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## Killam Annual Lecture 2008

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# 2008 Killam Annual Lecture

# "The Role of Science in Making Sound Environmental Policy"

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University of Alberta
Edmonton, Canada

***Izaak Walton Killam***
*Born in 1885 at Yarmouth, Nova Scotia.*
*Died in 1955 at his Quebec fishing lodge.*

***Dorothy Brooks Killam, née Johnston***
*Born in St. Louis, Missouri in 1899.*
*Died in 1965 at La Leopolda, her villa in France.*

**DR. DAVID SCHINDLER, OC, AOE, DPhil, FRSC, FRS**

**Killam Memorial Chair and Professor of Ecology**
**University of Alberta**

Dr. DAVID SCHINDLER, OC, AOE, DPhil, FRSC, FRS is Killam Memorial Chair and Professor of Ecology at the University of Alberta. His research on the effects of phosphorous and acid rain on lake chemistry was influential in leading to restrictions in phosphorous content in detergents and changes to air quality legislation throughout Canada. The recipient of many prizes and awards, including the Canada Council Killam Prize in 2003, Dr. Schindler is the only Canadian to have received the Stockholm Water Prize 1991 (and the first ever recipient), in addition he was awarded the 2001 NSERC Gerhard Herzberg Gold Medal for science and engineering, the Tyler Prize in 2006, as well as the Volvo International Environment Prize in 1998. He holds honourary doctorates from ten universities and was made an Officer of the Order of Canada in 2004. Dr. SCHINDLER has been Killam Chair at the University of Alberta since 1989.

# Foreword

*David Schindler* is a long time Killam stalwart. Since 1989 he has held the Killam Chair in Ecology at the University of Alberta, with water resources a specialty. In 2003 he was the Canada Council Killam Prize winner in Natural Sciences, and is a frequent presence at the gala dinners held at the U of A to celebrate its annual crop of new Killam Scholars and Fellows. So it was with a warm sense of family - almost of homecoming - that the Trustees invited David to give the 2008 Killam Lecture. And it was everything we had hoped for.

The Lecture took place in Edmonton on October 16, on the occasion (as is the case each year) of the annual conference of the Canadian Association for Graduate Studies (CAGS). The usual audience of Deans, Associate Deans and assistants from all of Canada's faculties of graduate studies was augmented by a good number of interested folk from Edmonton. Chief among these were *Eric Newell, OC*, former Chancellor of the U of A and *Arliss Miller, CM*, a noted philanthropist and keen supporter of the U of A. Eric's business career had been spent in the oil patch, most recently as Chair of Syncrude, largest of the players in the Alberta oil sands; in that capacity he had often met with, debated and taken advice from Dr. Schindler. For David's is one of the strongest voices of alarm on the subject of the ecological damage being caused to the environment by the petroleum industry, due to its insatiable appetite for huge and growing supplies of water for use in extracting oil from the tar sands. This, explains David, is particularly troublesome in a place like Alberta which, though blessed with a relative abundance of rainfall during the past few decades, is in fact an arid or semi-arid province. Thus the continued over exploitation of Alberta's water resource for industrial and even agricultural purposes is not sustainable, and ways must soon be found to do more with less – much less.

Nor is the scarcity of the commodity David's only theme. He is concerned too about the quality of our water resource, and in fact he was at the forefront of the drive to expunge phosphorus from common household products like detergents. Thus we have him to thank for the reductions over the past 30 years in the algal blooms that once threatened the viability of even our largest bodies of water, such as the Great Lakes.

Environmentalism is all the rage today, but frankly there is much about the movement that smacks of uninformed hype and ungrounded hysteria. How refreshing, then, to have at hand for our instruction people like Dr. Schindler, who insist upon hard science as the sole basis for the positions they take on the environment. And how vital it is – if real progress (as opposed to mere show) is to be made – that science, not politics, be the touchstone of decision-making about the environment.

Not that Dr. Schindler shrinks from expressing his views with force, and often to the point of provocation. As when he criticizes politicians not only for failing to follow good science, but for setting up reporting systems within government departments that positively prevent the views of the hard scientists from even being heard by the elected decision makers.

But presenting one's views with force and conviction are surely what makes a talk memorable. And those who heard Dr. Schindler give his Lecture, along (we confidently predict) with those who have the occasion to read it, will long remember his science-based cautionary message.

You can get extra copies of this Lecture from our Killam website: www.killamtrusts.ca

November, 2008
The Trustees of the Killam Trusts

# 2008 Killam Lecture
# The Role of Science in Making Sound Environmental Policy

Killam Trustees and distinguished guests, I thank the Killam Trustees for inviting me to present the 2008 Killam Annual Lecture. I have read several of the past Killam lectures, and I am very honoured to be asked to join such a prestigious, thoughtful, and intellectual group.

I have spent over 21 years of my career as an academic, 19 of them as the Killam Memorial Professor of Ecology at the University of Alberta. I am very grateful for the Killam support, for it has given me tremendous freedom to investigate topics that I have found to be intellectually satisfying and have considered to be important. One such topic is the role of science in formulating environmental policy, which I have chosen to talk about today.

I have also spent 22 years as a federal government scientist. During that period, I have seen the role of science in environmental policy making decline from being the best in the world forty years ago, to today when science has about the same influence on Canadian environmental policy as it does in most third world countries. I have seen strengths and weaknesses in science in both university and government systems, and have some ideas on how the strengths could be combined to increase our ability to perform the science and inform the policy that we critically need to protect and sustain our environment during the current rapid development.

Universities have the luxury of a near-continuous input of young, bright, and inquiring minds. Professors are free to pursue research that they regard as important, whether for the sake of curiosity, technological development, environmental protection, or social

responsibility. They are free to speak out on almost any topic, with the protection of tenure. There is a considerable amount of research money accessible to talented faculty from governments, foundations, or industries, depending on the topic.

In contrast, government scientists usually have their research constrained by political agendas. They are sometimes coerced into doing research that may be fashionable, but is not very meaningful. They do not have the protection of tenure, and speaking out publicly, even on issues of critical importance, can jeopardize their positions. Funding is tied closely to political interest. Long periods of static staffing and dwindling funds are generally punctuated (usually during an environmental crisis) with short periods of frenetic hiring and lavish funding. However, federal environmental scientists have the luxury of having few constraints on time in the field, whereas university professors spend many months teaching classes, participating in committees, and other university activities. At least in some cases, federal scientists still have the advantage of well-paid technical staff who are skilled at operating instruments, field logistics, and other critical aspects of environmental research.

I will now recount some of the experiences with both university and government systems that have shaped my thinking about how we might build a better system for connecting environmental science to policy. With the increasing scale and frequency of industrial development that we are experiencing today, we need to improve the process of inserting sound environmental science in a timely fashion to ensure that developments are made in an environmentally sustainable way. The urgency of doing so is not widely appreciated by politicians or developers who are anxious to get on with the business of making money and creating jobs, yet it makes sense to take a precautionary approach. It is generally much less costly to prevent environmental damage in the first place, rather than to mitigate environmental damage after it occurs.

We urgently need to adopt this philosophy. In the words of the well-known Canadian forester and philosopher Stan Rowe, penned almost 20 years ago:

> *"The maternal environment of all humanity is the world, the Earth, now increasingly weakened and ill from too much child-bearing. Badly overpopulated and polluted, short on nourishing resources and with restorative powers crippled, the planet lacks a health care plan and a corps of dedicated healers."*[1]

Note that I used the word *environmentally* sustainable. As Michael Smith pointed out in his 1998 Killam lecture, the phrase "sustainable development" has become an oxymoron. In business circles, "development" is used as a euphemism for "growth." As Michael sagely counsels us, "growth" is actually the antithesis of sustainability, because on a finite planet nothing can grow indefinitely. Furthermore, the maintenance of healthy ecosystems in perpetuity is inconsistent with unlimited growth of human populations and industry.

***The Old-Style University Approach: Few Links of Science to Policy***

I began my career in environmental sciences unaware of the large scale damage that bad political decisions were inflicting on the environment. Technological feats like the Hoover Dam on the Colorado River and the huge iron-mining pits of the Mesabi Range in my home state of Minnesota were widely regarded by lay people as marvels of the modern age. My fishermen friends believed that stocking any species of fish in any lake was good. Although sea lampreys were known to have devastated the lake trout fishery of the Great Lakes, no one mentioned that man might have caused the disaster.

That changed when I attended university. At 19, I was a bored student of engineering physics, hoping someday to have a career that would allow some freedom to enjoy the outdoors that I loved. That summer, 1959, I obtained a summer job to set up, calibrate, and run a bomb calorimeter for a professor at North Dakota Agricultural College, whom I had met by accident through a friend. Those were the days when energy transfer in biological food chains was an entirely new concept, one that Professor Gabriel Comita wished to investigate in lakes. He had no experience with bomb calorimetry, and when he found out that it had been the topic of one of our freshman physics laboratories, he invited me to work for him.

Comita also allowed me to borrow books from his well-stocked office shelves. The first book I read was Charles Elton's classic "The Ecology of Invasions by Plants and Animals."[2] The book, written the previous year, documented the enormous scales and rates at which humans were moving species around the planet and the devastating effects that some of them had when they invaded new ecosystems. This single book had an enormous impact on my life. I can still remember Elton's words, taken in part from Conan Doyle's "Lost World": " 'We have been privileged to be present at one of the typical decisive battles of history- the battles which have determined the fate of the world.' But how will it be decisive? Will it be a Lost World? These are questions that ecologists ought to try to answer." That autumn, I switched from physics to biology, and from the University of Minnesota to North Dakota Agricultural College (Moo U to its detractors, but soon to become North Dakota State University) where Comita taught. I later read Elton's "Voles, Mice and Lemmings,"[3] another work in applied ecology which documented the enormous problem caused by rodents to food stores during World War II. I was fully convinced of the importance of ecology in human affairs, and determined to become an ecologist. A Rhodes Scholarship made it possible for me to study directly with Elton.

For many years, it struck me as odd that Elton's *Ecology of Invasions*, written four years before Rachel Carson's *Silent Spring*,[4] describing a more important problem and written much more lucidly, never grabbed the public or political attention garnered by *Silent Spring* (though today, sixty years after it was published, citations of Elton's book are still increasing year after year, an amazing record for a scientific book, but one that is symptomatic of what is wrong with academic approaches to environmental policy problems). Elton was one of a handful of the most recognized ecologists of his day, whereas Carson was a relative unknown.

In retrospect, Elton's books were an important lesson in how *not* to make an important environmental issue publicly or politically visible in a timely way. Advocacy in those days was considered to be unbecoming for university scientists. As a good academic, Elton had not written his books to educate politicians or the public at large. Instead, they were written for his peers. Like so many works of science, they lay hidden for many years in the obscure corners of Ivory Tower libraries. Most environmental science done in universities today has the same problem. It is still written in obscure journals that are accessible only in Ivory Tower libraries, to be read by a few of the authors' peers.

This is one important problem that we must solve. We can no longer afford to wait decades for important scientific results to serendipitously trickle into environmental policy and management. With the rapid and huge scale of modern development, it is important to have excellent environmental assessments in hand when decisions are made and policies are approved, not years later when the only recourse is expensive mitigation. There is only one way to do this. Scientists must intervene directly in the policy arena, with their full range of knowledge, skills, and intuition. Before developments are approved, it is important to understand the full range of possible ecosystem responses, if costly mitigation later is to be avoided.

### *The Era of Strong Science-Policy Links for Water Protection in Canada*

Remarkably, there was a period in Canada when we had efficient and strong environmental protection, at least for aquatic ecosystems. In 1968 I joined the then Fisheries Research Board of Canada (FRBC),[5] the agency that was responsible for managing many of the country's freshwater and coastal problems. The FRBC was world renowned for its excellent work in fisheries management, one of the reasons that it attracted me. The FRBC consisted of a number of eminent Canadian fisheries scientists and limnologists, some of them world famous. The Board was given a sum of money by the Canadian government each year. It allocated these funds to different freshwater and marine fisheries stations to investigate and solve aquatic problems. The Board actually took the time to visit individual projects and ask probing questions about the science. The focus was on excellent science, not on political spin.

One concern of that time was on eutrophication, the appearance of huge algal blooms on lakes, and associated problems. Little was known about the problem. A symposium sponsored by the US National Academy of Sciences in 1967[6] featured many international experts who expounded on their pet theories of what caused eutrophication and how it might be controlled. Between them, the various theories included most of the elements on the periodic table! Most of the theories were supported only by short-term, bench-scale experiments done in university laboratories. It was at this symposium that I met Jack Vallentyne, who was to be my boss after I joined the Fisheries Research Board. I was hired to found the Experimental Lakes Area (ELA), to investigate how eutrophication could be controlled, using whole lakes as experimental vessels. There was particular concern about the rapid development of huge algal blooms on lakes Erie and Ontario. The press was already calling Lake Erie "dead." It was anything but, teeming with plant growth, but of a type that our society viewed as unfavourable.

In the early years of ELA, I had only to do the science…..no mean feat when the study lakes were miles from the nearest road. I would analyze the results of our whole-lake experiments, then write scientific papers describing the results. Vallentyne, a recognized expert on eutrophication who had a knack for public communication, would present the results and their interpretations directly to policy makers.

Within three years, our first experiments showed that eutrophication could be controlled by decreasing input of one element: phosphorus. Our first experiment proved that control of carbon inputs to lakes, proposed by the detergent industry, would be ineffective. The second experiment was to become world-renowned for its visual impact. We selected a lake that was shaped like an hourglass, Lake 226, and separated the two basins with a heavy waterproof curtain. We added nitrogen and carbon to both basins (controlling these two elements was often touted as necessary to control the eutrophication problem), but we added phosphorus to one basin. The basin receiving phosphorus turned green within weeks, supporting an enormous bloom of nuisance bluegreen algae (Cyanobacteria to scientists). The other basin remained in pristine condition. A single picture of the lake[7] had more impact on policy makers than hours of testimony by industry's propaganda campaign, designed to show that phosphate detergents were necessary and that reducing phosphorus alone would not be effective. Using our results, Vallentyne convinced the International Joint Commission to recommend to Canadian and US governments that it was necessary to control the input of phosphorus to reverse eutrophication of the Great Lakes. The Canadian government responded quickly, banning high-phosphate laundry detergents and requiring that phosphorus must be removed by sewage treatment plants in the Great Lakes Basin in 1973. The result was one of the biggest success stories in environmental science and policy. Lakes Erie and Ontario, and many other lakes where phosphorus inputs were controlled, began to

recover within a few years. It was exciting to do science that had such an immediate and important impact on ecosystem protection. The performance of the Fisheries Research Board and the ELA was internationally praised. Phosphorus control policies were enacted in many countries.

Little did I realize at the time that this efficient science-policy link would soon be destroyed, and that I would observe decades of dwindling influence of science on environmental policy as the ideal relationship between the Fisheries Research Board and policy makers was terminated.

***Political Interference: The Dwindling Influence of Science in Canadian Environmental Policy***

The Government of Canada disbanded the Fisheries Research Board in 1973. The Board's employees became part of Environment Canada, a part of the civil service under a new Minister of Environment. A few years later, this organization was separated into what are now the separate departments of Environment and Fisheries and Oceans (DFO)….a bizarre split that bureaucratically isolates fish from many important features of their environments.

Instead of answering to a panel of the country's most eminent scientists, we now reported to politicians and their deputies. Half of our building became occupied by bureaucrats who had little background in science, and no concerns about the role of science in making sound policy. There was little talk of major environmental problems and their solutions among our managers. Instead, the major concerns were on the sort of spin that would make the Minister of Fisheries look good, and to make it appear that funds had been well managed. In the words of John Ralston Saul:

> *"…they are committeemen…, always detached from the practical context, inevitably assertive, manipulative; in fact they are highly sophisticated grease jockeys, trained to make the engine of government and business run but unsuited by training or temperament to drive the car or have any idea where it could be steered…."*[8]

At about the same time, it was decided in Ottawa that the management of freshwaters was to become the mandate of provinces, with the federal government only responsible for international or cross-border matters, for marine systems, and for the North. Vallentyne refused to be a part of this ménage, and left the Freshwater Institute.

Before he left, Vallentyne called me into his office to discuss the eutrophication problem. While Canada had quickly chosen to manage phosphorus inputs to the Great Lakes as I described above, the USA had still not done so. The USA, governed by Richard Nixon and his advisors had just formed the Environmental Protection Agency. The EPA was still young and weak, and it was decided that decisions about nutrient control would be left to individual states in the Great Lakes Basin….seven of them draining into the Great Lakes. Vallentyne impressed upon me that I must now be the one to inject our scientific results into the policy arena.

This was not a simple matter in the USA. State-level hearings were held in various formats, sometimes with citizens' panels to hear submissions, other times in a judicial or quasi-judicial format. Big detergent companies and the Soap and Detergent Association (SDA) travelled to all hearings with a large, very polished band of "experts," ranging from scientists who would "prove" that phosphorus removal would not protect lakes, to home economists who would claim that alternative detergent formulations were

expensive, toxic, damaging to washing machines, or simply did not clean well. Opposing these views were ad-hoc groups of scientists, unique to each state. In many cases, little thought was given to the expertise of the scientists chosen…" let's get old doc so-and-so from the local University. He's a botanist so he will know about the problem." In some states, decisions were made quickly. The Lake 226 picture had a powerful influence on lay judges and hearing panels. But especially in states represented by poor scientific expertise, decisions were deferred. It took many years to get all of the states draining to the Great Lakes to ban phosphorus. Elsewhere, Vallentyne and I give a more detailed account of the battle to control eutrophication.[9]

The new "management team" of government bureaucrats thought that the ELA project should now be disbanded. The nutrient experiments had had their desired impact on Canadian policy. They began to refer to ELA in bureaucratise as a "sunset" program, in other words, in its twilight years. I could see analogous needs for large-scale experiments to inform policy on other scientific management problems. Widespread acid rain had been discovered in Scandinavia. While a few studies suggested that it was affecting some parts of eastern Canada, bureaucrats who were unfamiliar with the science believed that it was very local in scale.

I made a presentation to DFO managers pointing out that the geology of eastern Canada was as sensitive as that of Scandinavia, and that air masses moving from the USA were causing acidifying deposition that was just as high. I predicted that acid rain problems would be widespread here. Our departmental bureaucrats were cynical. At the time, they believed that only a small area around Sudbury Ontario was affected. One middle manager accused me of inventing the acid rain problem to keep ELA from being closed! Clearly, acid rain was too complicated a problem for most DFO managers to grasp. Little had changed in bureaucracy since Aldo

Leopold wrote about his experience with American bureaucrats, 40 years earlier:

> *"For political consumption a new thought must always be reduced to a posture or a phrase. It has happened before that great ideas were heralded by growing pains in the body politic, semi-comic to those onlookers not yet infected by them."*[10]

Unfortunately, Leopold's words are still true today.

No DFO money was forthcoming for acid rain research despite my presentation.

Fortunately, we were able to start a few key whole lake experiments with outside funding. The money came from the new Alberta Oil Sands Environmental Research Program (AOSERP), which was formed to examine the environmental impacts of the first large-scale developments in oilsands mining. We convinced AOSERP managers that we could do large-scale experiments that would explore the early symptoms of acid rain, allowing them to determine when damage from acidifying emissions was beginning and how lakes were affected. Two years later, after evidence that the acid rain problem in Canada was widespread, the federal government launched its own acid rain program. DFO was then happy to claim ELA as evidence that they had recognized the problem early!

Government bureaucrats were not impressed by scientific evidence. Here is one example: In the late 1970s, they picked a target for reducing acidifying emissions of sulphur oxides to where wet deposition was less than 20 kg/ha/y as sulfate. This target was literally picked from the air. I reviewed the acid rain problem for the premier journal Science in 1988,[11] at the invitation of the editor. I concluded that deposition would have to be reduced to between 10 and 16 kg/ha/y to be effective, based on several types

of scientific studies. I gave lectures across North America and Europe using this evidence, predicting that at 20 kg/ha/y we would eventually lose up to 1/3 of the natural biota in lakes. I was accused by DFO bureaucrats of undercutting Canadian policy, and told that I must submit the text of any talk to the Department of External Affairs for review six weeks before I was to deliver it. I gave too many talks to write them out, so that would have been a huge handicap. I also had no intention of distorting science to meet a political objective. I found out from my lawyer that if I remained an American citizen and did my lecturing on holiday time, I could not be stopped by Canadian bureaucrats. Ironically, I had to stop citizenship proceedings to best argue the case for strong policies to protect the Canadian environment. I renewed my citizenship application and became a Canadian citizen when I left the federal civil service for the University of Alberta.

In the intervening years, there have been many more examples of muddle-headed bureaucrats distorting science to meet political objectives. The victims have been Atlantic cod[12] and mismanaged salmon stocks on both coasts.

Passing science up a long chain of command to senior bureaucrats and politicians was a futile exercise, and it still is. We all know the children's game where participants sit in a circle, and the first child whispers something into the second's ear, he then repeats it to the third, and so forth. By the time the information gets back to the first child, it is usually the subject of great amusement. Now imagine whispering science into the ears of a chain of a dozen people or more, where at least the last half dozen in the chain know little science.

Bizarre as the above examples seem, the role of science in environmental policy has continued to weaken. There has been a terrible devitalization of science and scientists in both federal

and provincial departments. The governments have made their scientists the tools of politicians, their results and opinions twisted if necessary for political gain. Government departments are run on "business" models that are totally unsuitable. A high proportion of senior bureaucrats have business backgrounds, and no experience in science. To them, it is the image that counts, not whether policies are effective. Under this system we have seen the approval of many environmentally damaging projects despite strong evidence showing that they would have disastrous consequences for the environment. Government scientists today are forced to communicate publicly through "official spokespersons".[13] Government scientists have been mysteriously silent about the management of the *Listeria* outbreak.[14] In another case, an Environment Canada scientist was forbidden to speak publicly about a book he had written on climate change, even though it was a novel.[15] The Canadian Wildlife Service has been largely disbanded.[16] Federal scientists knowledgeable about greenhouse warming and the necessary carbon reductions are also silenced, because the party in power does not want their position to be undercut.[13] Our pathetic attempts to reduce emissions of greenhouse gases by illusion, rather than by action has subjected Canada to international scorn.[17] This sort of science has no place in a democracy. We, the taxpayers of Canada and its provinces, pay for the activities of scientists in the civil service. They should inform us directly of problems and solutions, not have their message filtered through politicians and bureaucrats more concerned with giving the illusion that they are doing a good job of "minding the store" than communicating honestly and openly with Canadians.

In summary, at the very time when development that is damaging to the Canadian environment is proceeding at an unprecedented pace, we find ourselves with little ability to assess the damage done or to transmit scientific concerns to the Canadian public. In our government departments, policy makers are telling scientists what

they must say (or not say) to support policy, i.e. policy is advising science, topsy turvy from the way it should be.

### *Water Policy and Management in Canada: An Urgent Need for Science*

Politicians and the Canadian public seem to have little concern for water issues. They believe that we have an abundance of water. The country contains over two million lakes, including several great lakes. There is much talk of shipping water to the USA, and even sending tankers of water to countries where water is scarce. Much of the Canadian economy depends on dealing in "virtual water," via the harvesting of grain, meat, hydropower, and oil for export. Canada is the world's second largest exporter of virtual water, with 95 Gm3/y used to produce the above mentioned commodities. The myth of abundant fresh water has led us to believe that we really do not need to do much to conserve or protect it.

A closer look reveals a huge fallacy in the assumption of Canadian water abundance. Precipitation is low in the prairies and in the North. Fortunately, evaporation and evapotranspiration are also low, which is why lakes generally remain intact where they are not exploited by humans. If many Canadian lakes were empty, it would take 100 or more years to refill them. This annual rate of renewal is the true sustainable water supply. One can view the amount of water on the landscape as analogous to a bank account. Our interest rate, best represented by the runoff of water that flows to sea via our rivers, is very low. If we wish to sustain our water capital for the long-term, we must live off the interest. For a large part of the western prairies and the North, average annual runoff is less than 100 mm per year. In some areas of Alberta and Saskatchewan, it is less than half that.

**Renewable Freshwater Resources**
**Top 7 Countries**

| | % of global supply |
|---|---|
| Brazil | 12.4 |
| Russia | 10.0 |
| Canada | 6.5 |
| Indonesia | 6.5 |
| USA | 6.4 |
| China | 6.4 |
| Colombia | 4.8 |

Sprague 2006

Table 1

We also often hear that the USA and China are short of water. Yet on average, the runoff per unit area of Canada, the USA, and China are nearly identical (*Table 1*). Runoff is particularly low in the western prairies that are the source of much of Canadian agriculture. In short, Canada has no water to squander. With climate warming, it is important for Canada to develop economic strategies that rely less on exporting either water or virtual water.

***Important Lessons on Water Quantity from the Past***

Science has shown us a rather remarkable and frightening picture of water scarcity in the past, showing us how precarious our water balance really is, and why we urgently need strong water policies to protect it. The studies show that for the Canadian prairies, the 20th century was abnormally wet, perhaps the wettest century of the last 20 or so. In previous centuries, prolonged droughts were the norm, some lasting for decades. Even the "dirty thirties" would have been a puny drought in the 19th century and before.

From other studies, we know that the mid-North American continent was a much drier place in the mid-Holocene, four thousand to eight thousand years ago. Temperatures were very

similar to temperatures in the latter years of the 20th and early years of the 21st century.

Lake Winnipeg is a great lake (Lake Erie size, 24,400 km2). In the mid-Holocene the south basin of the lake was desiccated, and the north basin much reduced in size. Grasslands surrounded the south basin and much of the north basin of the lake, whereas at present, they reach only the extreme southwestern part. Scientists have deduced from pollen remains in lake sediments that the climate near the south basin of Lake Winnipeg in the mid-Holocene was similar to that of Medicine Hat, Alberta in the 20th century. The latter area has been termed the "Empire of Dust" by prairie historian David Jones[18] for the unsuccessful attempts by Europeans to turn its semi-arid terrain into productive agricultural land in the early 20th century.

There were few wetlands in the southern prairies during that period, and 14C analyses of the bottommost peat in contemporary wetlands indicate that many were formed only three to four thousand years ago. Clearly, the western prairies were a very dry place, at temperatures much cooler than those that are expected to occur in the next hundred years, due to the expected increases and long atmospheric lives of major greenhouse gases.

It is widely assumed that lakes of eastern Canada flowed to the sea as glaciers melted, because contemporary climates are quite humid. More recent work indicates that even the St. Lawrence Great Lakes were not connected in the mid-Holocene. The level of Lake Huron was tens of meters below the current outflow. Clearly, our lakes have a precarious water balance. Unless there are huge increases in precipitation (which are not predicted by current models), the water balance of mid-continental lakes will be adversely affected by the future warmer climates.

Taken together, physical studies indicate a bleak future for freshwater supplies, and the organisms, societies, and industries that depend on them, with a rapidly warming climate. While most contemporary climate models predict that precipitation will either stay the same or increase slightly, increases in evaporation and evapotranspiration calculated from predicted increases in temperature will exceed increases in precipitation. Earlier snow melts and ice-out dwindling glacial flows will change the seasonality of flows and disrupt the interrelationships between aquatic organisms. Ironically, "ground zero" for these problems will most likely be Alberta, where we most lavishly squander our water for irrigation and extracting oil or bitumen, and where there is the greatest resistance to taking any measures to curb climate warming.

We have already seen climate changes. In the western prairies, average annual temperatures have increased by 2-3° C in the past 40 years. Annual river flows have declined, most dramatically in summer. There is less snow, and spring melt is occurring earlier. Lake levels in most closed basins have declined.

Climate warming will cause changes to lake levels and flow regimes that will translate to huge financial losses to hydroelectric generation, irrigated agriculture, fisheries, and other industries. The effects on society could be expensive, perhaps catastrophic. If we are to minimize the potential for a water crisis, we must start planning now for careful water use and water conservation.[19]

Freshwater scarcity will not be the only problem to result from foolish climate and energy policies. I will give two of many examples.

There is considerable evidence that acid rain remains a substantial problem in eastern Canada. The emissions of nitrogen oxides, which have never been controlled, now play an important role in

acidifying soils and lakes. Critical nutrients for forest growth, such as calcium, magnesium, and potassium are regenerated only by the weathering of bedrock and mineral soils, a very long-term process. The losses are exacerbated by clear cut logging, which also removes critical nutrients from forested watersheds.[20] Strong evidence is once again there, buried in Ivory Tower libraries. No federal or provincial agencies have the resources or the will to find the science and to formulate control policies. The result will certainly be a long-term decline in forest productivity, and decreasing diversity in both forest and aquatic biota.

The oil (tar) sands present several freshwater dilemmas. Although water taken from the Athabasca River is recycled many times, it is eventually discharged to the environment in an extremely toxic state. It is not allowed to enter the river. Instead it is discharged to "tailings ponds" where it is hoped that someday nature may detoxify the tailings. The current area of the "ponds" is 131 km2 according to satellite surveillance by Global Forest Watch, i.e. "ponds" is a euphemism for a toxic great lake.

Despite the recycling, withdrawals from the river by oil sands companies are large. Government and industry are fond of stating that only 2% of annual flow is withdrawn, which is true. But the real problem is that withdrawals will be closer to 15% under ice in winter when all approved development is built, and that low flows are getting more common as the result of changing climate.[21] The oil sands pose many environmental problems, ranging from carbon emissions to water use and water pollution, and from social issues to lack of reclamation.[22]

In summary, I believe that the overall picture formed by past conditions and the spectre of continued warming makes strong water policy an urgent issue for Canada. There is a definite feeling among Canadians that we need strong federal water policy. In 2004,

an Ipsos-Reid poll found that 97% of Canadians agreed with the statement "Canada should adopt a comprehensive national water policy that recognizes clean drinking water as a basic human right." There is a strong, and almost country-wide feeling that federal legislation should ban water exports from Canada. Despite these strong sentiments, government after government has ignored federal water policy. Look for evidence of water policy in any of the current election platforms! Clearly, there is an elephant in the parlor that cannot be ignored any longer.

***Past Attempts at Federal Water Policy: A Near Miss***

The lack of a water policy is an excellent example of a major shortcoming in Canadian environmental policy. In January of 1984, Canada struck a blue-ribbon panel to conduct an Inquiry on Federal Water Policy in Canada, chaired by Peter H. Pearse, a specialist in natural resources management from the University of British Columbia. After extensive hearings, the Pearse commission's 1985 report[23] formed the basis for drafting a federal water policy.[24] The legislation was to be implemented and enforced by Environment Canada's Inland Waters Directorate. Unfortunately, an election was called in 1988 and the legislation died on the order table. It was never resurrected. The newly re-elected conservative government under Brian Mulroney had the free trade agreement as its central focus. Freeing up trade with other countries did not seem well aligned with some parts of the draft water legislation, which recommended policies to prevent water export. New legislation was never re-drafted. A few years later, the Inland Waters Directorate was disbanded. Neither policy nor an implementation plan has ever been resurrected, despite widespread feeling in the academic and ecology communities that it is urgently needed.

Today there are many Canadian examples that underscore the need for strong federal water policy. The Walkerton incident

in 2001 caused a short-lived concern. There were plans within Environment Canada to apply to the Treasury Board for extra funds to shore up its freshwater programs that had been suffering from eroding budgets and declining personnel for many years. The attempt was usurped (along with all of the Treasury Board's extra money) by events following the 9/11 attacks. We have since had many more water quality incidents,[25] including the well publicized events at North Battleford and Kashechewan. Over-allocation of water from the South Saskatchewan River has caused Alberta to declare a moratorium on new water licenses, although human populations in parts of the basin are growing at over 5% per year. Similar problems are occurring in the Okanagan Valley. There are unresolved accusations that tar sands mining is causing human health problems in downstream communities.

There are also international disputes over freshwater. Many jurisdictions would like to use groundwater taken from within the Great Lakes Basin without returning it. The USA has recently chosen to ignore the Boundary Waters Treaty of 1909 and bypass the International Joint Commission in unilaterally deciding to divert Devil's Lake, North Dakota, into the Red River, flowing north across the international boundary. There is a dispute between Montana and Alberta ranchers over water from the Milk and St. Mary's rivers before the IJC. There is talk of diversion of water from Lake of the Woods to irrigate agriculture in the Red River Valley of North Dakota and Minnesota.[26] I could go on for several pages about national and international needs for strong federal water policies. I have used examples that involve water, but very similar criticisms can be made of the Canadian government's performance on other environmental laws and policies.[27]

During the period of decline of environmental science in federal departments, similar "downsizing" was happening in many provinces, under the guise of eliminating duplication and cutting the size of

the civil service. In Ontario, the world-famous Dorset Field Station was one victim. In Alberta, the Alberta Environment Department closed its chemistry laboratory and many senior personnel were given golden handshakes. Instead of duplication, it became obvious to aquatic scientists that often no one was minding aquatic ecosystems.

***Fixing the System: A New Role for Universities?***

It is clear that to plan sound, environmentally-sustainable development the Canadian system needs a major overhaul. The first thing that we must do to succeed in soundly managing our environment is to dissect science departments away from political ministries, where science is corrupted for political gain, and there is a bottleneck for the dissemination of science to the taxpayers who pay for it. Of course, there will be huge opposition to this from parties in power. Selective use of science by government to justify their mistakes and politically-motivated decisions is commonplace. With the cloak of science stripped away, ministers would be required to explain the true motivation for their decisions.

The current system for assessing and mitigating environmental impacts of new development is costly and ineffective. Here are some of the major practical shortcomings:

1. There is no true assessment of cumulative effects of development. For example, for each oil sands mine, cumulative effects are examined only on the footprint of that company. This is clearly ludicrous when companies are literally back to back over thousands of square kilometres, especially when effects on far-ranging birds and mammals are concerned.

2. The Environmental Impact Assessment (EIA) is usually done by hired consulting companies. Little time is spent in

field work. Often, only a few assessments are made, even for multi-billion dollar projects that cover hundreds of square kilometres. Very often, the field work is done by very poorly trained personnel. Much the same menu is used for assessing different projects. Many of the measurements made are totally useless. Huge tables of organisms identified only to family or order, or of elements analyzed in water or tissue are presented, whether they have any bearing on the environmental impact of the project or not. Some of the procedures used are scientifically invalid. For example, species diversity indices are frequently done on groups of organisms that are only identified to genus, or even to order or family. Little information is given on limits of detection for chemical analyses. It is an advantage to a consultant who wishes to write an EIA favourable for a development to have poor chemical equipment, which makes it easy to declare that "pollutant X was undetectable." A typical large project will have an EIA that occupies several feet of shelf space, containing perhaps ten pages of good science hidden among thousands.

3. There is seldom any post-development analysis. As a result, we never learn when errors were made in previous EIAs, and methods are never changed. One of the key elements of modern science is to learn from past mistakes to make progress. Modern Canadian EIAs are largely devoid of such mechanisms.

4. There are a large number of projects being evaluated at any one time. I am told by scientists who do the initial environmental assessments for federal departments that there are backlogs of hundreds of EIAs to evaluate, ranging from simple stream crossings to large mines. This backlog makes evaluators reluctant to recommend full scale assessments for

even large projects, because such recommendations trigger an even higher workload.

5. Hearing panels are often small and lacking in expertise. One reason is that many regard sitting on such panels as a complete waste of time. Often, after months of hard work panels find that their recommendations are ignored.

A new system of institutes separate from the political process could solve a number of these problems. Improvement of cumulative effects assessments could be one mandate, done largely by examinations of whether past predictions were accurate, and how prediction might be improved. Expertly done monitoring could be another major mandate. Long-term records could be kept. Companies proposing new or expanded development would have to pay to use the long-term data set as the basis for their EIAs, vastly improving on the few months of study with poor quality control that we currently have. They could expect their EIAs to be subjected to rigorous peer review, as is the tradition with other branches of science.

Another mandate would be to supply expertise to hearing panels. Senior members of the institutes might even be invited to serve on hearing panels.

There are some interesting precedents for government science within university settings. Under the Fisheries Research Board, the Freshwater Institute was placed on the University of Manitoba campus. Both organizations have benefited.

For the past few years, Environment Canada has quietly moved some of its most prominent scientists into university settings. Environment Canada and the University of Victoria jointly established a Water & Climate Impacts Research Centre (W-CIRC) located at the University of Victoria with a mandate to facilitate hydrological and

environmentally-based inter-disciplinary research assessing the impacts of climate change on Canadian water resources. In support of the mandate, they also jointly established an Environment Canada/University of Victoria Research Chair in the field of Climate Impacts on Water Resources, held by Dr. Terry Prowse. W-CIRC and the associated Chair are to foster collaboration between Environment Canada, university members, and other researchers. Such collaboration creates unique research synergies that increase the scientific capacity of Environment Canada to deal with its identified priority water-resource problems created by climate change/variability. A similar cooperative venture, to improve bio-assessment sciences for Canadian Rivers, has been created at the University of New Brunswick.[28]

These arrangements are a move in the right direction; however, employees are still not entirely free of the restrictions placed on civil servants. How refreshing it would be for government scientists to speak out with the same freedom as academic scientists, and the protection of tenure! And to hear politicians have to defend their anti-science policies: "I am making this decision despite what recent ecological science shows, and here's why…" that would reveal true political motives.

From the standpoint of universities, there should be advantages to research and teaching by combining with a large research institute. While we in academia often talk about interdisciplinary research and education, often the right expertise for a particular project is simply not available. We have been primarily teaching institutions, and quite rightly, an important part of our focus in hiring is on the teaching of core courses. If a large, interdisciplinary environmental research institute were an integral part of a university, it could recruit with a "research first" policy, with a smaller emphasis on teaching and graduate supervision. Our students could get a true interdisciplinary experience in such a setting.

My experience has been that universities are still rather insular places. Speaking out publicly on policy issues is not forbidden, but such efforts are not rewarded. Criteria for advancement and promotion still place heavy emphasis on the number of papers published in professional journals, dollars obtained for research, and the reviews of students. Staying within the confines of the Ivory Tower is still the safest route to advancement. I have found that many of my colleagues are not aware of impending important policy decisions, and many more are reluctant to undertake activities that might jeopardize their advancement or relations with potential funding sources. Perhaps a science-policy institute would encourage more Ivory-Tower scientists to reach out, and university administrators to reward them for doing so.

There are often temporal restraints that impede environmental research at universities at key times of the year. Most faculty must be in the region of their home institution to be available to teach during the term. One retired taxonomist reported to me that he'd discovered many new species of insects since he had retired, simply because he could travel in fall and winter to regions with high diversity, when his colleagues had returned to universities. An institute that put research first should not have this problem.

Environmental monitoring is another issue that is poorly suited to traditional universities. Running a monitoring program for a few years is unlikely to bring fame to faculty or degrees to graduate students (except, perhaps at the design phase). But long-term environmental records are one of the most valuable data sets that we have. Who would want to erase the climate or lake level or river flow data that our federal agencies have collected over the years? There have been many attempts to dismantle them by unappreciative bureaucrats, or to get "clients" to pay for the data. Luckily, most of these attempts to further business models within environmental science have not succeeded. In a university setting

where the value of long-term records in environmental research is recognized, there would not be a continuous battle to maintain such programs.

The combination of government science with universities could give us a uniquely Canadian way to research some of the complex problems that have so far largely been the sole preserve of richer and more populous nations. For example, in aquatic fields, the Woods Hole Oceanographic Institution, Scripps Institution, and Lamont-Doherty Earth Observatory have dominated the field of oceanography, as well as making enormous contributions to other branches of earth sciences. Huge, complex undertakings like GEOSECS,[29] which first defined deep ocean circulation patterns, were only possible because of such large centres of expertise. All of the above were once stand-alone research institutions, but all are now attached to major universities, in some cases to several. There are many similar models of medical research centres affiliated with universities.

The diversity of aspects that must be considered for sound environmental decision makes universities an attractive setting. Open debate of social, economic, and political as well as environmental aspects could be encouraged. Mechanisms could be set up to transmit scientific results and other information directly to politicians and policy makers. Of course, they would still have the power to disregard advice, but at least their reasons for doing so would have to be transparent.

Some listeners will probably notice that what I advocate has many similarities to the old Fisheries Research Board model. It is no coincidence that many FRB stations were located on university campuses. Lively academic debate was considered to be an integral part of healthy science. To meet modern demands, the model would have to be expanded to consider more than just fisheries science. There would be some growing pains, but it would be easy

to outperform the current system.

It is urgent that we try some new approaches when the current approach to environmental policy is clearly deficient. Humans are now the major predator, and the major herbivore, in almost all of the world's ecosystems. Canada is one of the few countries that still has the capacity to avoid this dilemma, but to do so we must have sound environmental policies, firmly grounded in good environmental science. In his 2005 book *Collapse,*[30] Jared Diamond lists eight environmental factors that have contributed to the collapse of past societies. He adds four more that are new to the industrialized world. Diamond is only mildly optimistic that we will be able to solve the problems in time to prevent widespread social collapse.

William Rees of the University of British Columbia, well known for his "Ecological Footprint" approach to the ecological impact of societies[31] is slightly more optimistic. In his review of Diamond's book,[32] he points out "that resilient societies are the nimble ones, capable of long-term planning and of abandoning deeply entrenched, but ultimately destructive core values and beliefs. This, in turn, requires a well-informed public, inspired leadership, and the political will to take decisions that go against the established order of things." Distinguished guests, it is urgent that Canadians exercise their agility and leadership in the field of environmental policy. We were once recognized as having a superior process for doing so. It is time that we reclaimed that high ground.

October 16, 2008

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## *THE KILLAM ANNUAL LECTURES**

1995 **Dr. David L. Johnston**
Chair, Canadian Institute for Advanced Research;
Former Principal, McGill University
"*Research at Canadian Universities and the Knowledge Based Society*"
HART HOUSE, UNIVERSITY OF TORONTO

1996 **Dr. Richard A. Murphy, PhD**
Director, Montreal Neurological Institute, McGill University
"*Government Policy and University Science: Starving the Golden Goose*"
THE UNVERSITY OF CALGARY

1997 **Hon. Peter Lougheed, PC, CC, QC**
Partner, Bennett Jones Verchere; Coporate Director;
Former Premier of Alberta; Chancellor, Queen's University
"*The Economic and Employment Impact of Research in Canada*"
READING ROOM, HOUSES OF PARLIAMENT, OTTAWA

1998 **Dr. Michael Smith, CC, OBC, PhD, DU, DSC, LLD, DCL, FRS, FRSC**
University Killam Professor, and Peter Wall Distinguished Professor of Biotechnology, University of British Columbia;
Nobel Prize Laureate in Chemistry, 1993
"*Science and Society in the Forthcoming Millennium*"
HYATT REGENCY HOTEL, VANCOUVER

1999 **Dr. Björn Svedberg**
Chairman, the Royal Swedish Academy of Engineering Sciences;
Chairman, Chalmers University of Technology, Gothenberg;
Former President and CEO, L.M. Ericsson AB.
*"University Research as the Driving Force for the Development of a Modern Nation in the Next Millennium"*
PIER 21, HALIFAX

2000 **Prof. J. Robert S. Prichard**
Prichard – Wilson Professor of Law and Public Policy and President Emeritus, University of Toronto;
Visiting Professor, Harvard Law School
"*Federal Support for Higher Education and Research in Canada: The New Paradigm*"
ST. BONIFACE GENERAL HOSPITAL RESEARCH CENTRE, WINNIPEG

2001 **Dr. John R. Evans, CC**
President Emeritus, University of Toronto;
Chair, the Canada Foundation for Innovation;
Chair, Torstar Corporation and Alcan Aluminum Ltd.
"*Higher Education in the Higher Education Economy: Towards A Public Research Contract*"
MONTREAL NEUROLOGICAL INSTITUTE, MONTREAL

2002 **Dr. Martha C. Piper, DSc, LLD**
President and Vice-Chancellor, The University of British Columbia;
Director, Canadian Genetic Diseases Network
"*Building a Civil Society: A New Role for the Human Sciences*"
NATIONAL LIBRARY OF CANADA, OTTAWA

2003 **Shirley M. Tilghman, PhD**
President, Princeton University
Professor of Molecular Biology, Princeton University
*"The Challenges of Educating the Next Generation of the Professoriate"*
THE UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER

2004 **W.A. Cochrane, OC, MD, LLD, FRCP(C), FACP**
Former Paediatrician-in-Chief, Izaak Walton Killam Hospital for Children in Halifax; Founding Dean of Medicine, and former President, University of Calgary; Former Chairman and CEO, Connaught Laboratories Ltd.; President, W.A. Cochrane & Associates, Inc.
*"Commercializing University Scientific Discoveries: Issues and Challenges"*
THE FAIRMONT NEWFOUNDLAND, ST. JOHN'S

2005 **The Honorable Kenneth Prewitt, PhD**
Carnegie Professor of Public Affairs, Columbia University
Former Director of the US Census Bureau, former President of the Social Science Research Council, former Senior Vice President of the Rockefeller Foundation, and former Director of the National Opinion Research Center.
"*A Higher Priority for Higher Education: Two Perspectives*"
*"Investing in Higher Education: The Responsibility of the University"*

**The Honourable Robert Rae, PC, OC**
Former Premier of Ontario; Partner, Goodmans LLP, Chancellor of Wilfred Laurier University and Chair of the Canada Unity Council
"*A Higher Priority for Higher Education: Two Perspectives*"
*"Convincing the Public and Governments to Do More: The Case for Higher Education"*
THE FAIRMONT ROYAL YORK, TORONTO

2006 **Professor Bartha Maria Knoppers, PhD, OC**

Canada Research Chair in Law and Medicine, Université de Montreal. Former Chair of the International Ethics Committee of the Human Genome Organization and member of the International Bioethics Committee of the United Nations Educational, Scientific and Cultural Organization (UNESCO).
Co-founder of the International Institute of Research in Ethics and Biomedicine (IIREB).

"*Biotechnology: The Human as Biological Resource?*"
L'ASSEMBLÉE NATIONALE, QUÉBEC CITY

2007 **Dr. Peter J. M. Nicholson, CM**

President and Chief Executive Officer, Council of Canadian Academies
As of February, 2006 the inaugural president of the Council of Canadian Academies. He has served in numerous posts in government, business, science, and higher education. Before assuming his current position, he was Deputy Chief of Staff, Policy in the Office of the Prime Minister of Canada.

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**2008 D.W. Schindler OC, AOE, DPhil, FRSC, FRS**

Dr. Schindler is Killam Memorial Chair and Professor of Ecology at the University of Alberta. The recipient of many prizes and awards, including the Canada Council Killam Prize in 2003, Dr. Schindler is the only Canadian to have received the Stockhom Water Prize 1991, as well as the Volvo International Environment Prize in 1988. He holds honourary doctorates from four universites and was made an Officer of the Order of Canada in 2004.

*"The Role Of Science In Making Sound Environmental Policy."*
SUTTON PLACE HOTEL, EDMONTON, ALBERTA

*NOTE: The positions held by the Lecturer(s) are stated as at the date the Lecture was given.*

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