination and the elaboration of environmental research, than diffuse ties with insignificant clique formation? In other words, are research networks "better" when they are tight with influential core groups and individual leaders, or when untied chemists are brought together to interact professionally and forge new bases of collaboration?

Although we do not claim to resolve that query in this project, it would seem likely that a combination of these could balance opposite network forces tending either to diffusion or concentration of interaction. The answer would involve understanding this balance and its changes over time. The results of combining the elements in compatibly balanced organization include the forging of new ties <u>and</u> multisectoral leadership via open cliques of established ties. Disciplinary growth would ensue from the resulting stimulation of research.

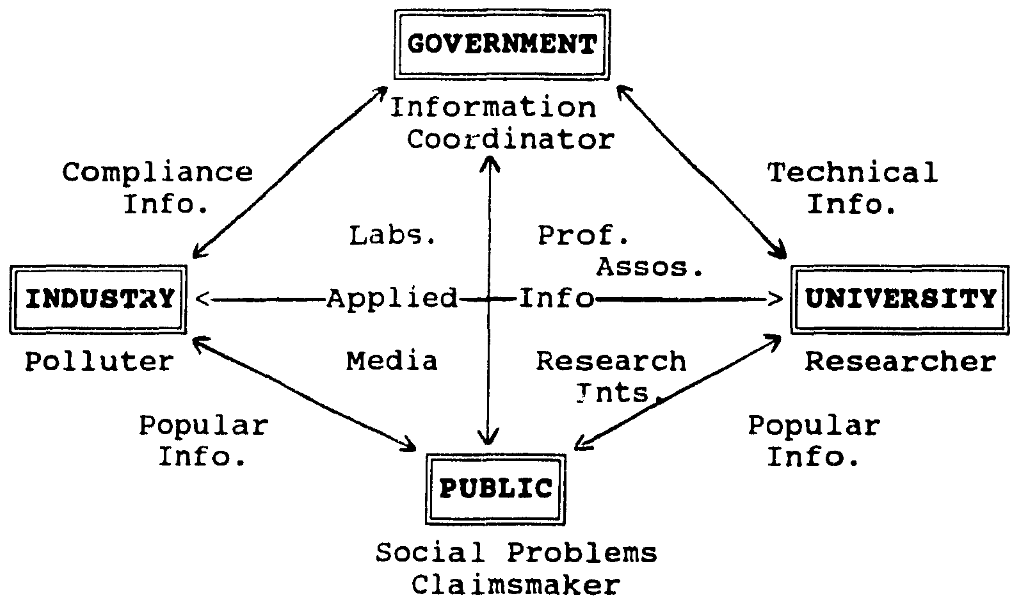
Section III
Conclusions

It is only with caution that we are able to summarize the nascent status of environmental chemistry. This requires a sociological frame within which we may begin to interpret our initial perceptions. In this section we attempt to do both by relating professional relationships and structures of chemical environmentalism to theory.

The diagram on the following page represents a social system of institutional relationships and information flow between dominant stakeholders. The examples in the center of the diagram represent groups related to any of the four stakeholders, possibly concurrently, which confronts them to each other via conflicting interests and evidential claims. The players and relationships are presented as ideal for the sake of simplicity.

Several things underlie this picture of the "system". First, international influences are omnipresent. In the case of environmental policy-making, the Canadian government and scientists from other sectors were prominent in UNEP and WCED proceedings. This international agenda became a blueprint for domestic command and control policies whose influences may dominate our diagram (e.g., the predominant direction and objective of information flow).

Second, all the types of information can be sought and acquired by the four stakeholders, although some may originate from, and be monopolized by any one, or be shared by any two or more (e.g., the public may have access to compliance information or university research).



Third, the groups in the center of the diagram constitute a pool of available resources. They are the medium through which the major players interact. To these groups, we could easily add unions, health organizations, funding agencies, publishers, and so forth.

Fourth, all actors are potential polluters and compliers, as well as professional claimsmakers, information coordinators, researchers, and agenda makers. The actors in the diagram though, are related to by their predominant role (e.g., industry is the most significant polluter). Finally, the direction of information flow happens to be asymmetrical, or nonreciprocal. As our research suggests, most of the substantive information flows bottom-up to government where it is interpreted and redistributed downward in altered forms like public relations, compliance regulations, funding, and conference organization.

Relevant to our research findings, the diagram presents what would be one of the most plausible scenarios. Industry and university are indirectly tied via government initiatives. Government is the coordinator of the Green Plan agenda, as well as a dominant presence in our CIC sample. In initiating ecological claims, the public and its activist groups have to contend with the more resourceful and professional R & D sectors. Pollution is largely of industrial origin, and the information provided upward is not necessarily the same as that imposed downward (e.g., research data up versus public relations down).

The diagram also helps us visualize the status of environmental chemistry. Both in terms of sectoral perspectives and association membership, our study identifies government as an organizational leader. It also tells us that academia is not yet, but may soon become environmentally significant. An environmental chemistry institute at Carleton will begin offering graduate training this year. It constitutes institutional change resulting from trisectoral interaction (p.8). Also, CIC university respondents were well tied to government environmental chemistry leaders. Given that political powers concerning environmental initiatives are decisive, academia may have little choice, and much incentive, to "green".

The diagram further reflects our study in that industry is a major claimant for and against environmental theory and practice. It has the financial resources and interest to research production methods that reduce or circumvent environmental liability and compliance costs. However, without common political ties, which is the dominant locus of conference participant mobilization, the industry's CIC-based network is loose-knit, and its individual chemists are restricted to marginal roles with little decision-making in the CIC's organizational issues.

In the institutional system, scientists negotiate social order. In our case, we suggested that a series of environmental research sites and programs are being systematically stimulated by the CIC, and other associations, across the country. This provides local arenas for the elaboration and diffusion of a broad-based common ecological language (e.g., "sustainable development", "responsible care", "environmental accountability", "zero tolerance") - a discourse coalition that constitutes a basis for interaction, problem articulation, consensus formation, and shared commitments in a field of coherence and legitimacy. And, because Green Plan initiatives, academic environmental chemistry, and CIC greening are all in early stages of development, we may soon see the meshing of local research sites into new environmental disciplinary and multidisciplinary specialties.

There are several indications and sources of an emerging academic multidisciplinary, trisectoral, environmental chemistry;

- There is a new academic institute in Ottawa.

- Industry/government funding to universities has established a potential basis of academic environmental research programs.

- There exists a nascent coalition between scholars and policymakers via professional association interaction and a bourgeoning common language.

- There is a developing multidisciplinary environmental chemistry (chemical engineering, polymer chemistry, atmospheric chemistry, chemical oceanography, geochemistry, occupational health, etc.). Many of these were present at the 1991 CIC environmental symposia, although only a few respondents (6 of 35) were actually from outside chemistry.

- A few recently marketable discoveries such as biodegradable plastic, phosphate (nitrate) alternatives, polymer recycling, and new analytical techniques, have established chemistry's environmental viability and credibility.

- Chemists in political and industrial decision-making positions are able to promote chemistry's environmental salience.

- CEPA and the Green Plan have created new markets for academic science in a new open territory. The assessment of

20,000 chemicals over an extended period of time, for example, could spill over to academic labs. Further regulation will motivate industry to seek technical assistance from universities. The consequent environmental participation of academic chemists could clean up the discipline's public image as non-environmental, or "chemical".

- Academic chemistry's aging professoriate and declining graduate enrollment will be mitigated by the recruiting new researchers into an enlarged chemical subdiscipline related to new environmental markets.

In the institutional system, order is both the medium and outcome of scientific change. That is, the reciprocity between old social structures and current scientific interaction yields new social structures. This approach (e.g., Giddens, 1984; Hagendijk, 1990) assumes the knowledgeability of scientists concerning the social organization of science - its systems and relationships. Because knowledge is power, scientists are able to employ and exchange organizational resources provided by networks, professional associations, and funding agencies. This often precipitates change in the process, perhaps including the mandating of research networks, the emergence of chemical specializations, the professionalization of social (environmental) problem-solving and, therefore, disciplinary greening.

We have proposed a potential avenue of change;

```
      1                          2
Institutional <———> Sectoral Network
  Structures               Interaction

        =>Greening of Chemistry
          Disciplinary Growth
                   3
```

where;

1. Funding, recruiting, administrative, and other institutional channels, selectively promote research opportunities. They themselves change, amd initiate change, via the expansion of scientific interaction and knowledge.

2. Information exchange (cooperation and competition), the elaboration of a common language, perspective sharing, and consensus formation are made possible through CIC interaction.

3. Change takes the form of the professional legitimation of environmental chemistry, the expansion of specialties, the emergence of chemical research institutes, new professional chemical associations, and plural professional association membership.

As a discipline, chemistry constitutes a locus of the broader environmental movement. Chemists lobby for regulatory change in all sectors, share technical authority with other scientific disciplines, are professionally organized (e.g., the CIC), and offer their expertise to organized environmental groups. Some are policy-makers, while others are managers, researchers, or professors. In the process, scientific knowledge (research) enters an arena of interests cooperating/competing for, and defining, environmental niches and jurisdictions.

In our "sewage sludge" case, for example (p.15-17), industrial chemists identified a problem for which they had the remedy. However, by entering an arena of public and political stakeholders, this project became vulnerable to other environmental and capital interests. It was made unviable because government yielded to public outcry, while concurrently justifying its own investment in the "oil from sludge" technology. Because oil could first be extracted from sewage, then sold to cement manufacturers as an energy source for their kilns, environmental jurisdiction was imposed by government rather than negotiated. The public was appeased, and public investments were safeguarded, while an ecological sewage disposal program was converted into an environmentally unfriendly fossil fuel emission agenda.

The greater the political visibility and the economic stakes, the more environmental chemistry enters a social world of potentially transforming influences. For example, industrial projects, and funding schemes, influence research problem selection, resource allocation, professional legitimacy, collaborative research ties, and so forth. Contradictions in this system emerge between collective (disciplinary) and individual autonomy, between cooptation and independence, leaving value tensions that reflect changes in scientific culture. (Cozzens, 1990; Hackett, 1990;

Restivo, 1988). Many of these contradictions are evident in our interview data (p.25 and Appendix V);

> "Traditionally, the field is more theoretical. We are the "Homo Chemicus" of university work. We would rather seek research opportunity (selfless devotion, intellectual curiosity) than rewards and industrial projects."

> "The field is much more practical. (New) material science is the leading edge in chemistry - impractical theory doesn't advance the field at all, it becomes introspective, closed."

Such value tensions question the role of chemistry, its position in the sectoral system, and the importance of theory versus application, of autonomy from versus dependence on external interests.

By considering natural history (who the interested individual and group participants are, how they relate to each other, their claims, resources, organizations, interactions, and perspectives) we are able to look at why academia lags, how industry adapts, the status of organized environmental groups, how viable environmental innovations are socially deconstructed while others are championed, and the intricate politics of professional environmentalism. We may then begin to understand the processes and parameters of disciplinary greening relative to concurrent institutional change.

The outlook for environmental chemistry is not yet clear. We may guess that the government network will continue to expand abroad and locally, industry will elaborate its technical and political skills, and universities will provide their expertise to the environmental information market. Ultimately, but certainly not immediately, academia will realign several chemical specialties to produce an umbrella environmental organization - a subdiscipline made up of a multisectoral chemistry network. Then, an integrated language and knowledge base could resolve confounded social-environmental problems. Much will depend on the permeability of the disciplines and sectors involved, their degree of open interaction. The extent to which environmental chemistry becomes an established academic specialty of sustainable research programs will partially rest on how willing and able academic chemists are in negotiating markets for ecological innovations.

Multisectoral chemical environmentalism in Canada is recent. We surely will see a widening of the interaction web, a proliferation of political initiatives, and an eclectic appropriation of environmental problems by disciplines and stakeholders. Whether they will be coordinated and efficient remains to be seen. Witnessing the process evolve from its origins provides strategic research interest. It invites subsequent analyses that should perhaps include studies of future CIC conferences, CIC constituent associations, the Institute of Environmental Chemistry, the Canadian Chemical Producers Association, and other nodes of the environmental chemistry network.

Methodology

(I) Methodological History of the Research

A) Eleven preliminary and informal interviews, ranging between five and forty minutes, were done with McGill University chemical researchers. They provided initial perspectives on chemistry, and brought attention to the Canadian Chemical News journal in which the CIC national conference schedule is made public. Because of the many environmental symposia scheduled for the June 1991 meeting, it was decided to survey the last thirty years of CIC conferences. The results indicate a sharp increase in the current number of environmental papers from a 1990 peak of some 35 papers to a 1991 presentation of 150. (Introduction:10).

B) We outlined the disciplinary structure of academic chemistry (Appendix II), the history of Canadian political initiatives (Appendices I and VI), a literature and conference review of the sectors' environmental perspectives (Section I), and a selective review of scientific interaction literature (Section II:28-29).

C) 150 questionaires were distributed personally, and/or through session chairs, among those who presented research papers or organized sessions at the 1991 CIC environmental symposia. Methodological issues, as well as the questionaire format and coding, are provided below.

D) Network data on the CIC environmental chemist sample are interpreted, including (Section II);

1) Frequency distributions and statistical means by sector (Appendix VII).

2) Asymmetrical matrix of intra- and intersectoral ties between respondents (p.31).

3) Asymmetrical organization matrix (p.34).

4) Density, degree, and centripetal measures of matrices (p.32-33, 35).

5) Hierarchical cluster analysis of tie distances, and ego network indices (size, density, prominence) (p.40-41).

(II) Methodological Issues

Although a sample N of 35 does not constitute a basis for strong generalization of the results from many of the survey questions, it is a population proportion sufficient for network analyses (23.3%, 35 of 150 CIC environmental participants). The respondents are all in decision-making positions, and thus are a sample of leadership in chemical environmentalism around the Great Lakes. The sample, on the other hand, is not consistently representative. Few polymer chemists for example, responded to the questionnaire. These however, were most active in CIC environmental (recycling) sessions, and are members of the largest academic environmental specialization (Appendix II).

Chemists from public environmental groups were also underrepresented in the sample (only one, a non-chemist, was invited to the conference). Many organized groups like Greenpeace, and Pollution Probe should be considered professional in that they do recruit chemists, engineers, and so forth, to strengthen their evidential claims. Their limited participation in the conference does depict their marginal professional status as environmental claimants. Comments from all the three R&D sectors during panel discussions on environmental law reflect this perception in their description of public groups as; "environmental fascists", "eco-terrorists", "technically incompetent", using old data, and misinforming the public. Of the respondents, only 6 (3 from each university and government) are members of environmental groups like Greepeace, and Worldwatch, including three multiple group members. These participants were however, presenting themselves as chemists from the R&D sectors, and not representatives of public interest.

The CIC is comprised of three constituent professional associations (Appendix III). Our sample may not accurately reflect chemists' environmental activity without looking at these more specialized networks. It may also constitute a basis for discussing chemistry's sectoral greening and disciplinary growth, but not for assessing scientific environmentalism since we are interested uniquely in chemistry, and therefore have not accounted for other professions active in multidisciplinary environmentalism (i.e. the International Association of Great Lakes Research includes chemists, engineers, and other scientific professionals in its membership). The research here however, does suggest that if a central discipline like chemistry is not greening, scientific and broad-based environmentalism are certainly diminished in their potential to yield adequate public policy reforms (e.g., political initiatives without technical rationale).

The 1991 CIC conference may have produced considerable environmental research relative to previous years because the Great Lakes are one of the, if not the, most prominent environmental locus of scientific concerns in the world (Appendix VI). On the other hand, the CIC anticipates much environmental research at the next two conference locations in Alberta and Quebec (Appendix III).

We decided that a measure of chemical environmentalism should include the active roles in the CIC conference (the organizing of sessions and presenting of research). We therefore did not survey those persons only attending the sessions because their interest may be ephemeral depending on the way sessions and topics are organized (more diversified session topics and organizers attract more chemists from all R&D sectors). Secondly, their ties to CIC participants would be uncertain, perhaps very weak, and thus not necessarily informative. Finally, for the purposes here, an audience survey of that size would be costly and involve several methodological problems.

Three respondents were not included in the network question, and thus constitute one-way ties. This should have minimal effect on the results (two were last minute presentation replacements, postdoctorates, therefore were not listed on the CIC's conference agenda with which our network question was prepared).

The 1989 directory used in the Appendix II survey may not contain all current Canadian chemists, but should provide a reflective sample of all but the most junior.

Given these issues, the results of this research are exploratory in that we elaborate and interpret a core of necessary data to provide researchable questions.

(III) Questionaire Design

Name: ____________________________

Age: ______

		Year Degree/Supervisor
Alma Mater: BSc	__________________	________________________
MSc	__________________	________________________
PhD	__________________	________________________
Other(s)	__________________	______________ ________
	__________________	________________________

Current Position:

Company/Government/ University: ______________________

Department: ______________________

Status/Position: ______________________

Research Specialty: ______________________

years in position: _____

How much do you think your field researches environmental issues?

1 2 3 4 5 6 7 8 9 10

very little — very much

How much should your field research environmental issues?

1 2 3 4 5 6 7 8 9 10

much less — stay same — much more

How coordinated do you think government/industry/university sectors are in tackling environmental issues?

1 2 3 4 5 6 7 8 9 10

not well — very well

In terms of environmental (chemical) application, what do you think of the process from theory to reality today?

1 2 3 4 5 6 7 8 9 10

slow — efficient

Why do you think this is so?

____
____
____
____
____
____
____
____

Are you, or have you ever been, a member of an environmental movement? (e.g. Greenpeace, etc.)

____ No
____ Yes
(Please indicate which one(s), where, and year):

____
____
____
____
____
____

Please summarize below how you perceive the environmental movement in Canadian chemistry. How widespread is it? Is there any resistance to it? Is there a leading group of proponents?

Please list other Canadian chemists you know of who are professionally involved in environmental research.

Name	Name of University/Government/Company

Please indicate below which of your professional ties you feel are/have been most important to your research (use back of last page if needed).

Name	Government/ Company/University	Location	Years Known

Of the people presenting at or organizing sessions for the 1991 Canadian Chemical Conference, please indicate below the persons you have professional ties with by showing the frequency of contact (times per day/week/ month/or year), and the length of time you have known the person on this basis).

(The names of the 150 conference respondents were deleted for anonymity).

Name	Freq.	Length
______	______	______
______	______	______
______	______	______

Etc.

Why would you say you maintain these ties?

____
____
____
____
____
____
____

Please indicate 1 to 5 (for low to high) the priority you place on the professional objectives below:

___ to publish
___ career advancement
___ recognition of skills
___ to learn
___ be in company of people with similar interests
___ to contribute to scientific knowledge
___ selfless research
___ other(s), (please specify):

____
____
____
____

Have you, or will you present a paper at the 1991 Canadian Chemical Conference in Hamilton?

______ No
______ Yes

If yes, which sessions?

____
____
____
____

How did you learn about these sessions? Were you asked by organizers to present, or did you learn about it from another source and decide to submit a paper to organizers? (Please indicate names and/or titles of sources).

____
____
____
____
____

Did you organize or chair a session for the 1991 conference?

_____ No
_____ Yes

If yes, please indicate which one(s), how you became involved, and why you did?

____
____
____
____
____

Please indicate below any additional comments you may have concerning the themes or presentation of this questionaire. (Use back of page if necessary).

(IV) <u>Questionaire Coding</u> (SPSS-x statistical program)

Q1. Age

Q2. Highest Degree
- 1 = BSc
- 2 = MSc
- 3 = PhD
- 4 = Postdoctorate

Q3. Year Highest Degree Conferred

Q4. Employment Sector
- 1 = Government
- 2 = Industry
- 3 = University

Q5. Position
- 1 = Federal Government
- 2 = Provincial Government
- 3 = Postdoctorate
- 4 = Professor
- 5 = Research Associate
- 6 = Department Chair
- 7 = Upper Management

Q6. Years in Position

Q7. Current environmental research 1 to 10 Scale

Q8. 1 to 10 scale

Q9. Sectoral Coordination 1 to 10 Scale

Q10. Application 1 to 10 Scale

Q11. Member of Environmental Movement 1 = yes
2 = No

Q12. Movement 1 = Greenpeace
2 = Deleted Value
3 = World Watch
4 = Chesepeake Bay Foundation
5 = Multiple Membership

Q13. Professional Objectives Scales 1 to 5

Q14. Conference Participation 1 = Paper Presentation
2 = Chair/session organizer
3 = Both

Q15. Discipline 1 = Chemistry
2 = Physics
3 = Mineral Sciences
4 = Management

Q16. Employment Location 1 = Ontario
2 = Other
3.= U.S.

Appendix 1

Department of Environment (DOE) made up of;

- Atmospheric Environment Service
- Conservation and Protection Service
- Canadian Parks Service
- Administration Program

DOE's Parliamentary mandate consists of (Conway, 1990; DOE, Annual Report, 1989-90)

- Arctic Waters Pollution Act
- Canada Shipping Act
- Canadian Wildlife Act
- Canadian Environmental Protection Act
- Canadian Environmental Assessment Act
- Canadian Environmental Week Act
- Department of Transport Act
- Fisheries Act (sec. 36-44)
- Game Export Act
- Historic Sites and Monuments Act
- International River Improvement Act
- Lake of the Woods Control Board Act
- Migratory Birds Convention Act
- National Battle Fields at Quebec Act
- National Parks Act
- Weather Modification Information Act

DOE also collaborates with;

- Canadian International Development Agency
- Canadian Standards Association
- Standards Council of Canada
- Federal Environmental Assessment Research Council
- Canadian Environmental Advisory Council
- Council of Resource and Environmental Ministers
- Water Research Institute of Canada
- World Meteorological Organization
- United Nations Environmental Programme
- World Commission on Environment and Development
- Provincial Ministries of Environment
- Other federal government departments and branches (energy, wildlife, fisheries, etc.)
- Etc.

Continued on next page.

History of Canadian Environmental Policymaking

Canadian Domestic Initiatives

Sources: (Conway, 1990; DOE Annual, 1989-90; DOE, Env. Update, 1989, 90, Annual reports; Donahue, 1991; Environment and Policy Society; Ecodecision, 1991, v.1 #1, Environment, 33:4, 14-45).

1868 - Fisheries Act

1871 - Atmospheric Environment Service.

1947 - Dominion Wildlife Service.

1960 - Department of Forestry.

1969 - Government Organization Act (GOA) - creation of Department of Fisheries including an Environmental Quality Directorate (EQD).

- Air Pollution Control Division in Dept. of Health and Welfare.

1970 - Fisheries Act amended to include pollution prevention and control.

- Canada Water Act, Arctic Waters Pollution Act, International Rivers Improvement Act, Canada Shipping Act.

1971 - Department of Environment (DOE), second in world after France, Jack Davis first Minister - response to debate over detergent phosphates.

- Clean Air Act receives Royal Assent.

1973 - Canadian Wildlife Act.
- Canadian Environmental Advisory Council (CEAC).

1974 - Federal Environmental Assessment and Review Office (FEARO)
- Environmental Protection Service (EPS) (formally EQD).

1975 - Environmental Contaminants Act.
- Ocean Dumping Control Act.

1976 - Air Pollution Technology, Oil Spill Technology, and Northern Technology centres.

1979 - DOE splits from Dept of Fisheries through GOA.

1983 - Measures for Energy Conservation in New Buildings.

1984-87 - DOE publishes through EPS Collection Enviroguide TIPS (technical information for problem spills - 150 manuals dedicated to individual chemicals).

1988 - (18 June) Canadian Environmental Protection Act (CEPA) replaces Clean Air Act, Ocean Dumping Act, Environmental Contaminants Act, Canadian Water (Nutrients) Act. Compilation and risk assessment of Domestic Substance List (20,000 of 50,000 chemicals on the market). Specification of a Priority Substance List (44 chemicals prioritized on the Domestic Substance List to be assessed within the next five years intending to produce 64 regulations within three years) (CEPA Report, March 1990:13). Other CEPA mechanisms include the List of Toxic Substances (CEPA, 1988: 508), the List of Prohibited Substances, the Restricted Substances List (CEPA, 1988:510), and the New Substance notification clause (CEPA, 1988:15-16). (**Appendix IV**). CEPA constitutes "Cradle to Grave" management of toxic chemicals.

- (June) Environmental Choice Program - EcoLogo attributed via performance standards set and certified by the Canadian Standards Association.

- Energuide labelling for home appliances.

- National Waste Reduction Plan - 50% by 2000, opening of an Office of Waste Management.

1990 - National Packaging Protocol - 50% reduction of package waste by 2000.

- Canada's Green Plan - originally drafted by Lucien Bouchard, but later revised by the federal Minister of Environment replacement, Robert DeCotret, before being made public. It promises $3 Billion plus $1.3 million/year until 1997 (of which $850M go to the study and reduction of chemicals in air, water, land, and $350M go to elaborating sustainable development) (DOE, Env. Update, 1989-90; Green Plan).

- Aquaculture Strategy.

Forthcoming:

1991 - Canadian Youth Advisory Council on Environment and Development

- Code of Environmental Stewardship
- Second National State of the Environment Report
- Drinking Water Safety Act
- Environmental Innovation Program
- Federal Pesticide Registration Review Team Report
- Federal Policy on Wetland Conservation
- National Energy Efficiency & Alternative Energy Act
- Wild Animal and Plant Protection Act

1992 - Canadian Agri-Food Advisory Council for Environmental Sustainability
- Co-operative Wildlife Ecology Research Network at Canadian universities
- Great Lakes Pollution Prevention Centre
- National Sustainable Fisheries Policy and Action Plan
- Office of Waste Management
- University-based National Toxicology Network

1994 - National State of the Environment Reporting Organization

Canadian International Initiatives (Ibid.);

1972 - First United Nations Conference on the Human Environment (**UNCHE**) in Stockholm led to the establishing of the United Nations Environment Programme (**UNEP**) - Maurice Strong (Canada) first executive director, and current Secretary General of UNEP.

1978 - (Nov.) Great Lakes Water Quality Agreement with US.

1984 - (October) World Commission on Environment and Development (**WCED**) convenes for the first time - initiated by Geoffrey Bruce (Canadian High Commissioner to Kenya, permanent representative to UNEP). Jim MacNeil (Canada) first Secretary General.

1985 - Helsinki Protocol on the Reduction of Sulphur Emissions or Their Transboundary Fluxes.

1985-87 - WCED Public Hearings - an intergovermental conference on sustainable development mostly held in (six) Canadian cities.

1987 - (Feb.) Canada ratifies the Montreal Protocol (CFC phase-out guidelines) adopted by forty countries by March 1990.
- (sept) Montreal adopts "sunset" policy

recommendations to phase out PCB's by 1997.

- WCED (Brundtland commission on environment and development) publishes "Our Common Future".

1988 - Group of Seven Economic Summit in Toronto endorses principle of sustainable development based on UNEP's WCED public hearings. Canada establishes International Center for Sustainable Development in Winnipeg, "Our Common Future" theme of first Environment Week Canada and of DOE's annual report).

- Toronto first World conference on the Changing Atmosphere.

- Canadian participation in the Intergovermental Panel on Climate Change (IPCC) mandated by UNEP and World Meteorological Organization (WMO).

- Canada co-sponsors WCED conference in Rio, Brazil 1992.

- Canada signs Sofia Protocol to reduce NOx (nitrogen oxides causing acid rain) to extend the Helsinki Protocol on Sulfur Dioxide 1985 - both falling under the Long Range Transboundary Air Pollution Convention overseen by the UNECE (UN's Economic Commission for Europe).

- As member of MARPOL (agreement regulating pollution of lakes) Canada attends International Convention for the Prevention of Pollution From Ships, thus updating the London Oil Spills convention guidelines.

1989 - Canada attends first International Environmental Summit in The Hague (prelude agenda-planning for Brazil 1992).

- (March) Canada signs Global Convention on the Control of Transboundary Movements of Hazardous Wastes.

1990 - (June) Montreal named United Nations secretariat to manage the Montreal Protocol Multilateral Fund of $240 million US, 15 of which is provided by Canada.
- Canada's Green Plan.

1992 - (June) United Nations Conference on Environment and Development (**UNCED**), "Earth Summit", Rio, Brazil. UNCED is second world conference on environment, follow-up to Stolkholm 1972.

Appendix II
Fields of Research Specialization in Canadian Graduate Schools of Chemistry *

Traditional Chemical Subdisciplines:

	#	(Avg. Age)
Analytical	174	(52)
Biochemistry	65	(49)
Inorganic	104	(50)
Organic	174	(52)
Physical	245	(52)
(Environmental)		
Subtotal	762	(51)

Specialized Subdisciplines:

Atmospheric Chemistry	1	(56)
Chemical Crystalography	2	(50)
Chemical Education	2	(57)
Chemical Oceanography	1	(--)
Chemical Physics	3	(48)
Chemistry of Occupational Health		
Chemistry of Pollutants		
Clinical Chemistry	11	(50)
Colloid Chemistry		
Electrochemistry	1	(57)
Forensic Chemistry		
History of Chemistry	1	(46)
Immunochemistry		
Material Science		
Medicinal/Phamaceutical Chemistry	11	(46)
Nuclear Chemistry	4	(55)
Organometallic Chemistry	1	(60)
Polymer Chemistry	24	(55)
Pulp and Paper Chemistry		
Quantum Chemistry		
Recycling Chemistry		
Solid State Chemistry	1	(52)
Space Chemistry		
Theoretical Chemistry	2	(57)
Toxicological Chemistry	1	(43)
Subtotal	66	(52)
Total	828	(51.5)

* These constitute self-reported academic research specialties in American Chemical Society, Directory of Graduate Research, 1989. The larger traditional areas consist of theoretical perspectives that cut across the smaller specializations. While the latter do have substantive environmental applications, there is **no** established academic environmental chemistry subdiscipline.

Appendix III
Environmental Sessions of the 1991 Canadian Chemical Conference

The Chemical Institute of Canada (CIC) is a cross-sector umbrella association for members of the Canadian Society of Chemists, Canadian Society of Chemical Engineering, and the Canadian Society of Chemical Technology. At the 1991 (74th) annual national meeting in Hamilton, Ontario, the CIC's environmental division organized the following joint (and non-joint) sessions (Canadian Chemical News 43:4, 1991);

a) Analytical Chemistry Division and the Environmental Division (also joint with the Canadian Association for Environmental Analytical Laboratories);

b) Chemical Education and the Environmental Division (also joint with Canadian Institute of Research for Atmospheric Chemistry);

c) Industrial Chemistry, Environmental Division, and Chemical Education;

d) Industrial Chemistry and Analytical Chemistry;

e) Environmental Division and Industrial Chemistry (also joint with the CIC's business and management division);

f) Environmental Chemistry, Industrial Chemistry, and Macromolecular Division;

g) Environmental Division, and;

h) New (polymer) Materials.

Session topics included;

- atmospheric chemistry
- determination of trace contaminants
- economics of environmental regulation
- environmental analytical laboratories
- groundwater chemistry
- opportunities for collaborative sectoral research
- polymer recycling
- public policy
- quality assurance
- and others relevant to the Great Lakes areas.

The preliminary symposia schedule for the 1992 (75th) conference in Edmonton, Alberta also promises much activity. Although only one joint symposia (analytical/ environment divisions) is certain to be organized, the environment division is preparing many session topics; landfill sites, pulp and paper, agricultural chemicals, bioremediation of contaminants, hazardous waste management, catalytic destruction of contaminants, environmental modelling, site sampling, trace analysis, standardization, etc. The 1993 conference in Sherbrooke, Quebec promises to yield several studies pertaining to polymers and recycling, the St-Lawrence seaway, CFC's, PCB's, and other local chemical issues.

Appendix IV

Chemical Lists and Assessment Parameters

(CEPA: 1988, 1990)

Priority Substance List

GROUP 1:	Arsenic and its compounds
	Benzene
	Pulp mill effluents (bleaches)
	Hexachlorobenzene
	Methyl tertiary-butyl ether
	Polychlorinated dibenzodioxins
	Polychloronited dibenzofurans
	Polycyclic aromatic hydrocarbons
	Waste crankcase oils
GROUP 2:	Cadmium and its compounds
	Chlorinated wastewater effluents
	Chlorobenzene
	Chromium and its compounds
	Creosote-impregnated waste materials
	Dibutyl phthalate
	1,2-Dichlorobenzene
	1,4-Dichlorobenzene
	1,2-Dichloroethane
	Dichchloromethane
	Di-n-octyl phthalate
	bis (2-ethylthexyl) phthalate
	Inorganic fluorides
	Nickle and its compounds
	Pentachlorobenzene
	Styrene
	Tetrachlorobenzene
	1,1,2,2-Tetrachloroethane
	Tetrachloroethyene
	Toluene
	Trichloroethylene
	1,1,1-trichloroethane
	Trichloroethane
	Xylenes
GROUP 3:	Aniline
	Benzidine
	Chlorinated paralfin waxes
	bis (2-cholroethyl) ether
	bis (cholromethyl) ether
	Chloromethyl methyl ether
	3,3-Dichlorobenzidine
	3,5-Dimethylaniline
	Methyl methacrylate
	Mineral fibres
	Organatin compounds

1/3 of priority substances are families of chemicals each comprising of another several hundred substances. Group 1 chemicals are targeted for initial assessment. There are currently about 50,000 chemicals on the Canadian market.

List of Prohibited Substances

Organohalogen compounds
Mercury and its compounds
Cadmium and its compounds
Persistent synthetic materials
Crude oil and its wastes, refined or distillate petrolium products and residues
High-level radioactive wastes and matter
Substances produced for biological and chemical warfare

List of Restricted Substances

Arsenic and its compounds
Lead and its compounds
Copper and its compounds
Zinc and its compounds
Organosilicon compounds
Cyanides
Fluorides
Pesticides and their by-products

List of Toxic Substances

Chlorobiphenyls ($C_{12}H_{10-n}Cl_n$ n>2)
Dodecachloropentacyclo biphenyls
Halogenated chlorofluorocarbon
Polychlorinated terphenyls
Asbestos
Lead
Mercury
Vinyl chloride

List of Permit Assessment Factors

1) Total amount and average composition of substance dumped
2) Form (solid, sludge, liquid, gaseous)
3) Properties: physical, chemical, biochemical, biological
4) Toxicity
5) Persistence
6) Bioaccumulation
7) Susceptibility to property changes and interaction with other materials
8) Probability of production changes reducing the marketability of resources

Appendix V

The following are selected quotes by chemists during informal interviews conducted at the McGill University chemistry department and the June 1991 CIC conference, as well as their responses to open-ended survey questions.

"Traditionally, the field is more theoretical. We are the "Homo Chemicus" of university work. We would rather seek research opportunity (selfless devotion, intellectual curiosity) than rewards and industrial projects."

"The field is much more practical. (New) material science is the leading edge in chemistry - impractical theory doesn't advance the field at all, it becomes introspective, closed."

"In my area, (atmospheric chemistry) environmental research per se is very, very limited. In academia there seems to be much resistance to touch a subject that is perceived "too applied"."

"There's really two extremes - the pure research with little or no applicability, and the mundane application like the polymer chemist that developed a new material to allow golf balls go higher and further."

"Our future lies in the courses we offer and not in research. Sometimes we tend to forget our responsibility to those that rely on us to learn. We need more "great performers" like Dr. ____________ who can sustain student interest."

"I am leaving my university position for a few years at least to work with industry. We (universities) are underfunded, and work with outdated equipment. I want to do environmental research in the real world where you can apply ideas to something concrete and relevant"

"I wouldn't do any environmental chemistry - there's no money or status in it - you wind up publishing in popular journals like The Ecologist or Environment."

"The lag time between theory and application depends on the idea, the (sub)discipline, and other things. Universities produce ideas, some of which may be useful, and these are made workable by more equipped and trained researchers (outside academia)."

"We don't really do environmental research per se, but we do have ideas that are applicable. A lot depends on whether or not somebody out there picks it up, or whether the guy who developed it pushes to sell it."

"I have not observed a strong swing to environmental issues. Rather, I have the impression that many researchers are "wrapping" their proposals or results in an "environmental" way to strengthen support for the kinds of work they have always been doing."

"There are many environmental chemists because that is where the jobs are, but I don't think these people are necessarily "environmentalists"."

In terms of environmental (chemical) application, the process from theory to application is slow because "there is not enough communication between academia, industry, and government."

Appendix VI
Highlights of Environmental Policy Initiatives in the Great Lakes

1909 - Canada-U.S. Boundary Waters Treaty establishes the International Joint Commission **(IJC)** (a binational agency settling border disputes).

1971 - Canada-Ontario Agreement **(COA)** signed to ease the 1972 binational agreement.

1912-72 - IJC conducts studies on Great Lakes pollution problems.

1957 - Ontario Water Resources Commission Act

1972 - IJC reports highlight the problem of phosphorus stimulated algal growth (excess nutrients/ eutrophication), which becomes the basis of the binational Water Quality Agreement **(WQA)**.

- An IJC branch, Pollution From Land Use Activities Reference Group **(PLUARG)**, is established to study non-point sources of pollution (watershed studies of agriculture, forestry, etc.).

1973 - Great Lakes Regional Office in Windsor, Ontario.

1978 - Amendment to the Water Quality Agreement to include point source pollution (industries, municipalities), toxic chemicals, dredging, vessel discharge, ecosystems, and socio-economic variables.

1981 - Great Lakes Atmospheric Deposition **(GLAD)** network (Water Quality Board branch).

- Joint (Canada/Ontario) Strategic Plan for Management of the Great Lakes Fisheries.

1983 - Annex 3 of WQA, under the Canadian-Ontario agreement, establishes the Phosphorus Task Force.

1985 - Completion of the Canadian phosphorus management plan.

- The primary advisor to IJC, Great Lakes Water Quality Board **(WQB)**, reported 42 areas of concern ("hot spots"), around the Great Lakes, containing 11 critical toxins (See map below).

- Federal Water Policy (Pearson Commission) report recommends provincial jurisdiction to include groundwater resources.

1986 - Establishing of Ontario's Municipal Industrial Strategy for Abatement **(MISA)** based on "best available technology economically achievable". MISA is administered through the Water Resources branch of the Environmental Services Division (Ontario Ministry of Environment).

1987 - IJC's WQB studies lead to the 1987 Protocol annexed to the WQA establishing the Remedial Action Plan (RAP) programme implicating the eight Great Lake states and Ontario.

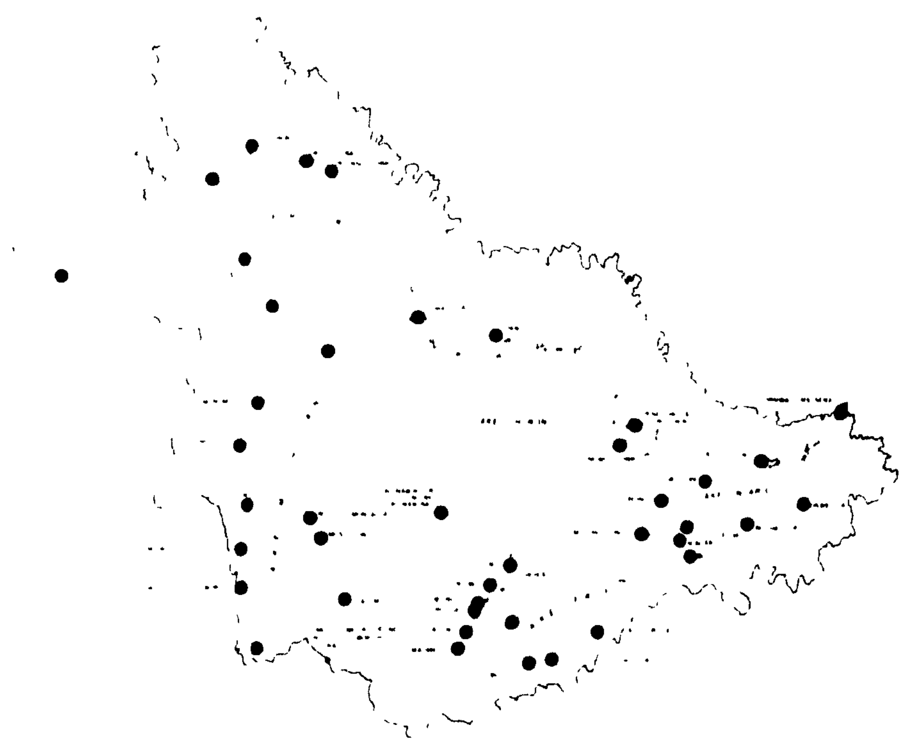
1989 - IJC's Virtual Elimination (zero discharge) Task Force composed of the WQA and IJC's Science Advisory Board.

1991 - Lake Superior Agreement on zero discharge

Some Non-Govermental Great Lakes Organizations

Centre for the Great Lakes
Council of Great Lakes Industries
Great Lakes United
Great Lakes Maritime Forum
International Association of Great Lakes Research
International Great Lakes Coalition
Pollution Probe

IJC Hot Spots



Appendix VII
Survey Results

Sector by Background Variables

	Government n=15	Industry n=10	University n=10	Total n=35
Average Age	45.6	44.9	46.2	46
Education:				
B.Sc.	2	3		5
M.Sc.	3	5		8
Ph.D.	10	2	8	20
Postdoc.			2	2
Avg. Year Degree Granted	1973	1972	1971	
Current Position:				
Chemists	11	8	10	29
Federal	11			11
Provincial	4			4
Postdoc.			1	1
Professor			6	6
Research Associate			2	2
Department Chair			1	1
Upper Management		10		10
Average Years in Position	6.4	5.9	12.8	8.4
Location:				
Ontario	13	10	3	26
USA	1		5	6
Other	1		2	3
CIC Participation:				
Paper	10	8	9	27
Chair	1	1	1	3
Both	4	1		5

Opinion on How Much Field Does Environmental Research

	Government	Industry	University	
Little	2	1	1	4
Neutral	1	1	1	3
Much	11	8	8	27
	14	10	10	34

Mean = average response on 1 to 10 scale = 7.97
Standard Deviation = 2.5

Opinion on How Much Field Should Do Environmental Research

	Government	Industry	University	
Less	0	1	0	1
Stay Same	6	2	2	10
More	7	6	8	21
	13	9	10	32

Mean = average response on 1 to 10 scale = 7.3
Standard Deviation = 1.87

Opinion on the Environmental Coordination of Sectors

	Government	Industry	University	
Not Well	8	8	6	22
Neutral	6	1	1	8
Well	1	1	1	3
	15	10	8	33

Mean = average response on 1 to 10 scale = 3.86
Standard Deviation = 2.3

Opinion on the Process
From Theory to Reality

	Government	Industry	University	
Slow	3	8	2	13
Neutral	7	0	2	9
Efficient	3	2	3	8
	13	10	7	30

Mean = average response on 1 to 10 scale = 4.7
Standard Deviation = 1.7

Membership in
Environmental Movements

	Government	Industry	University	
Yes	3	0	3	6
No	12	10	7	29
	15	10	10	35

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