Ecological Risk Assessment (ERA)

Appendix: Public Comments and Responses

Members of the public were invited to comment on the ERA Report from March 31, 2009 to September 4, 2009. As an important part of the public record of the study, all comments and responses have been collected as an appendix to the final ERA Report. All persons and groups who provided comments have also received their replies individually.

To be included in the formal public comment process, individuals providing comments were requested to include a name, address, phone number and email address. Questions and comments were to relate directly to the contents of the ERA report, and were to be submitted in writing, by mail, fax, email, or by using the Online Comment Form on the Sudbury Soils Study website.

A total of 7 formal public comment submissions were received during the comment period. Note that all comments have been reproduced here exactly as received. The SARA Group and the Technical Committee would like to thank all members of the public who took the time and effort to send in their comments and, in doing so, have contributed to the larger community discussion of the report.

The Technical Committee, with the assistance of the SARA Group, has prepared responses to all comments received. Technical Committee study partners for the Sudbury Soils Study include the Sudbury & District Health Unit, the Ontario Ministry of Environment, the City of Greater Sudbury, Health Canada First Nations & Inuit Health, Vale Inco, and Xstrata Nickel.

Residents with general inquiries concerning the Sudbury Soils Study can continue to use the toll-free number (1-866-315-0228) or email address (questions@sudburysoilsstudy.com) to get individual answers to their questions up to December 31, 2009. Note that these questions will not be included as part of the public record.

After January 1, 2010, information related to activities following the ERA can be found on the website: www.greatersudbury.ca/biodiversity

How to contact us:

BY MAIL: The SARA Group
512 Woolwich St., Suite 2
Guelph, ON N1H 3X7
BY PHONE: 1-866-315-0228
BY FAX: 1-519-763-1668
BY EMAIL: questions@sudburysoilsstudy.com

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period
(April 3 to Sept 4, 2009)

Comment: 1
Submission Date: April 13, 2009
Name: Roger Cunningham
City: Sudbury, ON
Affiliation:

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

Re: ERA results March 2009.

I have before me the condensed version of the report that came in the mail. It mainly deals with the impact the mining industry and somewhat the lumbering industry has on plant and wildlife groups to-day as a result of past activities.

My problem – I live in the City of Sudbury about halfway between the Coniston and the Copper Cliff smelter stacks. I have been gardening for 40 years.

Do the things I grow take up and store the Chemicals of Concern (COC)? I mainly grow tomatoes, potatoes, peas, beans, beets, cucumbers, blueberries and raspberries. Depending on how the above are prepared or how they last in storage consumption of some can last over the year.

If the produce from the garden is loaded with COC's and I'm eating it, am I now loaded with COC's? Or does the human body get rid of certain chemical and hoard the rest?

I've been getting the condensed reports over the years. If any of them had comments regarding back yard gardens, good or bad then I've missed seeing them.

I've just turned 80, and I'm still waking up every morning, so I guess the arsenic hasn't got me yet.

I'm not expecting a direct reply to this letter, but I'll be noting the comments to be published in the Appendix to the final ERA report.

Time flies – It doesn't seem like 7 years the SSS has been underway. Ive found it interesting and informative. Here's hoping that information gathered can be put to good use and make Sudbury and ongoing better place to live.

Regards
Roger Cunningham

Response:

Thank you very much for your letter of April and your interest in the Sudbury Soils Study.

We are aware there are many keen gardeners in Sudbury and for that reason we put quite a bit of effort into collecting and analyzing samples of home-grown vegetables in the Sudbury area. That information is provided in Volume II of the Sudbury Soils Study, the Human Health Risk Assessment. Numerous vegetable samples were collected in both the Coniston and Copper Cliff areas.

The short answer is different types of vegetables take up chemicals of concern differently than others. Amending the soil with lime or bone meal to raise the soil pH can help reduce the accumulation of metals in the garden soils. We can say with confidence that the home grown vegetables do not pose a risk to people consuming them. However, it is always good practice to properly wash and prepare vegetables to remove any external soil.

Should you have any other questions please do not hesitate to contact us.

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period

(April 3 to Sept 4, 2009)

Comment: 2
Submission Date: May 2009
Name: Allan Montgomery
City: Sudbury, ON
Affiliation:

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

The Ecological Risk Assessment (ERA) of the Sudbury Soils Study (SSS) recommended that the lakes in the Killarney Park area and Lake Wanapitae to the north of Sudbury be excluded from further ERA. The basis for this decision in the ERA is that the Killarney Provincial Park area and Lake Wanapitae have been "Primarily affected by acid rain, and not metals from smelter air emissions". (Vol. 3, Ch. 5, p 5-87). However, data previously collected by the Ministry of the Environment shows that is not the case.

A 1973 research paper written by James R. Kramer, Professor of Geology at McMaster University, compares both sulphate and nickel rates of fall measured at MOE monitoring stations in and around the Sudbury area. The rates are correlated to wind direction and to data for the same period from the U.S. EPA. The five stations Dr. Kramer referenced were: Skead, Gogami, Temagami, Jamot, and Killarney. All of these stations, with the exception of Skead, are 50 or more miles from Sudbury.

Figure 1 on page 22 shows the change in rate of sulphate fall for all five stations, referenced to both the mean and maximum rates of fall measured in the U. S. The study notes that there were some declines in some years, but the biggest decline recorded was during the August-September shutdown in 1972, which resulted in a ten-fold reduction of both nickel and sulphate fall at the reference stations. The conclusion reached was that "this dramatic decrease for the most part must be due to the shut-down." (Kramer, p 22).

Figure 2 on page 23 shows the change in rate of fall for nickel at the 5 reference stations, and these results are compared to the both mean rate of nickel fall in the U.S., and the average maximum falls recorded in the entire U.S. network. Dr. Kramer concluded that "The mean of all analyses for Northern Ontario (4.6×10^{-5} gram nickel /meter^2/day) is about 6 times the mean for all stations in the continental USA" and that "the mean rate of fall for all stations in Northern Ontario is only slightly less than (80%) the maximum measured rate of fall of nickel for all stations in the U.S.A."(Kramer, p 23). The maximum level of nickel fallout was recorded at Philadelphia. (Kramer p 22)

As a way of integrating the U.S. and Ontario studies, Kramer compared the readings of four stations downwind from Detroit and adjacent to Sarnia and two major power plants and found the "rates of fall of nickel slightly less than the mean rates of fall for continental U.S.A. This is no artifact; the rate of fall of nickel is excessive and is very widespread in Northern Ontario. One is not exaggerating to conclude from the data that most of Northern Ontario has been subjected to rates of fall of nickel ten times the rate of fall of nickel in the continental U.S.A. "(Kramer, p 23)

Also of note is that "Killarney exhibits a rate of fall of nickel and sulphate in excess of the mean rate of fall for the continental U.S.A. This is true for all periods except one! The rate of fall for Killarney is in excess for all periods sampled in comparison to the mean rate of fall of adjacent stations in the U.S.A."(Kramer, p 23)

As this pollution had existed for decades before Dr. Kramer's analysis of the 1970-1972 data, it is safe to assume that these pollution levels have deposited nickel particulates in both the Killarney Park area, in the Lake Wanapitae area, as well as further north and east of Sudbury. The assertion by the ERA that these two areas have been "Primarily affected by acid rain, and not metals from smelter emissions" (Vol. 3, Ch 5, p 5-87) is open to doubt. These areas should be given the same level of concern as the Sudbury area, as they have clearly been subjected to same kinds of metal pollution. If the purpose of the Sudbury Soils Study was to fill in data gaps on the effects of metal particulate emissions, excluding these areas from further study would only perpetuate gaps in our data of metal pollution in areas which were clearly subjected to it.

Work Cited (*Attached)*

Kramer, J.R., "Atmospheric Composition and Precipitation of the Sudbury Region." Alternatives Vol 2, No.3, (Spring 1973): 19-25.

Response:

Thank you very much for the information you provided at the Public Advisory Committee meeting in early May. I reviewed both the paper by Dr. Glenn Parker concerning metal levels in elk in the Sudbury area, as well as the paper by Dr. Kramer (1973) on metal deposition in the Killarney park area.

The phenomenon of cadmium accumulation in the kidneys and liver of ungulates including elk, moose and deer is an interesting one. As I stated at the information session at Science North these animals accumulate high levels of cadmium in the wild naturally. The very elevated cadmium levels in the one elk were, as Dr. Parker pointed out, inconsistent with the other samples. They are interesting from a scientific perspective but one cannot base scientific conclusions based on one animal. However, even though the ERA is complete, I hope to follow up with Dr. Parker on this matter.

The comments in the ERA pertaining to the Killarney Parks area were provided in Chapter 5, the Aquatic Problem Formulation. This chapter is a summary of existing information and did not involve any new studies or collections. The recommendations provided in this chapter are simply that, recommendations pertaining to future possible work. At this time there are no plans to undertake further risk assessment studies with lakes or aquatic systems. The Fresh Water Co-op Unit affiliated with Laurentian University continues to study and monitor lakes over a wide geographical area in the Sudbury basin. I would encourage you to contact Dr. John Gunn or Mr. Bill Keller at the Co-op Unit to find out which areas they are actively studying and to learn the scope of their studies.

Thank you for your continued interest in the Soils Study.

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period

(April 3 to Sept 4, 2009)

Comment: 3a
Submission Date: August 31, 2009
Name: Joan Kuyek, Chair
City: Sudbury, ON
Affiliation: Community Committee on the Sudbury Soils Study

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

Dear Sir or Madam:

Thank you for the opportunity to comment on the Ecological Risk Assessment. The Community Committee on the Sudbury Soils Study engaged Environmental Defence Canada to help us respond to the ERA, and they, in turn, engaged Glen A. Fox to do the analysis for them. We have been pleased with the quality of Dr. Fox's work and agree completely with his findings.

As a result, we have submitted his findings as ours, accompanied by his impressive CV.

We hope that the City of Sudbury, in particular, will pay attention to his findings, and ensure that any proposals for enhancing Biodiversity in the Sudbury Region take his recommendations into account.
We believe that Dr. Fox's findings make the need for further study obvious, and call on the Province and the City to ensure these additional studies are undertaken.

We especially want to note that the work undertaken by Sudbury scientists to fulfill the first Objective of the study – "the extent to which the Chemicals of Concern are preventing the recovery of regionally representative, self- sustaining terrestrial plant communities" is considered to be superb, by Dr. Fox, with the exception of severe limitations on the number of reference sites.

On the other hand, the wildlife assessment, undertaken by Intrinsic Environmental Services, is considered to be problematic. The lack of "ground-truthing" for effects on wildlife and the reliance on questionable modeling is similar in character to the Human Health Risk Assessment, and raises many of the same concerns.

The key findings in Dr. Fox's analysis are the following:

- The weight-of-evidence suggests terrestrial plant communities in the Greater Sudbury area have been and continue to be impacted by the chemicals of concern (COC) in the soil and other factors such as soil erosion, low nutrient levels, lack of soil organic matter, and/or low soil pH.

- The validity of that conclusion hinges on the results from the 3 reference sites. Ideally, one would like an equal number (18) or twice as many reference sites as test sites. Further selecting a number of reference sites in an area with similar geological, botanical, and climatic characteristics would have allowed the possibility of separating the localized impacts of the atmospheric deposition of metals from the confounding influences of declining levels of acid precipitation, climate change, and other non-metal stressors.
- Assessment endpoints explicitly define characteristics or attributes that are important to protect and which are potentially at risk. The chosen endpoint for terrestrial wildlife, population persistence, is inadequate as this may occur due to constant immigration. It is felt that the appropriate endpoint for terrestrial wildlife would have been adequate survival and reproduction to maintain a stable population.
- There are not accurate, real, or current measures for many of the variables required by the risk assessment model. Of the 25 dietary “items” used in the risk assessment, 80% were estimated. All the inter-individual and interspecific variation in metal content that results from an individual food organism’s “taxonomy”, physiology, ecology, and behavior is eliminated. This reduces the confidence in the model conclusions.
- It is felt that the approach applied to the exposure assessment, which is the only site- and VEC-specific component of the risk assessment, compromised the risk assessment, making it difficult to say anything about the likelihood of adverse effects of a COC on any valued ecosystem component (VEC).
- The efforts of assessors’ to ground-truth conclusions using existing field information on reproductive success and population trends relied heavily on data that was anecdotal or qualitative. Quantitative data on ducks and loons suggest that numbers have responded positively to improved food resources and habitat quality that have accompanied reductions in acid deposition. However, whether or not adverse effects of metals pollution is limiting these increases in numbers and breeding success is unknown.
- The effect of the exposure to a “cocktail” of COC should be of concern. The cumulative impact of exposure to multiple chemicals and habitat quality plus potential frank or sub-lethal toxicity must be investigated.
- The problem formulation for a possible future detailed aquatic risk assessment highlights the lack of information on Sudbury-specific metal impacts on algae, macrophytes, invertebrates, additional species of fish, and amphibians. The marshes and wetlands have not been studied recently. It is therefore difficult to determine if metals are having a significant deleterious effect on these populations directly or through reductions in food or habitat quality.

The Community Committee on the Sudbury Soil Study came together in the summer of 2008 as result of public concerns with the process and findings of the Sudbury Soil Study Human Health Risk Assessment.

The purposes of the Committee are:
* To ensure that the Sudbury public provides their informed consent for the risks to the environment and human health from historic and current mining and smelter activities, and determines effective response to those risks.

* To move the Ontario Government and its agencies to respond effectively to the Sudbury Soil Study findings. This response must ensure that contamination from mines and smelters in the Sudbury region is properly identified, remediated and (where it cannot be remediated) contained, and that those whose health might be affected (or may be affected) by contamination are provided with diagnosis, treatment and (where this is not possible) with compensation.

Members of the Committee sit as individuals or representatives, and are added by invitation of the Committee. Committee members are from a variety of backgrounds and include individuals from the unions, the university and community college, from health care and the environmental community. The Committee has a Steering Committee, consisting of Rick Grylls, retired, former President Local 598 CAW, Homer Seguin, retired, Steelworkers, Monique Beaudoin, Health Promoter, Centre de Sante Communautaire, and Joan Kuyek, consultant, formerly of MiningWatch Canada. Joan Kuyek chairs the Committee.

We hope that our submission will help the community understand and deal with the long-term impacts of mining and smelting on Sudbury Soils.

Yours truly,
Joan Kuyek, Chair

(Attached Mr. Fox Report – see Comment 3b)

Response:

Thank you for submitting your comments regarding the Sudbury Ecological Risk Assessment (ERA), on behalf of the *Community Committee on the Sudbury Soils Study*. A more detailed response to the review by Mr. Glen Fox will be provided to your committee separately, and is included as an Appendix to the final ERA report.

The City of Greater Sudbury, in conjunction with Vale Inco and Xstrata Nickel, has initiated a Biodiversity Action Plan. Responding to the findings of the ERA, this Action Plan will focus on enhancing rehabilitation and recovery of the regional landscape, and is expected to address many of points raised in Mr. Fox's review, over the longer term. The Biodiversity Action Plan is scheduled to be available for public review in November and released to the public in December 2009. Both mining companies have committed funding for the plan over a 5-year period beginning in 2010. Additional studies related to the ERA are being sponsored directly by the mining companies.

Since your comments represent a summary of the points raised in Mr. Fox's review, please refer to the details provided in Response #3b.

Thank you for your comments on the ERA. Your feedback will help to ensure that the study findings are communicated effectively, and that the final report represents an important milestone in the scientific understanding of this region and its environmental conditions.

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period
(April 3 to Sept 4, 2009)

Comment: 3b
Submission Date: August 31, 2009
Name: Joan Kuyek, Chair
City: Sudbury, ON
Affiliation: Community Committee on the Sudbury Soils Study

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

(Attached Mr. Fox's Report: An Evaluation of the Environmental Risk Assessment of the Sudbury Soils Study, August 31, 2009)

An Evaluation of the Environmental Risk Assessment of the Sudbury Soils Study

August 31, 2009

Prepared by Glen A. Fox

SUMMARY OF KEY FINDINGS

- The weight-of-evidence suggests terrestrial plant communities in the Greater Sudbury area have been and continue to be impacted by the chemicals of concern (COC) in the soil and other factors such as soil erosion, low nutrient levels, lack of soil organic matter, and/or low soil pH.
    - The validity of that conclusion hinges on the results from the 3 reference sites. Ideally, one would like an equal number (18) or twice as many reference sites as test sites. Further selecting a number of reference sites in an area with similar geological, botanical, and climatic characteristics would have allowed the possibility of separating the localized impacts of the atmospheric deposition of metals from the confounding influences of declining levels of acid precipitation, climate change, and other non-metal stressors.
- Assessment endpoints explicitly define characteristics or attributes that are important to protect and which are potentially at risk. The chosen endpoint for terrestrial wildlife, population persistence, is inadequate as this may occur due to constant immigration. It is felt that the appropriate endpoint for terrestrial wildlife would have been adequate survival and reproduction to maintain a stable population.
- There are not accurate, real, or current measures for many of the variables required by the risk assessment model. Of the 25 dietary "items" used in the risk assessment, 80% were estimated. All the inter-individual and interspecific variation in metal content that results from an individual food organism's "taxonomy", physiology, ecology, and behavior is eliminated. This reduces the confidence in the model conclusions.
- It is felt that the approach applied to the exposure assessment, which is the only site- and VEC-specific component of the risk assessment, compromised the risk assessment, making it difficult to say anything about the likelihood of adverse effects of a COC on any valued ecosystem component (VEC).
- The efforts of assessors' to ground-truth conclusions using existing field information on reproductive success and population trends relied heavily on data that was anecdotal or qualitative. Quantitative data on ducks and loons suggest that numbers have responded positively to improved food resources and habitat quality that have accompanied reductions in acid deposition. However, whether or not adverse effects of metals pollution is limiting these increases in numbers and breeding success is unknown.

- The effect of the exposure to a "cocktail" of COC should be of concern. The cumulative impact of exposure to multiple chemicals and habitat quality plus potential frank or sublethal toxicity must be investigated.

- The problem formulation for a possible future detailed aquatic risk assessment highlights the lack of information on Sudbury-specific metal impacts on algae, macrophytes, invertebrates, additional species of fish, and amphibians. The marshes and wetlands have not been studied recently. It is therefore difficult to determine if metals are having a significant deleterious effect on these populations directly or through reductions in food or habitat quality.

An Evaluation of the Environmental Risk Assessment of the Sudbury Soils Study
Prepared by *Glen A. Fox*
August 2009

INTRODUCTION

BACKGROUND

For more than a century, the geological landscape and mixed boreal forest of the Greater Sudbury area have provided prosperity to the community through timber harvesting, and mineral and base metals extraction. These forestry, mining, and smelting operations have dramatically altered the landscape. Historical smelting operations have resulted in acidic, metal-containing atmospheric deposits which have denuded and altered the vegetation, and contaminated the soil, water, and biota. However, ecosystem recovery and transformation have been occurring since the mid-1970s due to emission reductions, wide-scale liming and fertilizing of damaged lands, and vegetation planting initiatives aimed at the "regreening" of the Sudbury landscape.

In 2001, the Sudbury urban and regional soils surveys collected approximately 8,400 soil samples from about 1,150 sites and analyzed them for 20 metals and metalloids. This was followed by a remote sensing analysis to examine changes in areas of vegetation impacted by emissions and by restoration efforts for the period 1976-2003. These two comprehensive landscape scale surveys provided the justification for the Environmental Risk Assessment (ERA) and informed the scientific approaches taken.

At the request of the Community Committee on the Sudbury Soils Study, Glen A. Fox provided this review of the Environmental Risk Assessment component of the Sudbury Soils Study. He was contracted by Environment Defence. This is his report.

ERA GOAL AND OBJECTIVES

The goal was "to characterize the current and future risks of chemicals of concern (COC) to terrestrial and aquatic ecosystem components from particulate emissions from Sudbury smelters and to provide information to support activities related to the recovery of regionally representative, self-sustaining ecosystems in areas of Sudbury affected by the COC." (SARA, Vol. III, ES2).

Further to this, the four objectives of the ERA are as follows:

1. Evaluate the extent to which the COC are preventing the recovery of regionally representative, self-sustaining terrestrial plant communities

2. Evaluate risks to terrestrial wildlife populations and communities due to the COC

3. Evaluate risks to individuals of threatened or endangered terrestrial species due to the COC

4. Conduct a comprehensive Problem Formulation for the aquatic and wetland environments in the Sudbury area to facilitate a more detailed risk assessment in aquatic/wetland ecosystems

GENERAL NOTES ON RISK ASSESSMENT

Risk assessment is a quantitative assessment of the probability of deleterious effects under given conditions. The four components of all risk assessments are stressor identification, exposure-response, exposure assessment, and risk characterization.

1. *Stressor identification* – identifies stressors, in this case a subset of metals (COC), present with known potential to cause biological impairment.

2. *Exposure-response* – characterizes the relationship between controlled exposure to the individual metal and biological responses such as toxicity under controlled conditions in laboratories and establishes a threshold exposure (dose) above which toxicity is likely to occur (the Toxicity Reference Value).

3. *Exposure assessment* – a site-specific characterization of the exposure of the individuals or population of a particular species of concern (VEC) to a specific metal through food, water, air, and soil.

4. *Risk Characterization* – an evaluation of the degree to which an individual's calculated exposure to a specific stressor exceeds the toxicity threshold. If probabilistic methods are used, a risk assessment can determine the likelihood that risks to an exposed individual will exceed a particular risk level of concern.

GENERAL NOTES ON PROBABILISTIC RISK ASSESSMENT

Probabilistic risk assessments (PRA) use probability models to represent the likelihood of different risk levels in a population (i.e., variability) or to characterize uncertainty in risk estimates. In the probabilistic approach, inputs to the risk equation are described as random variables (i.e., variables that can assume different values for different individuals in the population) that can be defined by a probability function. These probability functions describe the range of values that a variable may assume, and indicate the relative likelihood (i.e., probability) of each value occurring within that range for the exposed population. After determining the appropriate functions and parameter values for the selected variables, the set of probability functions are combined with the toxicity reference value in the exposure and risk equations to estimate a cumulative distribution of risks. In an ERA, risk distributions may reflect variability or uncertainty in exposure and/or toxicity.

The most common numerical technique for PRA is Monte Carlo simulation, where the computer selects a value for each variable at random from a specified probability distribution function and calculates the corresponding risk. This process is repeated 10,000 times, each time saving the set of input values and corresponding estimate of risk. Each iteration, in effect, represents a single individual and the collection of all iterations, a population.

In a PRA, distributions used as inputs to the risk equations can characterize the inter-individual variability inherent in each of the exposure assumptions. By characterizing variability with one or more input distributions, the output from the Monte Carlo simulation is a distribution of risks that could occur in that population.

An essential concept in PRA is the distinction between “variability” and “uncertainty”. *Variability refers to true diversity or heterogeneity inherent within a population* due to individual or temporal differences in exposure and response. *Uncertainty occurs because of lack of knowledge*. Uncertainty can often be reduced by collecting more and better data, whereas variability can be better characterized but it cannot be reduced or eliminated.

GENERAL NOTES ON RISK ASSESSMENT UNCERTAINTY

Potential sources of uncertainty in risk assessment can be divided into one of three broad categories:

1. *Parameter uncertainty* – uncertainty in an estimate of an input variable in a model. Parameter uncertainty can occur in each step of the risk assessment process from data collection and evaluation, to the assessment of exposure and toxicity. Sources of parameter uncertainty may include systematic errors or bias in the data collection process, imprecision in the analytical measurements, inferences made from a limited database when that database may or may not be representative of the variable under study, and extrapolation or the use of surrogate measures to represent the parameter of interest.

2. *Model uncertainty* – uncertainty about the model structure (e.g. exposure equation) or intended use.

3. *Scenario uncertainty* – uncertainty regarding missing or incomplete information to fully define exposure.

THE ENVIRONMENTAL RISK ASSESSMENT

THE PROBLEM FORMULATION

The problem formulation for the ERA included a review of ecological information, the definition of the study area, selection of COC, the selection of valued ecosystem components (VECs), and the identification of assessment endpoints.

THE STUDY AREA

The study area was defined by the area from which soil samples were collected for the Sudbury Regional Soils Project and encompasses approximately 40,000 km^2 of the Sudbury basin. For the wildlife ERA, the study area was subdivided into three zones whose boundaries were defined on the basis of metal concentrations in the soil, wildlife species foraging areas, and terrain. In addition, four communities of interest identified in the Human Health Risk Assessment were evaluated for some of the valued ecosystem components.

IDENTIFYING CHEMICALS OF CONCERN

COC are chemicals present in the study area that pose the greatest potential for exposure and risk to the components of the ecosystem. The Technical Committee established three criteria which must be satisfied in order to identify a metal as a Chemical of Concern:

1. Concentrations must equal or exceed criteria published in MOE's *Guidelines for Use at Contaminated Sites in Ontario* (1997);
2. Metal must be present across the study area; and
3. There must be scientific evidence that the metal originates from smelter operations.

Of the 20 metals measured in the Sudbury Soil samples, the Technical Committee identified arsenic, cobalt, copper, lead, nickel, and selenium as Chemicals of Concern. Cadmium, well known for its toxicity, did not meet these criteria or other more liberal criteria, and was eliminated as a COC by the Technical Committee. However, MOE requested that cadmium be considered a COC for the terrestrial ecological risk assessment (ERA).

Toxicity of these COC to Wildlife

Of greatest concern are nickel, cadmium, lead, and selenium which have been associated with significant toxicity to individuals or their habitat.

- **Nickel**. In their comprehensive literature review, Outridge and Scheuhammer (1993) suggested that there was potential for toxic effects in wildlife and alterations in diet quality due to alterations in aquatic macrophyte communities and food chains near the nickel smelters in Sudbury, based on concentrations measured in environmental media. In particular they suggested that young waterfowl and other waterbird species habitually feeding on aquatic macrophytes around Sudbury may have experienced potentially lethal levels of dietary nickel, at least in past decades. Macrophyte species richness was inversely correlated with nickel concentrations in lakes in the Sudbury region (Yan et al. 1985). Sublethal toxic effects of oral nickel exposure include growth inhibition, neuromuscular dysfunction, and reproductive impairment. Adverse effects due to nickel exposure should be suspected at concentrations >10 µg/g DW in the kidneys (Outridge and Scheuhammer 1993). Nickel levels in the kidneys of several muskrats from the Sudbury area measured by Parker (2004) were substantially above the range of 3 to 8 µg/g(DW) considered by Outridge and Scheuhammer (1993) to be the NOEL for most mammals.

- **Cadmium** is a nonessential metal that is released into the environment from metal smelting and the burning of coal. It is accumulated by most organisms throughout life. The highest concentrations accumulate in the kidney and it is here that damage is first observed or adverse functional changes occur. Studies of small mammals suggest that insectivores such as shrews and moles are likely to accumulate the highest concentrations and are therefore at greatest toxicological risk. Widespread kidney damage was observed in shrews from a polluted smelter site (Hunter et al. 1984). No toxic effects of cadmium have been reported in wild bird populations apart from kidney damage similar to that observed in dosed birds. Testicular damage has been found in birds at dietary concentrations that cause kidney damage. The critical concentration in kidneys of both birds and mammals is 100 µg/g WW (Cooke and Johnson 1996, Furness 1996).

- **Lead** is a nonessential, highly toxic metal and notorious enzyme poison. Lead affects the central nervous system, excretory system, hematopoietic system, cardiovascular system, and the gastrointestinal system. Mammals, chronically exposed to relatively low doses similar to conditions often encountered in environments with lead-polluted soils, may have significant sublethal effects. Chronic, low-level exposure during the prenatal and post natal stages in mammals may cause physical growth retardation and irreversibly disturb brain development resulting in neurobehavioral deficits. Although most cases of lead poisoning in wildlife result from lead ingestion from spent shot, bullet fragments, fishing sinkers or lead-based paints, toxic exposures can occur in birds occupying or feeding in an area near a point emission source, such as a lead mining area (Chupp and Dalke 1964, Beyer et al. 1985, Blus et al. 1991).

- **Selenium** is an essential component of several metalloenzymes that have very important physiological roles. It is also very toxic and has a very low margin between deficiency and excess. Within certain physiological limits, the body appears to have a homeostatic mechanism for retaining trace amounts and excreting the excess. Toxicity occurs when intake exceeds the excretory capacity. Base metal mining and smelting are important sources of anthropogenic selenium. In aquatic systems, selenium is readily taken up from solution by food-chain organisms and can quickly bioaccumulate (500 - 35,000x) to concentrations that are toxic to the fish and wildlife that consume them. Therefore >2 μg/L in water is considered highly hazardous to the health and long-term survival of fish and wildlife (Lemly 1996). Food chain organisms containing 3μg/g (DW) are potentially lethal to fish and wildlife that consume them. Selenium is efficiently transferred in eggs from parents to offspring where it is teratogenic and embryotoxic. Reproductive success is more sensitive to selenium toxicity than are growth and survival of juvenile and adults in both fish and birds. When livers of egg-laying female birds contain more than 3 μg/g (WW) selenium, reproductive impairment is possible (Heinz 1996). Aquatic herbivores or omnivores may ingest and accumulate more selenium than piscivores or insectivores.

IDENTIFYING VALUED ECOSYSTEM COMPONENTS

A VEC is a biological species, population or community that is ecologically significant, is important to people, has economic and/or social value and can be evaluated in a risk assessment. Several criteria, including trophic position and feeding guild, were used to select candidate VECs from a long list of plant and animal species present in the Sudbury area. Those selected were:

Plant and Invertebrate VECs:

- Terrestrial plant communities
- Blueberry
- Soil invertebrate communities

Wildlife VECs:

- American Robin
- Ruffed Grouse
- Peregrine Falcon
- Northern Short-tailed Shrew
- Meadow Vole
- Moose
- White-Tailed Deer
- Red Fox
- American Beaver

Aquatic/wetland VECs

- Common Loon
- Muskrat
- Mallard

Assessment: *The species chosen as valued ecosystem components to model are very appropriate and were selected through scientific review and extensive Stakeholder consultation. However, they represent very diverse diets and thereby complicate the risk assessment process.*

ASSESSMENT ENDPOINTS

Assessment endpoints are explicit expressions of what is to be protected, and defined by a species, population or community and a characteristic or attribute that is important to protect and which is potentially at risk. The assessment endpoints chosen were as follows:

- For plant communities, self-sustaining forest ecosystem
- For soil invertebrate communities, survival and reproduction of soil and litter biota, including earthworms
- For threatened/endangered wildlife, survival and reproduction of individual Peregrine Falcons in the city of Greater Sudbury and surrounding area
- For other terrestrial wildlife, population persistence in the city of Greater Sudbury and surrounding area

Assessment: *The assessment endpoint of population persistence for terrestrial wildlife implies that population persistence is adequate, even if it is persists only because of constant immigration. Adequate survival and reproduction to maintain a stable population would have been a more appropriate endpoint.*

EVALUATION OF THE ENVIRONMENTAL RISK ASSESSMENT

The following assessment is organized according to the objectives proposed within the ERA.

Objective 1. EVALUATE THE EXTENT TO WHICH THE COC ARE PREVENTING THE RECOVERY OF REGIONALLY REPRESENTATIVE, SELF-SUSTAINING TERRESTRIAL PLANT COMMUNITIES

The remote sensing analysis provided a synoptic and temporal view of the change in vegetation cover over the Greater Sudbury area. This “coarse scale” information was integrated into the planning of the ERA. This ERA clearly recognized that regionally representative, self-sustaining terrestrial plant communities are a fundamental requirement of any stable terrestrial ecosystem.

Several lines of investigation were undertaken to address Objective 1, which ranged from site-specific, detailed characterization of the plant community to the detailed examination of the abiotic and biotic characteristics of the supporting soils. Detailed chemical, physical, and biological data were gathered from 18 test sites, one historically-limed and regreened site, and 3 reference sites for a total of 22 field sites. Sites were selected on transects extending out from one of the three smelter locations and ranged from 1.8 to 41.3 km from the nearest smelter.

An experimental approach was also applied to assess the growth of test plant species in these soils under controlled conditions, and to determine the confounding role of soil pH in plant growth. Parallel experiments were conducted to assess the survival, reproduction, and growth of earthworms, a critical component of the soil biotic community in these soils. The rate of leaf litter decay was also experimentally assessed *in situ*.

The assessors concluded that terrestrial plant communities in the Greater Sudbury area have been and continue to be impacted by the COC in the soil. Terrestrial plant communities are also impacted by other factors such as soil erosion, low nutrient levels, lack of soil organic matter, and/or low soil pH.

Objective 1 Assessment: *The techniques chosen, the execution, and the above conclusions based on the weight-of-evidence are appropriate. However, the strength of these conclusions hinges on the results from the reference sites. The investigators had difficulty finding reference sites and had to discard one with the net result of 3 reference sites for 18 test sites. Ideally, one would like an equal number or twice as many reference sites as test sites. The assessors recognized this problem, but it does weaken their conclusions.*

Assessor Recommendations: *The investigators should have gone further afield and selected a number of reference sites in an area with similar geological, botanical, and climatic characteristics. This would have allowed the possibility of separating the localized impacts of the atmospheric deposition of metals from the confounding influences of declining levels of acid precipitation, climate change, and other non-metal stressors.*

Objective 2. EVALUATE RISKS TO TERRESTRIAL WILDLIFE POPULATIONS AND COMMUNITIES DUE TO THE COC, and

Objective 3. EVALUATE RISKS TO INDIVIDUALS OF THREATENED OR ENDANGERED TERRESTRIAL SPECIES DUE TO THE COC

Terrestrial wildlife populations and communities are dynamic and diverse; the distributions of many species are changing in response to climate change and habitat fragmentation. This is particularly true for birds. The majority of the 300 bird species that are present in the Sudbury area are migratory, and are present for a few days or weeks in the spring and fall. The migratory bird species that actually breed in the Sudbury area only reside there for 4 to 6 months. It is currently believed that populations of migratory birds are greatly influenced by conditions they encounter the other 6 to 8 months of the year.

The assessors acknowledged the presence of some endangered species in the area. However, they concluded that it is unlikely that COC from the smelters are having a direct effect on these species. They did not consider sublethal effects.

For non-endangered terrestrial wildlife, it was concluded that "it is unlikely that metals in soil are exerting a significant direct toxic effect on VEC populations in the Sudbury area. However, previous effects of smelter emissions on habitat quality…may be having a continued influence on birds and mammals in the study area".

Overall, the likelihood of toxicity was addressed by application of a probabilistic risk assessment. Thus, it is here that an overall assessment of the ERA methodology is considered appropriate.

EXPOSURE ASSESSMENT

The purpose of the exposure assessment was to estimate the amount of each COC received by each VEC on a daily basis. *The exposure assessment is the most critical and the only site- and VEC- specific component of the risk assessment.* Exposures to COC from ingestion of food, soil, sediment, and water were estimated using a total daily intake (TDI) model. The model parameters included body weight, sediment/soil intake rate, water intake rate, food intake rate, proportions of individual dietary items consumed, and concentrations of COC in each item ingested, as well as the relative absorption factor for each COC. The various components of each wildlife VEC's diet were determined from the literature.

Estimates of COC concentrations for the components of the wildlife exposure model were derived in most cases from actual measured values in a variety of abiotic and biotic media from the Sudbury area, including surface water, sediment, soil, fish, plants, and invertebrates. COC concentrations in algae, aquatic plants, and benthic invertebrates had to be estimated using uptake factors and equations from the literature because Sudbury-specific data were not available. Literature-derived models were used to predict concentrations in benthic invertebrates, aquatic plants and vegetation, and small mammals.

According to the assessors, "some wildlife species have dietary preferences that can include a large number of different food items. For example, a herbivore (i.e., white-tailed deer) may consume forbs, grasses, twigs, buds, fruits, nuts and seeds throughout the year on a seasonal basis. In order to simplify this complexity, the exposure model only included dietary items that comprise at least 5% of the total diet of each species and divided the vegetation items into only two items – shoots or roots. This simplification was also necessary because measured or predictive models that could be used to estimate concentrations for each dietary item are unavailable in the scientific literature or on a site-specific basis." Additionally, "it is practically impossible to sample each dietary item that an animal consumes on a frequent basis and with sufficient coverage to fully characterize the chemical concentrations in every diet item across the entire Sudbury Study area. To compensate for this lack of information, the wildlife exposure model used surrogate models or best available and scientifically-defensible information to estimate the exposure that wildlife would receive on a chronic basis from food". Thus, of the 25 dietary "items" used in the risk assessment, 80% were estimated.

The origin of the metal concentration used for each food item as used in the exposure assessment, and an assessment of its validity, is summarized in the following table.

Diet Item	Measured or Estimated	Description of sample or base for derivation and source of equations used	Validity
Water	M	Single samples from 30 locations representing 80 (10%) of lakes. As, Se, and Pb below MDL	Represent 10% of lakes. No real values for As, Se, Pb
Sediment	M	Data from literature, many .10ys old. 8 to 81 samples from 6 -14 lakes	Very Questionable
Soil	M	100s of samples measured per site	High
Fish	M	73 fish of 5 species from 8 lakes	Represent 1% of lakes
Amphibians	E	Considered to be fish	Biologically Questionable
Small mammals	E	Soil using equations from literature	Highly Questionable
Birds	E	Considered to be small mammals	NONE
Benthic invertebrates	E	Sediments using equations from literature	Very Questionable
Worms	E	Soils using site-specific equations based on 17 earthworm-soil pairs	Only for earthworms
Terrestrial invertebrates	E	Soils using site-specific equations based on 17 grasshopper-soil pairs	Only for grasshoppers
Aquatic plants	E	Water using equations from literature	Biologically Questionable
Plant shoots	E	Soil using site-specific equations based on 17 soil-*Deschampsia* shoot pairs	Only for *Deschampsia shoots*
Plant roots and tubers	E	Soil using site-specific equations based on 15 soil-*Deschampsia* root pairs	Only for *Deschampsia roots*

As per this chart, all species of insects become a generic insect – a grasshopper; all birds and mammals become a generic terrestrial vertebrate - a small mammal; and all plants and plant parts become one of two parts of a generic plant based on a single plant species –

bunch grass (*Deschampsia* sp.) for the risk assessment. All the inter-individual and interspecific variation in metal content that results from an individual food organism's "taxonomy", physiology, ecology, and behavior is therefore eliminated. Because important data components for the model were so greatly over simplified, it is difficult to have confidence in the conclusions.

Evaluation: Given that the exposure assessment is the only site- and VEC-specific component of the risk assessment, it is felt that this approach compromises the assessment. To further illustrate, Parker and Hamr (2001) reported concentrations of cadmium, cobalt, copper, nickel, and lead in terminal twigs of Beaked Hazel, Red Maple, Red Oak, Trembling Aspen, White Birch, White Cedar and clippings of Deschampsia (representing species browsed by elk) from an area near Sudbury. This sample would be equivalent to "plant shoots" in this exposure assessment. Within that spectrum of 7 species and 2 locations, mean concentrations varied 9 -11x for cadmium, 2.4x for cobalt, 3.3x for copper, 4.5x for nickel, and 1.8x for lead. For this suite of metals in these tissues, concentrations ranked as follows Deschampsia<Red Oak<Red Maple<White Cedar<White Birch<Beaked Hazel<Trembling Aspen. Clearly Deschampsia is a poor surrogate for Trembling Aspen, let alone all species of plants. The roots and rhizomes of the Cattail have been documented as efficient accumulators of nickel and copper on Sudbury area marshes (Taylor and Crowder 1983). There is clearly a wide variation in the metal concentrations among species of plants, and likely variation among individuals of the same species depending on soil contamination, age, and physiological state. Some plant tissues would receive metals predominantly from absorption and translocation within the plant (roots, wood, shoots, leaves, seeds), while others like leaves and bark would also adsorb metals from the air, and in the case of roots, from the soil.

EFFECTS ASSESSMENT

The effects assessment for the ERA determined the levels of exposure to each COC that are not expected to result in adverse effects in each VEC. These chemical doses are the Toxicity Reference Values (TRVs).

The selection of chemical- and species-specific TRVs included a comprehensive search and review of the toxicological literature related to the COC and VECs; TRVs were then selected or derived according to the following order of preference; IC20, LOAEL, NOEL (NOEL only for the endangered Peregrine Falcon). TRVs were adopted from two recent US EPA sources which represent the most comprehensive review of toxicity data available.

Evaluation: Considerable effort was made to examine as many studies as possible to determine toxic concentrations, and to then characterize these values statistically to arrive at a conservative toxicity reference value.

RISK CHARACTERIZATION ASSESSMENT

The risk characterization determined the likelihood of adverse effects to wildlife populations occurring as a result of exposure to an individual COC in the study area by combining the results of the exposure assessment with those of the effects assessment. The predicted exposure ratio (ER) represents the potential risks to individuals within a population, or the probability of an individual receiving a particular exposure.

$$\textit{Exposure Ratio (ER)} = \frac{\textit{Predicted Exposure Estimates}}{\textit{Toxicity Reference Value}}$$

90% or greater probability of an ER less than or equal to 1.0: Signifies that most estimates of exposure are less than the TRV, indicating that adverse effects can be ruled out.

Greater than 10% probability of an ER greater than 1.0: Signifies that the potential for adverse effects is not ruled out; however, the significance of this potential must be judged according to the degree of uncertainty and degree of conservatism incorporated into the risk assessment, as well as site-specific information (ground truthing).

Evaluation: According to the assessors, variability was poorly characterized and uncertainty (lack of knowledge) high for 6 of 8 (75%) of the data elements used to estimate exposures including metal concentrations in environmental media and the various medium-to-biota uptake models. The variability is characterized poorly because sample numbers are low for the area of coverage, there were too few species or groups, and the study was performed only at one time period. Coverage is missing from many regions across the study area. The uncertainty suggests that collection of additional data is likely to improve our understanding of the existing data distributions. Site-specific conditions were significantly different (>10x) from assumptions and methodologies in literature.

Variability in dietary apportionment is required in the ERA model to account for individual, geographic, and seasonal differences in available food items and the wildlife species' preference. The thorough review of the literature should have characterized this well. However, the number of dietary items and the species they represent was low causing concern over biological relevance.

The validity, accuracy, or adequacy of the model cannot be assessed. However, it is important to note that as per the US EPA (2001)

> *All models are simplified, idealized representations of complicated physical and biological processes. Models can be very useful from a regulatory standpoint, as it is generally not possible to adequately monitor long-term exposure for populations at contaminated sites. However, models that are too simplified may not adequately represent all aspects of the phenomena they were intended to approximate or may not capture important relationships among input variables. Other sources of model uncertainty can occur when important variables are excluded, interactions between*

inputs are ignored, or surrogate variables that are different from the variable under study are used.

Objective 2 and 3 Assessment: *Conclusions associated with the result of the modeling are limited and overly simplistic, based on many estimated parameters, values obtained from unrelated studies, and too few species for reliable characterization of the metal content of food items and diets. Models have inherent limitations and the results they generate are only as good as the data used for the various parameters. The conclusion that the COC are unlikely to have a direct effect on threatened or endangered species is based entirely on distribution and not whether or not the COC are actually a problem. Additionally, long-term sublethal effects (e.g., behavioural and reproductive issues) were not addressed.*

Assessor Recommendations: *The most profitable lines of investigation would be the determination of whether (a) local exposure to any of the chemicals of concern is likely to result in toxicity, (b) breeding populations and/or species diversity are reduced on test sites relative to reference sites, and (c) measurements of metals in appropriate target tissues of valued ecosystem components approach or exceed concentrations associated with sublethal or lethal toxicity. Specifically in terms of endangered species, it is felt that the numbers and reproductive success of the Peregrine Falcons breeding in the Sudbury area should be followed on an ongoing basis.*

Objective 4. CONDUCT A COMPREHENSIVE PROBLEM FORMULATION FOR THE AQUATIC AND WETLAND ENVIRONMENTS IN THE SUDBURY AREA TO FACILITATE A MORE DETAILED RISK ASSESSMENT IN AQUATIC/WETLAND ECOSYSTEMS

An aquatic problem formulation was developed as an information gathering and interpretation stage to focus the approach for a possible future detailed aquatic risk assessment. It identified the common loon, mink, and mallard as VECs and used the same probabilistic exposure modeling methodology that was used to identify possible toxicity as was used for terrestrial wildlife for Objective 2.

Using that methodology, the assessors found no evidence of acceptable risks for arsenic, cobalt, copper, lead, or nickel in these species in any portion of the study area. However, unacceptable risks from selenium exposure were predicted for mink, loons, and/or mallards for all four areas in which they were assessed. The assessors had low confidence in the results of the modeling of exposure to selenium and therefore elected to ignore these findings. The potential risks to these species were related to sediment concentrations of selenium and the uptake of selenium into benthic invertebrates. The same water and sediment dataset was used for all four zones/areas, and included only a single selenium analysis for sediment from each of 8 lakes. It is presumed that one equation was used to model all benthic invertebrates from tiny snails to crayfish, the latter being important components of the diet of mink and loons.

The assessors concluded, however, that given the extensive aquatic research and monitoring studies that have been conducted in the study area during the past two decades, no detailed aquatic ecological risk assessment is planned at this time.

Objective 4 Assessment: *The ERA is incomplete without an assessment of possible effects in the aquatic ecosystem. The problem formulation further highlights the lack of information on Sudbury-specific metal impacts on algae, macrophytes, invertebrates, additional species of fish, and amphibians. As marshes and wetlands have not been studied recently, determining if metals are having a significant deleterious effect on these populations directly or through reductions in food or habitat quality is difficult. Aquatic ecosystems have the potential to receive smelter-derived metal contamination by direct atmospheric deposition and as leachate from soils that is transported in runoff.*

Assessor Recommendations: *It is felt that the following information would assist in the ERA process:*

- *Comprehensive water chemistry for each lake selected for study (would expand the Se data set)*
- *Comprehensive sediment chemistry for each lake selected for study (would update and expand the sediment data set and provide more data for Se)*
- *Sequential extraction of sediments to determine bioavailability (would provide real, local site-specific data for bioavailability)*
- *Chemical and biological data for marshes and wetlands (would update from the 1980s)*
- *More comprehensive data for fish*
- *Laboratory bioassays and measurements of uptake by benthic organisms from sediments using sediments from lakes of interest (would provide real, site-specific data on uptake by benthic organisms)*
- *Characterization of benthic community communities and use in bioassays*
- *Characterization of algal and macrophyte communities and use of algal bioassays*
- *Characterization of zooplankton communities and use in bioassays*
- *Evaluation of species diversity and populations of amphibians using call surveys*

It is further believed that collecting the above data would help clarify whether metals are having deleterious impacts in the aquatic ecosystems of the area, while providing a solid baseline against which to measure the results of any remedial measures.

A WAY FORWARD: MEASUREMENT OF METALS IN APPROPRIATE TARGET TISSUES OF VALUED ECOSYSTEM COMPONENTS

Conclusions associated with the modeling were based on many estimated parameters or values obtained from unrelated studies; too few species and individuals were used to characterize the metal content of food items and diets. Models have inherent limitations and the results they generate are only as good as the data used for the various parameters.

The assessors' "ground-truthed" their conclusions using existing field information on reproductive success and population trends; however, most of the data are anecdotal or qualitative. One quantitative dataset that was examined was the Christmas bird count. That analysis showed that wintering numbers of two year-round residents, the Black-capped Chickadee (Poecile atricapillus) and Downy Woodpecker (Picoides pubescens) have been increasing in the Sudbury area, but are doing so at a significantly lower rate than they are on nearby Manitoulin Island, which is not influenced by metal smelter emissions. This observation was not discussed.

The mallard is the most abundant duck species in the Sudbury area (McNicol et al. 1995). Extensive surveys of waterfowl pairs in the Sudbury region 1993-2002 found a significant increase of 9% in pair counts of dabbling ducks (includes mallards) on highly acidified lakes (pH<5.3), a 7% increase in lakes of pH 5.3-6.0, and a 1% decrease in lakes of pH >6.0 (Weeber et al. 2004). Breeding density of common loons in Sudbury correlated strongly with open water area and pH (McNicol et al. 1995). Persistently low pH and unsuitable nesting habitat in close proximity to Sudbury restricted the recruitment of loons to those areas. However, an increase in recruitment close to Sudbury was observed in the 1990s (McNicol et al. 1995). Between 1993 and 2002, Weber et al. (2004) reported an 11.7% annual increase in the pair counts of Common Loon and Common Mergansers in Sudbury lakes of pH <5.3. These duck and loon data suggest that numbers have responded positively to improved food resources and habitat quality that have accompanied reductions in acid deposition. However, whether adverse effects of metals pollution is limiting these increases in numbers and breeding success is unknown.

To a wildlife biologist, ground-truthing would consist of some systematic census work, such as use of trapping and track boards for small mammals (the voles and shrews in particular) building on the work of Robitaille and Linley, breeding bird censuses, comparison of the two Ontario Breeding Bird Atlases for the periods 1981-85 and 2001-2205 to detect changes in distribution and abundance, waterfowl numbers, and productivity estimates. Waterfowl pair and brood counts could follow the methods of McNicol et al. (1995) and Weeber et al. (2004) and current data collected for those sites common to their study areas and the area encompassed by this ERA. Loon numbers and productivity could be estimated using the methodology of the Canadian Lakes Loon Survey.

Amphibian diversity and numbers could be assessed using the methodologies used by Ontario FrogWatch and Marsh Monitoring Programs.

To a wildlife toxicologist, appropriate ground-truthing would consist of collecting specific tissues from those species and locations for which the EC exceeded 1 and measuring the COC concentrations therein. Those concentrations could be compared to tissue residue guidelines and published reviews to see how close they are to concentrations where various forms of toxicity (both sublethal and lethal) are known to occur. Efforts should be made to obtain a sufficient number of matched kidneys and jaw bones of deer, moose, beaver, and muskrat to provide a good sample of older individuals in which to look at age-related bioaccumulation and the physiological significance of renal cadmium (Moose and deer) and nickel (muskrat) concentrations.

Recommendation: Overall, measuring metal concentrations in critical tissues of individuals would bypass modelling assumptions and provide a **r**eal measure of likely toxicity and the concentration of the toxic metal in the animal's tissues collected on the study site in question. Such current, real-world data would either support the conclusions of the risk assessment or suggest that hazards have been underestimated and identify specific wildlife issues. Population-level studies could also provide evidence of habitat-related effects. Systematically-collected data would also provide a baseline against which to evaluate the effectiveness of any remedial actions that are taken.

In the case of older individuals of long-lived species, real-world data would also provide a measure of the amount accumulated over the individual's life. This would be particularly informative for cadmium. An analysis of critical tissues (liver and kidneys) of the various VECs would be beneficial. Eight of 10 of the species for which tissue collection is recommended are harvested (hunted or trapped); however, for this sampling to be meaningful, a reasonably large sample of individuals from each site is required to assess variability. Collecting upper GI tract and crop contents might also be beneficial as these samples would provide a good idea of the metals content of the site-specific diet of those species. Particular attention must also be paid to year-round residents or those whose diets consists of metals-accumulating plants.

In the table below, the VECs (plus the muskrat); the period of the year which they are present in the Sudbury area;, their approximate life span; diet characteristics which might make them vulnerable to the toxicity of lead, cadmium, nickel, and selenium; and measurement timing which may best determine the likelihood of risks to these wildlife species and populations due to COC have been listed.

VEC	Present (months)	Life Span (years)	Diet components most likely to contain metals (COC)	Measure
Ruffed Grouse	12	<5	Aspen leaves, buds & apical tissues of	1(Fall)

			other trees and shrubs, insects	
Mallard	6-8	<5	Aquatic plants, aquatic invertebrates, snails	1 (Fall)
Common Loon	15 - 30	10 -15	Fish and crayfish	3
Peregrine Falcon	6 -12	10 -15	Birds of all types. Urban Peregrines feed primarily on Rock Doves	3
Robin	5 - 6	<4	Earthworms, large insects, snails	3
Meadow Vole	12	< 1.5	Grasses, shoots, insects	2 (Fall and Late Winter)
Beaver	12	10 -15	Bark of Aspens and Poplars	1(Fall and Winter)
Moose	12	15 - 20	Leaves, bark, twigs, shoots, water lilies	1 (Fall)
White-tailed Deer	12	3 - 12	Leaves, twigs, fruits of trees and shrubs and grasses	1 (Fall)
Mink	12	2 - 3	Crayfish, Fish, clams	1 (Fall and Winter)
Red Fox	12	6 - 10	Small mammals and birds	1 (Fall and Winter)
Short-tailed Shrew	12	6 - 10	Earthworms, insects, mice	2 (Fall and late Winter)
Muskrat	12	1 - 3	Root stalks and stems of cattails, other aquatic plants, clams	1 (Winter and spring)

Measures:
1 = harvested; collect tissues (Kidney, Liver), age individual, analyze for Se, Ni, Cd, Pb, (Hg)
2 = trap, collect tissues (Kidney, Liver), age individual, analyze for Se, Ni, Cd, Pb, (Hg)
3 = monitor breeding pairs and reproductive success

CONCLUSIONS

The Sudbury Area Soils Study is a very comprehensive project and assessment with great breadth, detail, and public involvement, as well as a comprehensive and open communications strategy. It sets the standard for investigations of the public's environmental and health concerns in terms of quality, depth, and transparency.

It is agreed that terrestrial plant communities in the Greater Sudbury area have been and continue to be impacted by the COC in the soil. It is also agreed that terrestrial plant communities are also impacted by other factors such as soil erosion, low nutrient levels, lack of soil organic matter, and/or low soil pH. This conclusion although weakened by the difficulty in finding assessment sits, is considered appropriate.

However**, there are points where methodology and/or conclusions are questioned.** Firstly, the assessment endpoint of population persistence for terrestrial wildlife implies that population persistence is adequate, even if it is persists only because of constant immigration. The appropriate endpoint would be adequate survival and reproduction to maintain a stable population. Secondly, the conclusions associated with modeling are limited and overly simplistic, based on many estimated parameters, values obtained from unrelated studies, and too few species for reliable characterization of the metal content of food items and diets. Given that the exposure assessment was the only site- and VEC-specific component of the risk assessment, this modelling makes it difficult to assess the actual likelihood of adverse effects of a COC on any VEC. Thirdly, there are limitations of chemical-by-chemical toxicity assessment such as this since the cumulative impact of multiple chemical exposure and habitat quality plus potential frank or sublethal toxicity is unknown. Fourthly, an assessment of possible effects in the aquatic ecosystem is needed to help clarify whether metals are having deleterious impacts in the aquatic ecosystems of the area. It would further provide necessary information to improve the risk assessment, and would provide a solid baseline against which to measure the results of any remedial measures.

Furthermore, while assessors' "ground-truthed" their conclusions using existing field information on reproductive success and population trends, most of the data are anecdotal or qualitative. Although there is evidence that numbers of dabbling ducks and loons are increasing in the Sudbury area, we cannot determine whether metal contamination is slowing this process. Terrestrial wildlife populations and communities are dynamic and diverse; the distributions of many species are changing in response to climate change and habitat fragmentation is known. Local, smelter-associated effects are superimposed over these more global effects and observational methods and do not allow us to separate local and global effects.

Measuring and analyzing the presence of metals in appropriate target tissues (liver and kidneys) of valued ecosystem components, is needed, even for the well-studied toxic metals cadmium, lead, and selenium. Doing so would bypass the assumptions and mathematical modelling, dietary sampling, etc. by providing a real measure of likely toxicity and the concentration of the toxic metal in the animal's tissues collected on the study site in question. In the case of older individuals of long-lived species, it also provides a measure of the amount accumulated over the individual's life and would be particularly informative for cadmium. Real-world investigations undertaken by G. Parker and students of Laurentian University have been quite revealing.

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Zoology (avian ecology and environmental physiology.)

M.Sc. 1985 University of Surrey, Guildford, UK.
Biochemical Toxicology

Employment History:

Medical Laboratory technologist, Worked in hospitals and Veterinary Pathology Department at University of Saskatchewan.

Research Assistant, Dept. of Zoology, University of Guelph, 1969-1971. (Avian Ecology)

Technical Assistant to the Director, Alberta Provincial Laboratory of Public Health, Edmonton. 1973-1974.(Clinical Pathology)

Toxic Chemical Biologist, Canadian Wildlife Service, Edmonton and Ottawa, 1974-1975. (wildlife toxicology field studies)

Wildlife Toxicologist, Canadian Wildlife Service, National Wildlife Research Centre, Hull. 1976-1985. (Field and laboratory investigations on the effects of environmental contaminants on fish-eating birds in the Great Lakes and the development of biochemical and physiological techniques to detect effects). Position and program terminated while I was on educational leave at the University of Surrey, UK, studying Biochemical Toxicology.

Environmental Contaminants and Pesticides Evaluator, Canadian Wildlife Service, National Wildlife Research Centre, Hull. 1986-1989. (Contaminant and pesticide regulation and field studies of impacts)

Contaminants Evaluation Officer, Canadian Wildlife Service, National Wildlife Research Centre, Hull. 1989-1992. (Contaminant evaluation under CEPA and bioeffects research and biomarker development in Great Lakes)

Most Recent Position:
Contaminant Effects Specialist, Canadian Wildlife Service, National Wildlife Research Centre, Hull/Ottawa. 1993-2005 (Plan, conduct and coordinate laboratory and field research on the effects of environmental contaminants on wildlife and their habitat, and provide advice and leadership to the CWS Contaminants Program and the broader scientific and regulatory community. (Reclassified from biologist to research Scientist in 1992). Retired March 31, 2005. Held as an Emeritus Scientist, 2005-2007.

ACHIEVEMENTS
Publications as of March 2006: 104 (primary author on 40) plus 9 prior to joining CWS

71 in recognized scientific journals
18 books chapters or conference proceedings
12 government departmental or other reports

Literature Citations: as of 1999, there were 479 citations for 29 first-authored publications, and 632 citations for 38 citeable co-authored publications. A total of 14 publications were cited 25 or more times.

Poster and platform presentations, lectures etc.: 89

International Service:
Appointed to the Science Advisory Board to the International Joint Commission on the Great Lakes for two successive 3-year terms and served two terms as Canadian co-chair for the SAB's Workgroup on Ecosystem Health

Areas of Expertise:
Wildlife health assessment and biological effects monitoring
Wildlife toxicology, particularly in the Great Lakes region
Environmental endocrine disruption
Ecoepidemiology and application of the Precautionary Principle

Glen A. Fox – Publications as of December 2008

Fox, G.A., R. Lundberg, C. Wejheden, L. Lind, S. Larsson, J. Orberg and P.M. Lind. 2008. Health of herring gulls (Larus argentatus) in relation to breeding location in the early 1990s. III. Effects on the bone tissue. *Journal of Toxicology and Environmental Health, Part A*. 71:1448-1456.

Breton, A.R., G.A. Fox, and J.W. Chardine. 2008. Survival of adult herring gulls (Larus argentatus) from a Lake Ontario colony over two decades of environmental change. *Waterbirds* 31:15-23.

Fox, G.A., K.A. Grasman and G.D. Campbell. 2007. Health of Herring gulls (Larus argentatus) in relation to breeding location in the early 1990s. II. Cellular and histopathological measures. *Journal of Toxicology and Environmental Health, Part A*. 70:1471-1491.

Fox, G.A., D.A. Jeffrey, K.S. Williams, S.W. Kennedy, and K.A. Grasman. 2007. Health of herring gulls (Larus argentatus) in relation to breeding location in the early 1990s. I. Biochemical measures. *Journal of Toxicology and Environmental Health, Part A*. 70:1443-1470.

Fox, G.A., P.A. White, S. Trudeau, C. Theodorakis, L.J. Shutt, and K.J. Fernie. 2005. DNA strand length and EROD activity in relation to two screening measures of genotoxic exposure in Great Lakes Herring Gulls. *Ecotoxicology* 14:527-544.

Fox, G.A., M.C. MacCluskie, and R.D. Brook. 2005. Are current contaminant concentrations in eggs and breeding female lesser scaup of concern? *The Condor* 107:50-61.

Drouillard, K.D., R.J. Norstrom, **G.A. Fox**, A.P. Gilman, and D.B.O. Peakall. 2003. Development and validation of a herring gull embryo toxicokinetic model for PCBs. *Ecotoxicology* 12, 55-68.

Kennedy, S.W., **G.A. Fox**, S.P. Jones, and S. Trudeau. 2003. Hepatic EROD activity is not a useful biomarker of polychlorinated biphenyl exposure in the adult herring gull (*Larus argentatus*). *Ecotoxicology* 12, 153-161.

Kuzyk, Z.Z.A., N.M. Burgess, J.P. Stow, and **G.A. Fox**. 2003. Biological effects of marine PCB contamination on black guillemot nestlings at Saglek, Labrador; Liver biomarkers. *Ecotoxicology* 12, 183-197.

McNabb, F.M.A. and **G.A. Fox**. 2003. Avian thyroid development in chemically contaminated environments: Is there evidence of alterations in thyroid gland function and development? *Evolution and Development* 5[1]: 1-7.

Burger, J. and **G.A. Fox**. 2002. In Memorium: David B. Peakall, 1931-2001. *The Auk* 119[3]: 812-814.

Fox, G.A., K.A. Grasman, K.A. Hobson, K. Williams, D.A. Jeffrey, and B.A. Hanbidge. 2002. Contaminant residues in tissues of adult and prefledged herring gulls from the Great Lakes in relation to diet in the early 1990s. *J. Great Lakes Res.* 28[4]: 643-663.

Ewins, P.J., D.V.C. Weseloh, **G.A. Fox**, C.A. Bishop, and T. Boughen. 2001. Using wildlife to monitor contaminants and their effects in the North American Great Lakes ecosystem. *In*: The Great Lakes of the World (GLOW): Food-web, health and integrity, Backhuys Publishers, Leiden, The Netherlands, pp. 341-362.

Fernie, K.J. and **G.A. Fox.** 2001. Contaminants and wildlife health in the Great Lakes Basin: An Overview. SWAT Report for the Canadian Wildlife Service, Environment Canada. pp. 1-36.

Fox, G.A. 2001. Wildlife as sentinels of human health effects in the Great Lakes - St.Lawrence basin. *Environ. Health Persp.* 109[6]: 853-861.

Fox, G.A. 2001. Effects of endocrine disrupting chemicals on wildlife in Canada: past, present and future. *Water Quality Research Journal of Canada* 36[2]: 233-251.

McNabb, F.M.A., R.J.R. McCleary, L.A. Fowler, C.M. Parsons, K.A. Grasman, and **G.A. Fox**. 2001. Thyroid function in polychlorinated biphenyl (PCB) exposed avian embryos and chicks. *In*: Perspectives in Comparative Endocrinology: Unity and Diversity, H.J.T. Goos, R.K. Rastogi, H. Vaudry, and R. Pierantoni [eds.], Monduzzi Editore, Bologna, Italy,

Grasman, K.A. and **G.A. Fox**. 2001. Associations between altered immune function and organochlorine contamination in young Caspian terns (*Sterna caspia*) from Lake Huron, 1997-1999. *Ecotoxicology* 10, 101-114.

Servos, M., P. Delorme, **G.A. Fox**, R. Sutcliffe, and M. Wade. 2001. A Canadian perspective on endocrine disrupting substances in the environment. *Water Quality Research Journal of Canada* 36, 331-346.

Servos, M., P. Delorme, **G.A. Fox**, R. Sutcliffe, and M. Wade. 2001. Proceedings of the 5-NR Workshop: Establishing a national agenda on endocrine disrupting substances in the Canadian environment. Government of Canada, pp. 1-340.

Fox, G.A. 2000. Perturbations in terrestrial vertebrate populations: Contaminants as cause. *In*: Environmental Contaminants and Terrestrial Vertebrates: Effects on Populations, Communities and Ecosystems, P. Albers, G.H. Heinz, and H. Ohlendorf [eds.], SETAC Press, pp. 19-59.

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Grasman, K.A., P.F. Scanlon, and **G.A. Fox**. 2000. Geographic variation in haematological variables in adult and prefledgling herring gulls (*Larus argentatus*) and possible association with organochlorine exposure. *Arch. Environ. Contam. Toxicol.* 248, 244-253.

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Servos, M., P. Delorme, **G.A. Fox**, R. Sutcliffe, and M. Wade. 2000. Establishing a National Agenda on the Scientific Assessment of Endocrine Disrupting Substances in the Canadian Environment: Executive Summary. Government of Canada.

Yauk, G.L., **G.A. Fox**, B. McCarry, and J.S. Quinn. 2000. Induced minisatellite germline mutations in herring gulls (*Larus argentatus*) living near steel mills. *Mutation Research* 452, 211-218.

Kuiken, T., **G.A. Fox**, and K.L. Danesik. 1999. Bill Malformations in Double-Crested Cormorants With Low Exposure to Organochlorines. *Environ. Toxicol. Chem.* 18[12]: 2908-2913.

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Fox, G.A. 1994. Scientific Principles: *In*: Applying Weight of Evidence: Issues and Practice. Report on presentations made at the 1993 Biennial Mtg. of the IJC. Gilbertson, M. and S. Cole-Misch, [eds.], Windsor, Ontario.

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Fox, G.A., B.T. Collins, E. Hayakawa, D.V.C. Weseloh, J.P. Ludwig, T.J. Kubiak, and T.C. Erdman. 1991. Reproductive outcomes in colonial fish-eating birds: a biomarker for developmental toxicants in Great Lakes food chains. II. Spatial variation in the occurence and prevalence of bill defects in young Double-crested cormorants in the Great Lakes, 1979-1987. *J. Great Lakes Res.*

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Fox, G.A. . 1991. What have biomarkers told us about the effects of contaminants on the health of Great Lakes wildlife. *IN Abstracts of the Cause-Effect Linkages II Symposium*, Michigan Audubon Society, Traverse City, MI, 27-28 September. pp. 15-17.

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Gilman, A.P., P. Béland, T. Colborn, **G.A. Fox**, J.P. Giesy, J. Hesse, T.J. Kubiak, and D. Piekarz. 1991. Environmental and wildlife toxicology of exposure to toxic chemicals. *In*: Human Health Risks from Chemical Exposure, The Great Lakes Ecosystem, R.W. Flint and J. Vena [eds.], Lewis Publishers, Inc., Chelsea, MI, pp. 61-91.

Houston, C.S., **G.A. Fox**, and R.D. Crawford. 1991. Unhatched eggs in Swainson`s Hawk nests. *Journal of Field Ornithology* 62[4]: 479-485.

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Fox, G.A. Platform presentation: The effects of DDE on the nesting ecology of the Merlin on the Canadian Prairies*. Annual Meeting of the American Ornithologists Union, 1978, Madison, WI.*

Fox, G.A. Effects of environmental contaminants on reproduction of non-human vertebrates. *Preventive Medicine Symposium, University of Ottawa. 1981*. Invited platform presentation

Fox, G.A. and A.P. Gilman. Unsatisfactory reproduction in gulls feeding in a highly contaminated food chain. Platform presentation*, Annual meeting of the American Public Health Association, Nov. 1981, Los Angeles, CA.*

Fox, G.A. Congenital anomolies in colonial fish-eating birds: a monitor for environmental teratogens. Platform presentation: *Annual meeting of the American Public Health Association, 14-18 Nov. 1982, Montreal.*

Fox, G.A. Pollutant-induced endocrine dysfunction in Great Lakes Herring Gulls. Invited platform presentation**:**Roundtable on Environment and Nutrition, *3rd International Symposium on Avian Endocrinology, 25-28 June 1984, New Brunswick, NJ.*

Fox, G.A. and D.V. Weseloh. Colonial waterbirds as indicators of environmental contamination in the Great Lakes. Platform presentation: "Birds as Bioindicators of Environmental Conditions*", 19th I.C.B.P. World Conference, 1986, Kingston, ON.*

Fox, G.A. Fish-eating birds as sensors of toxic levels of environmental contaminants in the Great Lakes. Platform presentation: *30th conference of the International Association for Great Lakes Research, 11-14 May 1987, Ann Arbor, MI.*

Houston, C.S., R.D. Crawford, L.D. Oliphant and **G.A. Fox**. Addled eggs in Swainson's Hawk nests in Saskatchewan. Poster presentation: *Annual Meeting of the Raptor Research Foundation, 1987, Boise, ID.*

Fox, G.A. and P.C. James. Impact of grasshopper sprays on Burrowing Owls in Saskatchewan. Poster presentation: *3rd Annual Meeting of Society Environmental Toxicology and Chemistry, 9-12 Nov. 1987, Pensacola, FL.*

Kennedy, S.W., **G.A. Fox** and R.J. Norstrom. Polyhalogenated aromatic hydrocarbon-induced porphyria in Great Lakes Herring Gulls. Poster Presentation: *3rd Annual meeting of Society of Environmental Toxicology and Chemistry, 9-12 Nov. 1987, Pensacola, FL*.

James, P.C., T.J. Ethier, **G.A. Fox** and N. Todd. New aspects of Burrowing Owl biology.
Platform presentation: *2nd Endangered Species and Prairie Conservation Workshop, Regina, SK., January 1989.*

Fox, G.A. and P.C. James. Impact of grasshopper sprays on Burrowing Owls in Saskatchewan.
Invited platform presentation**:** *2nd Endangered Species and Prairie Conservation Workshop, Regina, SK., January 1989***.**

Fox, G.A., B. Collins, T.J. Kubiak, J.P. Ludwig, D.V. Weseloh and T.C. Erdman. Incidence and prevalence of bill defects in Double-crested cormorants from Green Bay, Michigan. Platform presentation: *32nd conference of International Association of Great Lakes Research, 30 May-2 June, 1989, Madison, WI.*

G.A. Fox. Temporal and spatial variation in a battery of biomarkers in Great Lakes fish-eating birds in relation to known patterns of chemical contamination. Invited platform presentation**:** *32nd conference of International Association of Great Lakes Research, 30 May-2 June, 1989, Madison, WI.*

Fox, G.A. Practical causal inference - a lesson in applied epidemiology. Invited platform presentation***:*** *32nd conference of International Association of Great Lakes Research, 30 May-2 June, 1989, Madison, WI*

Fox, G.A., S.W. Kennedy and S. Trudeau. Temporal and spatial variation in a battery of biomarkers in Great Lakes fish-eating birds in relation to known patterns of chemical contamination. Poster presentation: *5th International Congress of Toxicology, 16-21 July, 1989 Brighton, UK.*

Fox, G.A. Temporal and spatial variation in a battery of biomarkers in Great Lakes fish-eating birds in relation to known patterns of chemical contamination. Platform presentation:*10th annual meeting of the Society of Environmental Toxicology and Chemistry, 28 Oct.- 2 Nov, 1989, Toronto, ON.*

Jessiman, B., M. Wong, **G.A. Fox**. Environmental risk from the current use patterns of Lindane. Poster presentation:*10th annual meeting of the Society of Environmental Toxicology and Chemistry, 28 Oct.- 2 Nov, 1989, Toronto, ON.*

Fox, G.A., S.W. Kennedy and S. Trudeau. Temporal and spatial variation in a battery of biomarkers in Great Lakes fish-eating birds in relation to known patterns of chemical contamination. Poster presentation: *6th International Symposium on Responses of Marine Organisms to Pollutants, Woods Hole, MA. 24-26 April. 1991*

Fox, G.A. Contaminant levels and effects in Great Lakes wildlife. Invited platform presentation*: Environmental Health Effects Workshop, Walpole Island First Nation. 28-29 August., 1991*

Fox, G.A. Biomarkers: what are they and what have they told us about the effects of contaminants on the health of Great Lakes wildlife? Invited platform presentation**:** *Cause-Effect Linkages II Symposium, Traverse City, MI. 27-28 November, 1991.*

Fox, G.A. Fish and wildlife studies. Invited platform presentation*: "Our Community, Our Health - A Dialog Between Science and Community" an IJC-sponsored Ecosystem Health workshop, 14-15 Sept., 1992 Ann Arbor, MI.*

Fox, G.A., K.L. Williams, D.A. Jeffrey and K.A. Grasman. Retinol homeostasis, a sensitive and relevant biomarker for PHAHs in fish-eating birds. Invited platform presentation**:** *Annual meeting of the Society of Environmental Toxicology and Chemistry, 8 - 12 Nov., 1992, Cincinnati, OH.*

K.A. Grasman, P.F. Scanlon and **G.A. Fox**. Preliminary analysis of hematological and immunological parameters in fish-eating birds in the Great Lakes. Invited platform presentation:*13th annual meeting of the Society of Environmental Toxicology and Chemistry, 8-12 Nov., 1992, Cincinnati, OH.*

Fox, G.A. Temporal trends in biomarker responses of adult herring gulls from seven Great Lakes colonies, 1974-1991. Platform presentation: *36th Conference of the International Association for Great Lakes Research,4-10 June, 1993, De Pere, WI.*

Fox, G.A. Scientific Principles. Invited platform presentation:Workshop on Weight of Evidence, 1993 *Biennial Meeting on Great Lakes Water Quality, 22-24 Oct, 1993, Windsor, ON.*

Grasman, K.A., P.F. Scanlon and **G.A. Fox**. Poster presentation. Environmental contamination and immune function in Great Lakes colonial waterbirds. *21st Conference of the International Union of Game Biologists, 15-20 Aug., 1993, Halifax, NS.*

Fox, G.A. and K.A. Grasman. Temporal trends in PCB and DDE burdens and biomarker responses of adult herring gulls from eight Great Lakes colonies and a maritime reference colony, 1974-1993. Invited platform presentation: *Wingspread Worksession on Environmentally Induced Alterations in Development: A Focus on Wildlife. 10-12 Dec., 1993, Racine, WI.*

Grasman, K.A., **G.A. Fox**, and P.F. Scanlon. Immunological biomarkers and environmental pollutants in Great Lakes fish-eating birds. Invited platform presentation: *Wingspread Work Session on Environmentally Induced Alterations in Development: A focus on Wildlife. 10-12 Dec., 1993. Racine, WI.*

Fox, G.A., and K.A. Grasman. Evidence of altered sexual development, endocrine and immune function in fish-eating birds of the Great Lakes. Invited platform presentation*: Special symposium on Environmental Endocrine Disruptors, Annual Meeting of American Society of Zoologists, 5-8 Jan., 1994, St. Louis, MO.*

Norstrom R.J., T.P. Clark, **G.A. Fox** and C.E. Hebert. Bioaccumulation of PCBs in Herring Gulls: QSAR and modelling approaches. Platform presentation: *Annual meeting of the Society of Environmental Toxicology and Chemistry, 30 Oct-3 Nov, 1994, Denver, CO.*

Grasman, K.A., P.F. Scanlon and **G.A. Fox.** Immunological biomarkers and environmental contaminants in fish-eating birds of the Great Lakes. Poster presentation: *Annual meeting of the Society of Environmental Toxicology and Chemistry, 30 Oct.-3 Nov., 1994, Denver, CO.*

Fox, G.A. Killing the messenger: chemicals that interfere with the body's "information highway".
Invited seminar: Organismal Biology Series, *Dept. of Biology, McGill U., Montreal, PQ., 1995*

Grasman, K.A., P.F. Scanlon and **G.A.Fox**. Immunological biomarkers and environmental contaminants of fish-eating birds of the Great Lakes. Invited platform presentation: *Annual conference of the International Association for Great Lakes Research, 28 May-1 June,1995, East Lansing, MI.*

Norstrom R.J., C.E. Hebert, **G.A. Fox**, S. Kennedy and D.V. Weseloh. The Herring Gull as a biomonitor of trends in levels and effects of halogenated contaminants in Lake Ontario: A 25-year case history. Platform presentation: *Annual conference of International Association for Great Lakes Research, 28 May-1 June, 1995, East Lansing, MI.*

Grasman, K.A., P.F. Scanlon, and **G.A. Fox**. Developmental immunotoxicicity of environmental contaminants in fish-eating birds of the Great Lakes. Invited platform presentation: *Wingspread Work Session on Chemically- Induced Alterations in the Developing Immune System: The Wildlife/Human Connection, 10 - 12 Feb.,1995, Racine, WI.*

Grasman, K.A., P.F. Scanlon and **G.A. Fox**. Organochlorine-induced immunosuppression in fish-eating birds of the Great Lakes. Poster presentation: *Annual meeting of the Society of Environmental Toxicology and Chemistry, 5 - 9 Nov, 1995,Vancouver, BC.*

Fox, G.A. and K.A. Grasman. Evidence, past and present, of endocrine disruption in fish-eating birds in the Great Lakes. Poster presentation: *6th International Symposium on Avian Endocrinology, 31 March - 5 April, 1996, Lake Louise, AB*

Fox, G.A. and K.A. Grasman. Evidence, past and present, of endocrine disruption in fish-eating birds in the Great Lakes. Platform presentation: *Annual conference of the International Association for Great Lakes Research, 26 - 30 May, 1996, Mississauga, ON.*

Kennedy, S.W., **G.A. Fox**, S. Trudeau, L.J. Bastien and S.P. Jones. Highly carboxylated porphyrins: biochemical markers of PCB exposure in Herring Gulls. Platform presentation: *Annual meeting of the Society of Environmental Toxicology and Chemistry, 17 - 21 Nov,1996. Washington, DC.*

Grasman, K.A., P.F. Scanlon and **G.A. Fox**. Immunological biomarkers and environmental contaminants in fish-eating birds of the Great Lakes. Invited platform presentation: *Symposium on Immunotoxicology, Annual meeting of the Society of Environmental Toxicology and Chemistry, 17 - 21 Nov., 1996, Washington, DC.*

Grasman, K.A., P.F. Scanlon and **G.A. Fox.** Immunological biomarkers and environmental contaminants in fish-eating birds of the Great Lakes. Invited platform presentation: Symposium on Aquatic Pollution-induced Immunotoxicity in Wildlife Species. *Annual meeting of the Society of Toxicology, 10 - 19 March, 1996, Anaheim, CA.*

Grasman, K.A. and **G.A. Fox**. Trends in biochemical markers in Great Lakes birds. Invited platform presentation: Workshop on Environmental Results: Monitoring and Trends of Effects Caused by Persistent Toxic Substances, *Biennial meeting of the International Joint Commission, 12-13 Sept, 1996, Windsor, ON.*

Grasman, K.A., P.F. Scanlon and **G.A. Fox**. Organochlorine-induced immunosuppression in fish-eating birds of the Great Lakes. Platform presentation: *Annual conference of the Wildlife Society, 1 - 5 Oct., 1996, Cincinnati, OH.*

Fox, G.A. Killing the messenger: chemicals that interfere with the body's "information highway". Invited lecture: Ecotoxicology course, *Department of Biology, University of Ottawa,* 1997.

G.A. Fox and K.A. Grasman. Evidence, Past and Present of Endocrine Disruption in Fish-eating Birds in the Great Lakes. Poster presentation. *Health Conference '97 - Great Lakes/St. Lawrence, May 12-15, 1997, Montreal*

G.A. Fox, S.W. Kennedy, S. Trudeau, C.A. Bishop, and M. Wayland. Hepatic Porphyrin Patterns in Birds as a Promising Measure of Effect and Bioavialability of PCBs and Other HAHs in Water and

Sediments. Platform presentation. *17th Symposium on Chlorinated Dioxins and Related Compounds, Aug. 25-29, 1997, Indianapolis, IN.*

K.A. Grasman, D.L. Hammersley, P.F. Scanlon, and **G.A. Fox** . Blood Plasma Proteins as Biomarkers of Contaminants in Fish-eating Birds of the Great Lakes. Poster presentation. *SETAC Annual Conference, Nov. 16-20, 1997, San Francisco, CA.*

G.A. **Fox**. Organized and chaired a plenary session entitled "Observed and Potential Impacts of Endocrine Disruption on Wildlife". *Gordon Research Conference on Endocrine Disruption, July 12-17, 1998, Plymouth NH,*

G.A. Fox. Biomarkers: What are they and what can they tell us about the effects of contaminants?". *1998 Conference of the Wildlife Society, Sept 22-26, Buffalo NY.*

G.A. Fox. Perturbations in Terrestrial Vertebrate Populations; Contaminants as a Cause. Invited plenary presentation. *Environmental Contaminants and Terrestrial Vertebrates. Effects on Populations, Communities, and Ecosystems, Oct 19-21, 1998, College Park, MA*. (SETAC-TWS-PWRC-sponsored symposium).

K.A. Grasman and **G.A. Fox**. Biomarkers for contaminant-associated immunosuppression in colonial waterbirds of the Great Lakes. *SETAC, Nov. 1998, Charlotte NC,*

K.A. Grasman, P.F. Scanlon, and **G.A. Fox**. An examination of the health of herring gulls (*Larus argentatus*) in the Great Lakes basin in the early 1990s: Association between hematological biomarkers and organochlorine contaminants. Poster presentation.
SETAC, 14-18 November, 1999, in Philadelphia, PA

M.E. Kelly, K.A. Grasman, and **G.A. Fox**. Gonadal histology of Great Lakes herring gulls. Poster presentation. *SETAC, 14-18 November, 1999, in Philadelphia, PA*

R.W. Jeffery, S.W. Kennedy and **G.A. Fox**. Cytochrome P4501A1 induction in avian hepatocyte cultures by PAHs: might Greater Scaup be at risk from embryotoxic effects of PAHs?
CWS Wildlife Toxicology Program Science Meeting, 4-6 October 1999, Ottawa.

G.A. Fox. From Wingspread to EDSTAC: What fell through the cracks? Opening plenary presentation. *5-NR EDS Working Group's workshop "Establishing a National Agenda on the Scientific Assessment of Endocrine Disrupting Substances", 13-17 Feb, 2000, Grandview Inn, ON*

G.A. Fox. Endocrine disruption in Canadian wildlife*. 5-NR EDS Working Group's workshop "Establishing a National Agenda on the Scientific Assessment of Endocrine Disrupting Substances", 13-17 Feb, 2000, Grandview Inn, ON*

G.A. Fox. The weight-of-evidence problem: Approaches to decision making in the face of uncertainy. *5-NR EDS Working Group's workshop "Establishing a National Agenda on the Scientific Assessment of Endocrine Disrupting Substances", 13-17 Feb, 2000, Grandview Inn, ON*

Norstrom, R.J., K.D. Drouillard, A.P. Gilman, and **G.A. Fox**. 2000. Toxicokinetics of PCBs in the herring gull (*Larus argentatus*) embryo. Assessing the impact of lipid metabolism on exposure and risk of hydrophobic chemicals of maternal origin. Paper, *IAGLR '00 Conference, Cornwall, Ontario, IAGLR.*

Grasman K.A., **Fox G.A.**, Burgess N.M., Kuzic Z.A., Jeffrey D. Effects of polychlorinated biphenyls on the immune system of Black Guillemots from Labrador. *SETAC-2000, Nashville TN.*

Kelly M.E., Grasman K.A., Burgess N.M., Kuzyk Z.A., **Fox G.A**.. Altered reproductive development in PCB-exposed Black Guillemot chicks. *SETAC-2000, Nashville, TN*.

Kelly, M.E., K.A. Grasman, and **G.A. Fox**. 2000. Gonadal histology of Great Lakes pipping embryos and 28-day herring gull chicks. *SETAC-2000, Nashville, TN,*

McNabb, F.M.A., L.A. Fowler, C.M. Parsons, K.A. Grasman, and **G.A. Fox.** Thyroid function in herring gulls from PCB-contaminated Great Lakes sites. *Society for Integrative and Comparative Biology, Jan 2001, Chicago, IL*

Norstrom R.J., Drouillard K.G., Gilman A.P., **Fox GA**. 2000. Toxicokinetics of PCBs in the Herring Gull (*Larus argentatus*) embryo. Assessing the impact of lipid metabolism on exposure and risk of hydrophobic chemicals of maternal origin. *IAGLR-2000, Cornwall, ON.*

Servos M, Delorme P, **Fox G**, Sutcliffe R, Wade M. 2000. A Canadian perspective on endocrine disrupting substances in the environment. *27th Aquatic Toxicity Workshop, St. John's, NFLD.*

Fox, G.A. Invited platform presentation: Wildlife as sentinels of human health effects in the Great Lakes-St. Lawrence Basin. 2001 Workshop on "Methodologies for Community Health Assessment in Areas of Concern, IJC, Windsor, ON

G.A. Fox. Ecotoxicology. Invited presentation. *The Application of Ecological Research to Conservation: East meets West", August 2001, Simon Fraser University, Vancouver, BC*

Kelly M, Grasman K, **Fox G**. Persistence of gonadal abnormalities in young herring gulls from the Great Lakes (1997-2000). Poster, *SETAC 2001, Baltimore MD.*

Kelly M, Grasman K, **Fox G**. Gonadal histology of Great Lakes herring gull embryos (1997-2000). Poster, *SETAC 2001, Baltimore MD.*

McNabb FMA, Fowler LA, Parsons CM, Grasman KA, **Fox GA**. Herring gulls from PCB-contaminated Great Lakes sites have altered thyroid function. Poster, *SETAC 2001, Baltimore MD.*

Fernie KJ, **Fox GA**, Shutt LJ, Trudeau S, Shugart LR. Polyaromatic hydrocarbons: effects of NDA and Hepatic biomarkers in herring gulls. Poster, *SETAC 2001, Baltimore MD.*

G.A. Fox. Wildlife as sentinels of human health effects. Invited presentation, *2002 Carolinas SETAC Annual Meeting, NCSU, Raleigh NC* .

FMA McNabb, **GA Fox**, KA Grasman. Comparison of variables for evaluating pollutant effects on thyroid function in birds. Platform presentation *SETAC-2002, Salt Lake City, Utah*.

RD Maher, KA Grasman, **GA Fox**, FMA McNabb. The effects of polychlorinated biphenyls on free thyroxine (FT4) concentrations in herring gull plasma. Platform presentation *SETAC-2002, Salt Lake City, Utah.*

KA Grasman, **GA Fox**, D Bennie, Nonylphenol in livers of herring gull chicks from the Great Lakes and the Bay of Fundy. Poster presentation *SETAC-2002, Salt Lake City, Utah*.

KJ Fernie, DA Jeffrey, **GA Fox**. Snapping turtles in selected Canadian Areas of Concern: Clinical chemistry results for adult males. Poster presentation *SETAC-2002, Salt Lake City, Utah*.

G.A. Fox and A. McNabb. Do chemicals cause thyroid abnormalities in Great Lakes herring gulls. *Director General's Science Forum 2003*, *Ottawa*

G.Fox, L. Shutt, K. Fernie, S. Brown, A. McNabb and K. Grasman. Endocrine disruption in wildlife of the Great Lakes of North America, Past and present. Invited platform presentation: *International Symposium on Environmental Endocrine Disrupters 2003, in Sendai, Japan*

ET Lavoie, KA Grasman, **GA Fox**. Contaminant-associated alteration in lymphocyte proliferation in Herring Gulls, Caspian Terns, and Black-crowned Night Herons from the Great Lakes., Poster presentation, *SETAC-03, Austin, TX*

M.E. Reeves, K.A. Grasman, and **G.A. Fox**. Effects of persistent organic contaminants on the developing reproductive organs of fish-eating birds. Platform presentation*. VIIIth International Symposium on Avian Endocrinology, June 6-11, 2004, Scottsdale, AZ*

F.M.A. McNabb and **G.A. Fox**. Thyroid disruption in Herring Gulls from the Great Lakes: Then and now. Platform presentation. *VIIIth International Symposium on Avian Endocrinology*, *June 6-11, 2004, Scottsdale, AZ*

G.A. Fox, D.A. Jeffrey, F.M.A. McNabb, and K.A. Grasman. Health of adult herring gulls in the Lake Huron-Detroit River-Lake Erie Corridor in 2001. Platform presentation. *Central Canadian Symposium on Water Quality Research, February 14-15, 2005, Burlington, ON.*

K.J. Fernie, R.J. Letcher, **G.A. Fox** and D.A. Jeffrey. Changes in systemic and organ function of adult snapping turtles in Canadian Areas of Concern in the lower Great Lakes. Platform presentation.
Central Canadian Symposium on Water Quality Research, February 14-15, 2005, Burlington, ON.

G.A. Fox, L. Shutt, C. Hebert, K. Fernie, P. Martin, S. Brown, J. Sherry, M. McMaster, A. McNabb, K. Grasman, and W. Bowerman. Health of Wildlife of the Great Lakes, Past and Present. Invited platform presentation, Workgroup on Ecosystem Health's Conference: *Chemical Exposure and Effects in the Great Lakes Today, March 29-31, 2005, Chicago, IL,*

K. J. Fernie, R.J. Letcher, D.A. Jeffrey, S. de Solla, and G.A. Fox. Changes in organ function of snapping turtles associated with hydroxylated- and parent persistent organic pollutants. Invited platform presentation,
SETAC-05, Baltimore, MD

G.A. Fox, L. Shutt, C. Hebert, K. Fernie, P. Martin, S. Brown, J. Sherry, M. McMaster, A. McNabb, K. Grasman, W. Bowerman, and M. Lind. Health of Wildlife of the Great Lakes, Past and Present. Invited Expert Panelist. *Wingspread '97 Revisited – ATSDR's Great Lakes Human Health Effects Research Program Expert Panel Meeting, February 9-11, 2006, Atlanta, GA*

R. Lundberg, **G.A. Fox,** and P.M. Lind. Do EDCs Effect Bone Tissue in Great Lakes Herring Gulls? *Poster presentation, Annual meeting of Society of Toxicology, March 2006, San Diego, CA.*

Response:

The Technical Committee and the SARA Group thank Mr. Glen Fox for providing a thoughtful review of the Sudbury Ecological Risk Assessment (ERA). Any scientific peer review contributes to the improvement of a report or publication by ensuring scientific rigor and clarification of important points.

It is important to point out that the completion of the ERA does not mean the end of field studies in Sudbury. Vale Inco and Xstrata Nickel have committed to funding additional aquatic studies with the Freshwater Co-op Unit of Laurentian University and can be contacted for more details. Xstrata Nickel has developed a Biodiversity Plan for their site and is conducting biological inventories. The City of Greater Sudbury has initiated the Biodiversity Action Plan with support from both Vale Inco and Xstrata Nickel. This plan will cover a broad spectrum of activities in response to the results of the ERA. However, it is the opinion of both the SARA Group and Sudbury Soils Study Technical Committee that the results of the ERA provide sufficient information to allow risk management decisions and actions to proceed.

Please find below the SARA Group's responses to Mr. Fox's comments on the ERA. A summary of Mr. Fox's comments appear in italics, with responses immediately following each comment. We have not commented on the introductory pages of Mr. Fox's report, which outline the ERA process and other aspects of the Sudbury Soils Study.

Objective #1 Assessment (plant community):

COMMENT (Page 2): *Ideally, one would like to have an equal number (18) or twice as many reference sites as test sites.*

COMMENT (Page 2 and 11): *The techniques chosen, the execution, and the above conclusions based on the weight-of-evidence are appropriate. However, the strength of these conclusions hinges on the results from the reference sites…. The assessors should have gone further afield and selected a number of reference sites in an area with similar geological, botanical, and climatic conditions. This would have allowed the possibility of separating the effects of localized impacts of atmospheric deposition of metals from the confounding factors of declining levels of acid precipitation, climate change and other non-metal stressors.*

> **Response:** In the design of the ERA, the study team selected one reference site per transect of test sites, or one reference site per smelter site. This is considered an appropriate approach in standard ERA methodology. To have one reference site for each test site is unnecessary given the objectives of the plant community assessment. The results of the assessment determined that plant communities at each of the test sites were either moderately or significantly impacted by smelter emissions and other historical stressors. This provided sufficient information to inform risk managers, and has resulted in the development of a Biodiversity Action Plan for Greater Sudbury. It is very unlikely that information gathered from additional reference sites would change the study conclusions or the resulting risk management decisions.

For this ERA, the study team selected reference sites with similar geology, botanical and climatic conditions as the test sites. A detailed description of these reference sites – in terms of soil chemistry and vegetation community – turned out to be a significant contribution of the ERA. Going further afield would only have decreased the similarity between the reference and test sites. From the onset of the ERA, we recognized that the Sudbury ecosystem was in a state of transition due to influences such as reduced smelter emissions (ie. chemical deposition from precipitation), and climate change. However, it was not the goal of the ERA to define and quantify these variables.

We remain confident that the ERA achieved the necessary results for Objective #1, which will support risk managers in their future recovery efforts. These sites may also be used for further studies, by researchers at Laurentian University or the City of Greater Sudbury, which may contribute to addressing questions that were outside the scope of the ERA.

Comments on Objectives #2 and 3 (wildlife assessment):

COMMENT (Page 10): Assessment Endpoints – *A more appropriate assessment endpoint for terrestrial wildlife would have been "adequate survival and reproduction to maintain a stable population".*

Response: The SARA Group agrees that stating the assessment endpoint as indicated by Mr. Fox would be more specific. The assessment endpoint used in the ERA was "population persistence", which includes consideration of survival and reproduction to maintain the population. Toxicity Reference Values (TRVs) used in the ERA were based on survival, growth and reproduction endpoints. However, regardless of the terminology used to express the endpoint, the analysis (and result) would be the same.

COMMENT (Page 12): Endangered Species –*The SARA Group "did not consider sublethal effects" on endangered species.*

Response: Sub-lethal effects were considered in the analyses for endangered species. The TRVs chosen to assess endangered species were *no-observed-adverse-effect levels* (NOAELs) for survival, growth and/or reproduction, as data were available and appropriate. The TRVs for endangered species were lower, therefore more protective, than TRVs used for non-endangered wildlife species. This is standard ERA methodology. For more details, please refer to Section 4.2.1 of the ERA technical report.

The ERA considered the "direct effect" of chemicals on wildlife studied. Both "direct effect" and "indirect effect" are defined in the glossary, which can be found in the full technical report, as well as the Summary Report. Direct effect refers to effects caused by the toxic action of a chemical on the animal itself. By comparison, an effect on the animal's habitat would be an indirect effect.

COMMENT: Exposure Assessment –*The exposure assessment is the most critical and the only site- and VEC-specific component of the risk assessment* ***(page 12)****.The validity of the exposure model* *assumptions for wildlife is questioned **(Table on page 13/14).** Of the 25 dietary "items" used in the risk assessment, 80% were estimated.*

Response: Sampling of the diverse diets of all valued ecosystem components (VECs) from across the study area is neither necessary nor feasible in adequately assessing risk for this ERA. Where no site-specific data are available, it is standard practice in ERA to use models available in the scientific literature to estimate uptake of chemicals into wildlife dietary items. These scientific models were used in combination with the available site-specific data (see Chapter 4 for details). To account for the variation in uptake of metals into plants, the ERA used a "probabilistic" approach in the exposure model. Please see Section 4.4.5.3 for a discussion of this topic.

Using a probabilistic approach is intended to incorporate the uncertainty and variability in the exposure assessment, as noted by the reviewer in his report (page 12). Mr. Fox states: "*Overall, the likelihood of toxicity was addressed by application of a probabilistic risk assessment. Thus, it is here that an overall assessment of the ERA methodology is considered appropriate."*

Lending further scientific support to this ERA approach, the Independent Expert Review Panel (IERP) stated the following in its professional peer review (Page 20): "the approach for the wildlife exposure modelling reflected the current state-of-the-science and standard practice; use of the ORNL [Oak Ridge National Laboratory] model was justified." The IERP report went on to say: "The Panel recognized that there are shortcomings to the current approaches, and complimented the authors for acknowledging these in their discussion of uncertainties."

COMMENT: Risk Characterization – *The standard ERA approach of using models to assess risk was criticized **(page 14-15 of review)**. Mr. Fox recommends **(page 16)** determining whether a) local exposure to any COCs is likely to result in toxicity b) breeding populations and/or species diversity are reduced on test sites relative to reference sites, and c) measurements of metals in target tissues approach or exceed concentrations associated with sublethal or lethal toxicity.*

Response: The first recommendation "to determine whether local exposure to COCs is likely to result in toxicity" was completed in the ERA. The standard ERA approach for wildlife uses scientific models to estimate risk. Models are developed to be conservative (to over-estimate, and not under-estimate, risk). Long-term sublethal effects (e.g., growth, reproduction) were inherently addressed (see Section 4.2.1) in selection of the TRVs which are used as the basis for risk characterization. Therefore, if a risk assessment model shows that there is no unacceptable risk, then no further assessment is warranted. The results of the ERA modelling suggest no further assessment is needed for terrestrial wildlife related to direct exposure to metals.

The IERP panel noted (page 25): "the approach for estimating exposure ratios and resulting risks used current and commonly accepted approaches."

Regarding the second recommendation (comparison of breeding populations and/or species diversity at test sites relative to reference sites), Mr. Fox acknowledges that "*terrestrial wildlife populations and communities are dynamic and diverse; the effect on distributions of many species in response to climate change and habitat fragmentation is unknown. Local, smelter-associated effects are superimposed over these more global effects and observational methods and do not allow us to separate local and global effects."*

The test and reference sites chosen for the ERA were based on the plant community and would not be appropriate, or of sufficient size, for evaluation of wildlife populations.

Wildlife populations vary dramatically over years, as a result of natural influences. Therefore, an evaluation of the reduction in species diversity or breeding populations must take these variables into account. If population studies were conducted, a multi-year study would be required. Studies of this type are outside the scope of most ERAs. The Technical Committee requested a focused ERA completed over a relatively short time-frame so that risk management and recovery measures could be implemented in a timely manner.

Field studies conducted by other researchers suggest that habitat suitability has a significant influence on wildlife populations. The ERA in Section 4.2.2.1 summarizes the ongoing research of Professor Robitaille at Laurentian University. His work shows that small mammals are present in Sudbury where habitat is suitable. Therefore, a survey of small mammals may not provide sufficient information to conclude whether animals are absent due to metals in the environment, or lack of suitable habitat. This issue was discussed in Sections 4.6 and 6.1.2. Information available specific to other VECs is provided in Section 4.2.2.3. Section 6.1.4 discusses how remediation to address impacts to the plant community will also affect wildlife and recommends that wildlife habitat suitability be considered during remediation planning for plant communities. Monitoring wildlife response to changes in the plant communities resulting from risk management measures could be considered as part of the remediation plan for Sudbury.

Regarding the third recommendation, (measurement of metals in appropriate target tissues of valued ecosystem components): tissue sampling data could be used to address exposure to and effects of some chemicals in some animals. However, based on site-specific factors (e.g., the COCs in Sudbury), and the results of the risk assessment modelling, sampling of wildlife tissues is not considered necessary. This conclusion is based on the following:

1. The Canadian Council of Ministers of the Environment (CCME) offers Tissue Residue Guidelines (TRGs) only for concentrations of chemicals in dietary items, to protect wildlife consumers. There are no TRGs for wildlife tissues that are protective of the sampled organisms.
2. The US EPA (2007) *Framework for Metals Risk Assessment* acknowledges, in Section 6.3.6, that "Toxicity in wildlife from metals exposures is generally poorly understood and is *rarely quantified in field settings*."

3. There are few data relating contaminant concentrations in tissues to an adverse effect on survival or reproduction. The exceptions include Lead (Pb) in liver, Cadmium (Cd) in kidney, Mercury (Hg) in brains, and Selenium (Se) in eggs. (US EPA, 2007). However, due to the many shortcomings of the tissue residue approach, "this approach, although conceptually sound, requires significant research before risk assessors will find it useful." (US EPA, 2007)
4. Sampling of some tissues requires killing the organism, which is not desirable.
5. Mr. Fox suggests that tissue sampling should be done for Cd and Pb analysis. However, neither substance is a significant COC in Sudbury for the ERA (the smelters in Sudbury are copper and nickel, not lead). Cadmium concentrations in soil exceeded background concentrations by a marginal amount (most were <1.5x background).
6. Mr. Fox suggests that tissue sampling should be done for deer and moose. The predicted risks for moose and deer are so low (mostly a 0% probability of exceeding a TRV) that there is no reason to suspect adverse effects in these species.
7. Mr. Fox suggests that tissue sampling should be done for Nickel (Ni) in muskrat. However, as Outridge and Scheuhammer (1993) state, it is difficult to interpret tissue concentrations because "knowledge of the metabolically essential, or normal "base-line" concentrations of Ni is lacking; hence, the biological and toxicological significance of specific tissue concentrations is usually unclear." The researchers describe the literature in this area, and state: "In studies that specifically compared mammals in polluted and unpolluted habitats, similar Ni levels were almost always found in both groups (e.g., mink and otter near Sudbury, Ontario; Wren et al., 1988)." They also conclude that "in several instances" (3 studies are cited), "animals in contaminated areas had lower Ni body burdens than those in unpolluted habitats, despite elevated Ni concentrations in the soils and in plants growing in the area." This paper goes on to state that "Hillis and Parker (1993) observed that beaver livers and kidneys showed an increase in concentrations of Ni and Pb ... / ... with increasing proximity to the smelters in Sudbury. Nevertheless, concentrations were rather low (<3 ug/g DW), even in samples from the zones of highest contamination." One reason Outridge and Scheuhammer (1993) suggest for the low concentrations of Ni in internal organs was that animals can regulate Ni within a certain range of ingested doses. These researchers conclude that "tissue concentrations of Ni were not reliable indicators of potential toxicity in either mammals or birds."
8. Tissue sampling cannot be used to evaluate the uptake models used in the ERA, because the uptake models (e.g., soil to small mammal) do not predict concentrations in particular tissues.

The combination of these concerns suggests that sampling of tissues would not contribute conclusive information to the risk assessment analysis or risk management decision-making.

COMMENT: *The use of existing field data for "ground-truthing" was criticized* ***(page 18).***

Response: Mr. Fox suggests that the ERA "ground-truthed" the modelling results using available field data. The ERA does not make this claim. It is standard ERA practice to include any relevant field data results (collected as part of the ERA study, or available from other studies) in the Effects Assessment part of the ERA. This data is combined with the results of the modelling (in the Risk Characterization) to make a statement on potential risks. Again, this is a standard ERA approach.

COMMENT: *The effect of the exposure to a combination of COC may be of concern. The cumulative impact of exposure to multiple chemicals and habitat quality plus potential frank or sublethal toxicity must be investigated* ***(page 3 Summary).***

Most of the COC in the Sudbury ERA have different modes of toxic action and different target organs in the various wildlife species. Thus, the modeling approach and comparison of exposure to individual TRVs used in the ERA is the most effective method available in the science of risk assessment.

The laboratory toxicity studies conducted to address Objective #1 on plants and earthworms used site soil, which explicitly addresses the issue of multiple COC in the soil (as well as low pH and other factors). However, as evidenced in these studies, the process of quantifying the relative influence of each individual metal is limited by the current scientific knowledge of cumulative effects.

Qualitatively, the ERA did consider habitat quality relative to wildlife populations. The results of the study find that habitat quality is very likely affecting some species of wildlife, in some areas. Therefore, it is prudent to address habitat quality first, which will also (indirectly or directly), enhance certain wildlife populations.

Objective 4. Aquatic Problem Formulation

COMMENT (Page 16): *No evidence of acceptable risks for arsenic, cobalt, copper, lead or nickel.*

Response: This seems to be a typographical error. As discussed in the ERA, there is no evidence of unacceptable risks for these COCs. Please refer to Section 5.16 of the ERA (Tables 5.23 to 5.26) for a summary of the results.

COMMENT (Page 16): *The assessors had low confidence in the results of the modeling of exposure to selenium and therefore elected to ignore these findings.*

Response: The ERA does acknowledge the data gaps with respect to selenium. The ERA lists the uncertainties and data gaps that should be addressed before a comprehensive aquatic ERA can be completed (see ERA Section 5.17).

COMMENT (Page 17): *"The assessors concluded that, given the extensive aquatic research and monitoring studies that have been conducted in the study area during the past two decades, no detailed aquatic ecological risk assessment is planned at this time.".*

Response: Although no aquatic ERA was planned for Sudbury, the report highlights how the available research may be used in a future aquatic ERA. The ERA report states:

"The goals of any future ERA for aquatic life should determine the scope of the assessment. These will also assist with the delineation of the study area for the aquatic ERA. The numerous studies and long-term monitoring programs conducted by researchers in the Sudbury area will provide important ecological data that may be integrated into the detailed aquatic ERA. These studies have linked lake water pH to species abundance and community composition, dealing with fish, invertebrates, plants, and algae. The results from these programs can be used to help focus research efforts by illustrating the long-term trends in monitoring data, identifying which lakes have been significantly affected by acidification and/or metals, and which lakes may be disregarded from further research."

COMMENT (Page 17): Objective 4 Assessment – *The ERA is incomplete without an assessment of the aquatic ecosystem.*

Response: As stated in the Introduction to the Aquatic Problem Formulation, "The focus of the Sudbury Soils Study is the elevated level of metals in soil and their associated terrestrial ecological risks. The Technical Committee agreed that the emphasis of the ERA was the terrestrial environment." The ERA fulfilled the scope as identified by the Sudbury Soils Study Technical Committee.

COMMENT (Page 17): Objective 4 Recommendations – *Mr. Fox recommended a number of studies to fill data gaps.*

Response: The recommendations of Mr. Fox are consistent with the SARA Group's recommendations (as listed in Section 5.17 of the ERA report). The SARA Group had a few additional (or more detailed) recommendations (e.g., collection of background sediment chemistry data) as well.

Conclusion

The SARA Group acknowledges the comments contained in the detailed *Evaluation of the Sudbury ERA* as provided by Mr. Glen Fox. We appreciate the time spent reviewing this complex scientific report, and we are pleased to include this review as part of an Appendix (Public Comments) to the final ERA report.

Many of Mr. Fox's suggestions for additional studies have merit. However, it is important to note that, even with further studies, we do not believe the results or conclusions of the ERA would differ. More importantly, risk management activities are being developed in response to the ERA results. This is the cornerstone of a risk assessment, and it is gratifying to know that follow up actions are being implemented. We do recognize that many of the comments are of scientific interest and could be investigated further either as part of the Biodiversity Action Plan, or in future studies by university or government researchers.

References

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US EPA 2007. Framework for Metals Risk Assessment. EPA 120/R-07/001. March 2007. Available on-line at http://www.epa.gov/raf/metalsframework/pdfs/metals-risk-assessment-final.pdf

Outridge PM and AM Scheuhammer (1993) Bioaccumulation and toxicity of nickel: implications for wild mammals and birds. Environ. Rev. 1:172-197.

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period

(April 3 to Sept 4, 2009)

Comment: 4
Submission Date: September 3, 2009
Name: Naomi Grant
City: Sudbury, ON
Affiliation: Coalition for a Liveable Sudbury

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

Sudbury Soils Study Ecological Risk Assessment Report
Public comment submitted by Coalition for a Liveable Sudbury

The ERA's goals to characterize current and future risks of COCs to terrestrial and aquatic ecosystems, and to provide information that will support the recovery of regionally representative, self-sustaining ecosystems are very important ones. During the ERA and the Sudbury Soils Study in general, a good deal of valuable information has been collected to further these goals. There are also significant gaps that still need to be addressed. To effectively support and monitor the recovery of self-sustaining ecosystems, the importance of systematic data collection and analysis cannot be over-emphasized. With the ongoing research at Laurentian University and the FreshWater Co-operative, this should be very achievable. However, to be most effective, there must be clear responsibility to keep track of relevant data, address any gaps, and maintain consistency between recovery efforts and current findings.

Terrestrial Plant Communities

Despite a small number of control sites (which should be remedied with further study), this section provided strong evidence of the continued impact of COCs and related factors such as acidity, erosion and lack of organic material on terrestrial vegetation and plant communities, as well as the mitigating effects of regreening efforts. It also provided practical tools and information to assess the level of impact at a site, and to guide management and recovery.

Terrestrial Wildlife Populations and Communities

In this section, a risk assessment was carried out to evaluate risks to terrestrial wildlife populations and communities due to COCs. The value of a risk assessment is dependent on the validity of its underlying assumptions, as well as the quality of the input data. As acknowledged in the report, the results of this risk assessment were seriously weakened by limited relevant data, poorly understood variability and/or high uncertainty of data, simplified assumptions, and limited data for interpreting risk.

Whether or not wildlife populations are directly affected by COC toxicity, remediating habitat quality can only benefit wildlife, and is a key part of the protection of native wildlife. However, there can be no true assessment of either the present effect of COCs on wildlife or future changes in populations without good base-line data. It is important to collect and monitor data on representative species in an organized fashion, and to check recovery efforts against this data. This data should include population estimates, survival, growth, reproductive success, and levels of COC in tissue and/or blood samples.

Aquatic and Wetland Environments

This section provides a good review of the current knowledge base. It is clear that lakes, at least some aquatic wildlife, and likely wetlands continue to be impacted by COCs. It is also clear that there are important gaps in what is known. It is therefore of concern that no concrete follow-up appears to be planned, either as part of the Sudbury Soils Study, or as part of the Biodiversity Action Plan.
Again, it is important to collect and monitor data in an organized fashion complementary with recovery efforts. Although terrestrial revegetation along watersheds can reasonably be assumed to improve aquatic health, aquatic ecosystems have unique features and importance that must be taken into account in recovery efforts. In addition, the storage of COCs in some sediments could potentially lead to the release of high levels of COCs of risk to human health, wildlife and ecosystems in the event of significant disturbances to lake bottoms or reductions in lake water levels. This must be clearly addressed in any management plan.

Public Engagement

The Sudbury Soils Study has made many efforts to present the ERA to the public, and make it accessible to public comments and questions. Never-the-less, in public discussions and feedback from citizens, it is clear that overall people have not felt included in the process. There is great difficulty in understanding the information presented, and many people have the perception that scientific language is used as a barrier. It can be difficult to present the results of a complex study in a way that is both meaningful and easy to understand. However, communication can be improved in a number of ways: going out to the community in trusted forums that support frank discussion (rather than inviting the public to large, central presentations); making the effort needed for the general public to understand the key methods and findings (rather than giving the impression that they just have to trust the experts); using clear visuals, especially clear maps and models of the study area; being clear and direct about any weaknesses or uncertainties in the findings.

Response:

Thank you very much for your continued interest in the Sudbury Soils Study and comments provided on the Ecological Risk Assessment ERA). We have provided responses to your comments below. Both your comments and these responses will form an appendix to the ERA and will become publicly available.

The original comments are in italics below, followed by the response in plain text.

The ERA's goals to characterize current and future risks of COCs to terrestrial and aquatic ecosystems, and to provide information that will support the recovery of regionally representative, self-sustaining ecosystems are very important ones. During the ERA and the Sudbury Soils Study in general, a good deal of valuable information has been collected to further these goals. There are also significant gaps that still need to be addressed. To effectively support and monitor the recovery of self-sustaining ecosystems, the importance of systematic data collection and analysis cannot be over-emphasized. With the ongoing research at Laurentian University and the FreshWater Co-operative, this should be very achievable. However, to be most effective, there must be clear responsibility to keep track of relevant data, address any gaps, and maintain consistency between recovery efforts and current findings.

We agree that it is important to support and monitor the recovery of self-sustaining ecosystems in a systematic manner. In response to the ERA, Vale Inco and Xstrata Nickel have committed to funding additional aquatic studies with the Freshwater Co-op Unit of Laurentian University. In addition, the City of Greater Sudbury has initiated the Biodiversity Action Plan with support of both Vale Inco and Xstrata Nickel, which covers a wide spectrum of activities. These activities will include monitoring, data collection as well as implementation of re-greening initiatives. Please refer to the Biodiversity Action Plan (www.greatersudbury.ca/biodiversity) for details.

Terrestrial Plant Communities

Despite a small number of control sites (which should be remedied with further study), this section provided strong evidence of the continued impact of COCs and related factors such as acidity, erosion and lack of organic material on terrestrial vegetation and plant communities, as well as the mitigating effects of regreening efforts. It also provided practical tools and information to assess the level of impact at a site, and to guide management and recovery.

No reply required.

Terrestrial Wildlife Populations and Communities

In this section, a risk assessment was carried out to evaluate risks to terrestrial wildlife populations and communities due to COCs. The value of a risk assessment is dependent on the validity of its underlying assumptions, as well as the quality of the input data. As acknowledged in the report, the results of this risk assessment were seriously weakened by limited relevant data, poorly understood variability and/or high uncertainty of data, simplified assumptions, and limited data for interpreting risk.

Whether or not wildlife populations are directly affected by COC toxicity, remediating habitat quality can only benefit wildlife, and is a key part of the protection of native wildlife. However, there can be no true assessment of either the present effect of COCs on wildlife or future changes in populations without good base-line data. It is important to collect and monitor data on representative species in an organized fashion, and to check recovery efforts against this data. This data should include population estimates, survival, growth, reproductive success, and levels of COC in tissue and/or blood samples.

It is standard practice in risk assessment to identify uncertainties and data gaps in the study and to evaluate the impact of these uncertainties on the overall risk estimate. The report does not say that the uncertainties weaken the conclusions or results. The uncertainties are discussed in Section 4.4 of the ERA. In some instances, data with medium or high uncertainty may not have a significant influence on risk estimates (e.g., surface water concentrations, related to wildlife exposures). The risk assessment was conducted to over-estimate, not under-estimate, risk (that is, to be protective of wildlife). A risk assessment is designed to be able to make conclusions and recommendations in the face of uncertainty. Any outstanding issues that would contribute to successful remediation can be considered during the remediation phases of future work.

Baseline data regarding wildlife populations could be collected as part of future initiatives to monitor population response to habitat rehabilitation activities. However, wildlife populations are dynamic and respond to many natural and man-made factors. It also is difficult to separate the influences of these various factors (e.g., is an organism absent due to toxic effects of COCs, from the lack of habitat, or due to over-predation?). Population studies require significant time and resources and the results are often difficult to explain or attribute to specific factors. For these reasons population studies are not routinely part of a risk assessment. Monitoring populations after habitat is created or restored could be useful; Dr. Robitaille at Laurentian University has shown that small mammals are present in Sudbury where habitat is suitable.

It is possible to measure COC levels in tissues and/or blood of wildlife, however, there are many practical constraints to conducting such studies and obtaining meaningful results. In most cases the animal needs to be sacrificed to collect a sufficient sample to measure. There are ethical issues to consider for this type of study. Tissues can be collected from hunters or trappers on animals that have already been killed for another reason. This involves coordination of sample collection and excellent control of sample handling and preparation and understanding of where the animal came from. Lastly, and perhaps most importantly, it is necessary to attach meaningful interpretation to the results. There are very limited data on the biological significance of a certain metal level in a tissue of a wild animal. Many of the COC (ie. copper, nickel, selenium, cobalt) are also essential elements meaning that all animals require these in trace amounts. The concentration of these elements will vary naturally in animals from different geological regions unrelated to smelter emissions or other human sources.

The primary goal of a risk assessment is to provide information on which risk management decisions can be made. The collection of tissue or blood COC level data generally will not provide sufficient rationale to provide a basis for risk management, and are better suited to long term monitoring or scientific studies.

Aquatic and Wetland Environments

This section provides a good review of the current knowledge base. It is clear that lakes, at least some aquatic wildlife, and likely wetlands continue to be impacted by COCs. It is also clear that there are important gaps in what is known. It is therefore of concern that no concrete follow-up appears to be planned, either as part of the Sudbury Soils Study, or as part of the Biodiversity Action Plan. Again, it is important to collect and monitor data in an organized fashion complementary with recovery efforts. Although terrestrial revegetation along watersheds can reasonably be assumed to improve aquatic health, aquatic ecosystems have unique features and importance that must be taken into account in recovery efforts. In addition, the storage of COCs in some sediments could potentially lead to the release of high levels of COCs of risk to human health, wildlife and ecosystems in the event of significant disturbances to lake bottoms or reductions in lake water levels. This must be clearly addressed in any management plan.

As mentioned above, Vale Inco and Xstrata Nickel have committed to funding additional aquatic studies with the Freshwater Co-op Unit of Laurentian University. Also, the Ontario Ministry of the Environment and other researchers at Laurentian University, and other universities will continue to study the aquatic environment around Sudbury. The results of these studies may also fall under the umbrella of the Biodiversity Action Plan.

Public Engagement

The Sudbury Soils Study has made many efforts to present the ERA to the public, and make it accessible to public comments and questions. Never-the-less, in public discussions and feedback from citizens, it is clear that overall people have not felt included in the process. There is great difficulty in understanding the information presented, and many people have the perception that scientific language is used as a barrier. It can be difficult to present the results of a complex study in a way that is both meaningful and easy to understand. However, communication can be improved in a number of ways: going out to the community in trusted forums that support frank discussion (rather than inviting the public to large, central presentations); making the effort needed for the general public to understand the key methods and findings (rather than giving the impression that they just have to trust the experts); using clear visuals, especially clear maps and models of the study area; being clear and direct about any weaknesses or uncertainties in the findings.

Thank you for acknowledging that significant efforts were made to present the results of the ERA to the public and to make the study process available for comment and review. One of the key roles of the Public Advisory Committee (PAC) was to review key messages and material that was to be disseminated to the public to help ensure that it was understandable and not full of scientific jargon. The PAC spent considerable time and effort in this task. In addition a Communications Subcommittee was also involved to help the SARA Group and Technical Committee. The large scientific technical reports (both ERA and HHRA) were summarized in two “reader friendly” Summary Reports to boil down the key methods and results into a shortened version. The study results were also presented in 3-4 page *Update* Newsletters.

Despite these efforts we recognize lingering concerns with the public engagement process. Although the Sudbury Soils Study is now officially complete, the City of Greater Sudbury and the mining companies have initiated the Biodiversity Action Plan in response to the ERA results. The leaders of the Biodiversity Action Plan were also involved with the Sudbury Soils Study and listened to the concerns with the public consultation process. In response, the approach used to engage the public for the Biodiversity Action Plan did involve smaller focus groups, workshops and site tours.

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period
(April 3 to Sept 4, 2009)

Comment: 5
Submission Date: September 3, 2009
Name: Moira Ferguson
City: Sudbury, ON
Affiliation:

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

Dear committee,

I am not satisfied with the results of the testing so far nor am I satisfied with the cost. Where is this fifteen dollars coming from? It seems to me that the students in the ecology labs at Laurentian University have the expertise and the skills to perform many of these tests and I am sure that city residents would be more than happy to provide hair samples as well as soil samples from their gardens. I am so tired of the decision makers in this city assuming they can bamboozle us with needlessly complicated results and, even more insulting, theoretical models, when live samples are abundantly available. Animals will "crawl away and die", therefore the results would be confounded? Come on, get a grip. I want meaningful, cost-effective results and I will assist in this process to the limits of my ability. Fire the present members of the research team (but not the excellent and hard working Sudbury Soils Committee, which likely did not benefit much from the Fifteen Million) and ask local scientists and local methodologists, such as Oracle research, to perform the tests. People within this community have a vested interest in honest results.

Thank you,
Moira Ferguson

Response:

Thank you for your interest in the Sudbury Soils Study and comments provided regarding the Ecological Risk Assessment (ERA) received on September 3, 2009. Your comments are provided below along with a response from the Technical Committee members and the SARA Group. This comment and its response will be included as an appendix to the final ERA report and will become part of the public record.

The Ecological Risk Assessment (ERA) was performed as a means to further our understanding of the impacts of mining activity on Sudbury soils, and its potential effects on plant and wildlife populations in the Greater Sudbury Area. The results have revealed some very important information that will now be used to improve the recovery process and increase biodiversity in the affected areas.

The entire cost of the Sudbury Soils Study was funded by the two mining companies, Vale Inco and Xstrata Nickel. As such, all work was completed without the use of public funds. A number of Laurentian University faculty members received funding to conduct some of the sampling and analyses included in the study. However, due to the nature and complexity of the study, students were generally not directly involved.

As part of the study, soil samples were collected from many residential properties in the City of Greater Sudbury and surrounding communities, on a volunteer basis. We appreciate the participation of all local residents who offered support for the study.

The issue of sampling human tissues is not relevant to the ERA, since this was a study of plant and wildlife populations.

The Sudbury Soils Study is officially over and the involvement of the various committees and research groups is complete. The results of the ERA are now being used to enhance the recovery of the local environment. Later this year, the City of Greater Sudbury is releasing a Biodiversity Action Plan that will help coordinate ongoing and new initiatives in the area related to re-greening, future wildlife and vegetation studies and many other projects. This work is largely being funded by the two mining companies but will be administered and managed by the City. Members of the public, and researchers at local educational institutions, are being encouraged to participate. For more information on the Biodiversity Action Plan, please visit www.greatersudbury.ca\biodiversity. Additional studies related to the ERA are being sponsored directly by the mining companies.

Sudbury Soils Study:
Ecological Risk Assessment Public Comment Period
(April 3 to Sept 4, 2009)

Comment: 6
Submission Date: September 4, 2009
Name: Brennain Lloyd Roger
City: Sudbury, ON
Affiliation: Northwatch

Comment regarding the Sudbury Soils Study Ecological Risk Assessment:

Sudbury Soils Study Technical Committee
c/o Dr. Christopher Wren
Sudbury Area Risk Assessment Group
512 Woolwich St. Suite 2
Guelph, ON N1H 3X7

Dear Members of the Technical Committee:

Re. Northwatch Comment on the Ecological Risk Assessment Report Sudbury Area Risk Assessment, Sudbury Soils Study

We are pleased to provide our comments on the Ecological Risk Assessment Report for the Sudbury Soils Study, released by the Technical Committee on March 31st, 2009.

Northwatch is a regional coalition of environmental and social organizations in northeastern Ontario. Founded in 1988 with a mandate to promote the protection of the environment and the incorporation of environmental concerns into economic and social decision-making Northwatch's interests in the Sudbury Soils Study processes and outcomes include the use of risk assessment as part of the decision making process, the ability of the public to participate effectively in the various phases of the research and decision-making processes, the outcomes of the process relative to the protection of human health and the environment, and the options considered and selected for remediation. Northwatch has a similar interest in contaminated soils studies that have been conducted or are underway in Wawa, Cobalt and Virginia town following Ministry of the Environment sampling programs in those communities several years ago.

Our participation in the Sudbury Soils Study to date has included attendance at information centres and Pubic Advisory Committee meetings, and review of reports and materials that have been produced as part of the study process, including the Independent Process Observer's quarterly reports, SARA Group newsletters, study results including Volumes 1 and II and related summaries, and meeting reports and other materials made available through the Sudbury Soils Study web site. On November 1st, 2008 we provided comments to the Technical Committee on the Human Health Risk Assessment Report.

Since the release of the Ecological Risk Assessment in March, we have reviewed the Public Advisory Committee report, Independent Process Observers final report, SARA responses to comments on the Human Health Risk Assessment (HHRA), all of the summary documents, and several sections of Volume III and its many appendices. Due to the volume of material and the limited resources available to us, we have not yet completed our review at the time of this September 4th deadline for public comments. We will continue our review, and may provide supplementary comments at a later date.

Many of the concerns we expressed in our November 2008 submission on Volumes I and II of the Sudbury Soils study are outstanding, and also apply to Volume III, which reports on the ecological risk assessment. As noted above, we have carefully reviewed the response provided to our comments on the HHRA, but for the most part were unable to retire our key concerns.

Our concerns and comments can be grouped under five general categories:

- the findings and conclusions of the Sudbury Soils Study (Final Report, January 2008) raise questions about the basis for the subsequent Human Health Risk Assessment
- as with the Human Health Risk Assessment, we do not have confidence in the findings and conclusions of the Ecological Risk Assessment and hold the view that further work is required
- Volumes I, II and III are related, and there should be a final document prepared and presented that discusses the outcomes of the entire process, the relationships between the three main study areas, and presents the findings of the three study areas in relationship to each other and in relationship to “next steps” and the broader issues of public participation, decision-making, and the all-important questions of response and remediation
- the large volume of information to be reviewed and the highly technical nature of much of the material means that meaningful public involvement requires technical support
- the decision-making process that is to follow the Sudbury Soils Study process needs to developed, with clear opportunities and supports for public involvement and clarity around decision-making roles

As noted in the Sudbury Soils Study report Volume I, “risk assessments performed for different assessment purposes will use different methods”1. Further to our review of the Sudbury Soils Study Volume I we are left to question the purpose of this risk assessment process and the influence a given purpose will have on the selection of methods and approaches. In our view, the purpose of the Sudbury Soils Study should be to determine what action is required to protect human health and the environment in relation to soil contamination from mining and smelting in the Sudbury basin. The Ministry of the Environment has stated that the purpose is to “assess potential human health risks to residents related to exposure to arsenic and metals from soil, water, food, and air (and) potential risks to terrestrial and aquatic wildlife and ecosystem health of the Sudbury area from metals and arsenic in soils”2 According to these purposes, the approaches and methods should be conservative and protective, which would not include eliminating the most contaminated sample results and would not include opting for less protective standards.

Ecological Risk Assessment (Volume III, Final Report, March 2009)

For the sake of brevity, our comments are provided section-by-section in point form, as follows:

General

- throughout the document, the SARA group (and/or various authors) has argued the limitations of the Sudbury Soils Study so vigorously as to have effectively convinced the reader that it is neither comprehensive nor reliable; this may well be the case, leaving the reader - and the residents of the Sudbury basin - eager for news of when the real studies are going to be undertaken
- in various references the distinctions - or commonalities - between regreening, reclaiming, restoration, remediation are blurred; further, none of these terms are included in the glossary
- Ministry of the Environment Tables A, B and F are not included in the glossary, despite being referred to without explanation in the text of the reports; understanding these tables is important to being able to understand some sections of the report and the omission from the glossary is problematic

Chapter 1, Introduction

- many of Northwatch's concerns noted in our comments of November 2008 with respect to Volumes I and II of the Sudbury Study are outstanding and could be restated in comment on this section, ie the shortlisting of the Chemicals of Concern,
- we are concerned that the approach of defining and then responding to four objectives has resulted in an assessment that is too modular and compartmentalized, rather than cohesive and holistic
- the definition of what is an "acceptable" risk is key; this definition is not addressed and the residents of the Sudbury basin do not appear to have yet been engaged in making such a determination
- the decision to separate out the effects of SO2 emissions (ie exclude them from the evaluation of ecological risk) should not be listed as a "principal"(sic); while important to acknowledge this as the approach taken, it would be better described as a constraint or limit to the study, rather than as a principle of the study
- without the aquatic component, the ecological risk assessment is not, in fact, an ecological risk assessment; "ecological" studies can be generally defined as being studies of the interdependence of living organisms in an environment, and few environments - and certainly the environment of the Sudbury basin - can be described as being an environment without aquatic life systems; while we appreciate that the "problem formulation" of Chapter 5 "lays the foundation for future studies and monitoring", those studies and that monitoring are essential components of the ecological risk assessment that should have been done for this risk assessment

Chapter 2, Problem Formulation

- as with the HHRA, the description of the criteria used for selecting the Chemicals of Concern is confusing and contradictory, indicating in the first bullet quite categorically that the parameter must be above the levels in MOE Tables A or B, and then providing what we take to be a qualification in the following text, ie that Table F applies for soils with pH levels below 5.0
- as per our comments on the HHRA, we are not convinced that the the criteria applied to identify Contaminants of Concern is appropriate; in particular, we are concerned that application of the criteria that "the parameter must be present across the study area" means that some chemicals which are of concern in some but not all parts of the study area may have been excluded
- the selection of "presence" or "survival" as the endpoint for the Valued Ecosystem Components (VECs) is, in our view, overly blunt

Chapter 3 - Evaluating Objective # 1

- there is no executive summary for Chapter 3
- as per our comment under "General" about the lack of any definitions in the glossary ... the term "recovery" is also not defined; Section 3.1 is one of the sections that would benefit from a set of definition or a discussion of the terms recovery, re-greening, reclaiming, restoring, remediating, etc.
- the study identifies three variables / conditions that render the use of literature values as insufficient in addressing Objective # 1 of the Sudbury Soils Study (of evaluating the extent to which the chemicals of concern are preventing the recovery of regionally representative, self sustaining terrestrial plant communities), yet the Ecological Risk Assessment largely relies on the literature for values, in the absence of sufficient local information
- 18 test sites seems like a low number of test sites, given the extent of the impacted area and the variety of site conditions throughout that impacted area; we found no explanation or rationale for selecting 22 sites (i.e. versus a much larger number); we also question the placement of the sites, and the absence of any test sites in what could generally be described as the "common" area between the three stacks, i.e. within the area that is ringed by test sites CC-03, CC-01, CC-02, FB-05, FB-01, CON-05, CON-03, CON-06, CON-07, CON-08
- of even greater concern is the extremely low number of reference sites, and their placement; to have only three reference sites is questionable, to have all three reference sites in close proximity to the stacks is even more questionable, and to have selected test sites that are variously described as being "background level"3 or "near or below MOE Table "F" background level criteria"4 or "below the MOE 'Table F' background criteria levels"5 creates uncertainty about the quality of these sites and their suitability as reference sites; in our view, there should have been a much larger number of reference sites, from a larger cross-section of the same ecological site district[6]
- it's not clear whether the effort to find test sites with a pH between 4 and 5 means that all of the sites were between 4 and 5, of just some of them; if it is the former, then the suite of test sites could not be representative of the Sudbury environment unless all soils in the area were between 4 and 5, which they clearly are not; Tables 3.13 through 3.167 appear to indicate that only 3 of the 22 sites actually had pH between 4 and 5, so perhaps this is a case of poor writing rather than poor judgement
- the ERA incorrectly classifies the study area as boreal forest8; the southern portions of the Sudbury Forest9, which includes the study area, are Great Lakes St.Lawrence Forest, with the northern portions being in the transitional zone between the Great Lakes St. Lawrence and boreal forest regions; the Great Lakes St. Lawrence Forest is ecologically quite different from the boreal forest, and in generally more biologically diverse
- we were surprised to learn that two of the test sites were not accessible to the SARA group for data collection because they were on Vale Inco or Xstrata Nickel property10; this seems to be a limitation that should have been made entirely avoidable with communication and co-operation
- by appearances, we note that of the test sites for which a one description and picture were provided11, all but one were treed sites; the study area has a greater diversity of site conditions (including wetlands, fens, bogs, barrens, grasslands) and it is not clear why this diversity is not represented in the selection of test sites

- in our view, the conclusion that "the concentration of COC have in the paste impacted the plant communities, and are likely continuing to impede the recovery of a self-sustaining forest ecosystem in the Sudbury region"12 is an incredible understatement when contrasted to the actual findings13

Chapter 4 - Evaluating Objectives # 2 and #3

- a primary concern / question with respect to the exposure assessment is the degree to which estimates are based on real information about the study area versus extrapolations based on information from other sources or other locales and other conditions which may or may not be applicable or appropriate; while estimates for wildlife exposure are described as being based on actual measured values in the Sudbury area, several other estimates were "based on the literature because Sudbury-specific data were not available";14
- similarly, the ERA report describes the effects assessment as being largely based on literature reviews and data previously collected for other purposes, rather than data collected for the purpose of conducting a effects assessment for the Sudbury Soils Study Ecological Risk Assessment15
- overall, while extremely complex to read, the report creates an impression that repeated efforts were made to simplify the study and to approximate instead of actually estimate, rendering the validity of the study as questionable
- we note with interest that the meadow vole is the VEC that appears to be the most severely impacted16, and it is also the VEC with the smallest range and therefore the greatest exposure
- while the report contents might not irrefutably establish that there is ongoing harm from the Chemicals of Concern and their historic and continued release into the environment, nor does the report establish that this is not the case; as the saying goes "Absence of evidence is not evidence of absence"

Chapter 5 - Aquatic Problem Formulation

- the notion that lakes or rivers would be eliminated from a future aquatic ecological risk assessment17 because it had been impacted by mine effluent in addition to smelter emissions should be rejected; while we would agree that some effort should be made to determine which impacts are particular to or increased by the receipt of mine effluent, we strongly disagree that the receipt of mine effluent - presumably from the same mining operations that feed the smelters - would eliminate a lake or river from a future aquatic assessment
- this chapter is a cause of frustration, namely because it identifies numerous and significant gaps in data or information, and then comes to conclusions regardless of those gaps
- the shortlist of lakes that "may be considered for inclusion in a future aquatic ERA includes only five of the 300 lakes with the City of Greater Sudbury, representing only two watersheds; the rationale for including such a list could only be that it assisted the authors in completing a
- check-list of required items

Chapter 6 - Conclusions and Recommendations

- the term "risk management" is not defined in the Volume III glossary; as per our earlier comments about several other definitions not being in the glossary, this handicaps the reader - particularly those who do not work in this field on a professional basis - from fully understanding the author's meaning substituting the term "risk management" with a term such as remediation or restoration would provide a clearer and more positive understanding
- we appreciate the declaration in the second paragraph of this chapter that "this chapter is not intended to provide risk management strategies, or to definitively identify where risk management is required" but are of the view that the decision-making process and the decisionmaking body for these crucial next steps should be clearly identified, and they are not
- interestingly, the definition of what "recovery" does not mean is provided, but a definition of what recovery does mean is absent
- we agree with the summary that there are numerous sources of uncertainty in the risk models and information sets for both Objectives 2 and 318
- we agree with the study conclusion that ecosystem function has been and continues to remain impaired at many sites throughout the study area19
- while we agree that the degree to which a healthy ecosystem can be considered impaired can be determined by comparing its key structural and functional compoeenents and its processes to those of a healthy system, we are very strongly of the view that the comparisons must be done with a larger number of reference sites, and that at least the majority of reference sites must be more definitively outside the range of the same detrimental influences that have impaired the negatively impacted sites; in other words, there need to be more reference sites, and they need to be more broadly dispersed, presumably throughout eco site district 5E3
- the Volume III report in general, and Section 6 in particular, suffer from a lack of references; for example, the statement that "a self-sustaining system tends to be composed of 50 plant species or more" is extremely simplistic and potentially erroneous, but without a reference to place it in context and better understand the spatial scale etc. it is difficult to evaluate
- similarly to the previous comment, Table 6.5 lacks a reference, a spatial scale and geographic context
- we agree with the SARA group recommendations that risk management objectives be developed, and that stakeholders be consulted during the risk management process; we would further recommend that the engagement process include opportunities for members of the public and community organizations and agencies to engage at varying levels of detail and complexity, through a process which is iterative and inclusive
- we agree with the SARA group recommendation that the 22 sites established during the Objective 1 studies be retained for long-term monitoring studies; as per our earlier comments, additional reference sites should be added, and there should be consideration of the need for additional study sites, particularly for the aquatic ecoystems
- we agree with the SARA group recommendation that any future risk management related activities - including additional monitoring - include wildlife habitat; in addition, future work should look not just at the continued presence of a wildlife population, but also its vitality
- we agree with the ERA conclusion that "although there are uncertainties and limitations inherent in the data used for this ERA, it can be concluded that ecological receptors, particularly the plant community, continue to be at risk in the study area..."

Public Involvement and Decision-Making

In our submission of November 2008 on the Human Health Risk Assessment we provided comments on the public role and involvement in the Sudbury Soils Study up to that point in time. Those comments stand The following comments on what should follow the Sudbury Soils Study were first included in our November 2008 submission, and are being restated here, given their continued relevance and the lack of action in this sphere to date. .

> *In the first paragraph in the first volume of the first study we are told that the various studies "provide the basis for future decisions on the management of potential risks identified in the Sudbury study area"20, but in the thousands of pages that follow we find no discussion of that decision-making process, the opportunity for the public to be involved in that decision-making process, or the role and responsibilities of the Ministry of the Environment as the obvious decision-maker, given their regulatory responsibilities.*
>
> *While the following comments may not be deemed "relevant" to the review of the Ecological Risk Assessment by the Technical Committee, in our view there is a clear and pressing need for:*
>
> - *a clearly defined review exercise to follow the Sudbury Soils Study process*
> - *clear opportunities and supports for public involvement*
> - *clarity around decision-making roles with respect to requirements for future remediation and mitigation, and*
> - *confirmation by the Ministry of the Environment that they recognize their role as the lead decision-maker given their statutory responsibilities with respect to environmental protection, with the Ministries of Health and Labour, as well as federal agencies, also having certain responsibilities*
>
> *The Ministry of the Environment should now develop a proposed approach that addresses the above noted points, consult with the public and other decision-makers on its appropriateness, and provide a clear outline of the decision-making process(es) that is to follow the conclusion of the Sudbury Soils Study, taking into account the findings of the three volumes of the Sudbury Soils Study, public and other comments received in review of these studies, and other matters of related conerns.*

Our own recommendations for next steps are not inconsistent with the SARA group recommendations, which also identify a need for further work to develop risk management objectives and then strategies, and recommend stakeholder involvement. In addition, the next phase of investigation must involve more "real" data from the Sudbury area, and less extrapolations from the scientific literature and studies from other locations. Any exercise that relies on the use of models is by its nature going to be dealing with high levels of variables and uncertainties; using "real" data from relevant sources is essential if the results are to have any credibility or usefulness. In addition, the precautionary principle must be employed.

The precautionary principle21 directs that precautionary measures be taken, or an activity avoided, if the activity or a substance poses a threat to environmental or human health. The precautionary principle does not demand scientific certainty of the anticipated damage, but rather favours erring on the side of caution, and so on the side of health. In the case of the soils in the Sudbury basin that have been contaminated by a century of smelter emissions, this means not delaying any available action to reduce continued emissions and begin remediation of damages to date.

While we are disappointed that the public comment period for the ERA was wholly devoid of any presentations or workshops beyond the initial presentation on the release date, we are of the view that such activities would still be useful, and are essential in building a public understanding of the issues at hand and the decisions that are still to be made.

Conclusion

As indicated above, we agree with the Ecological Risk Assessment conclusion that "although there are uncertainties and limitations inherent in the data used for this ERA, it can be concluded that ecological receptors, particularly the plant community, continue to be at risk in the study area..." While we have many areas of disagreement with decisions taken or interpretations made throughout the study process, on this final and fundamental point we agree.

In closing, we remain committed to participating in future discussions with respect to the contamination of the Sudbury basin from mining operations, both ongoing and over the last century. . We look forward to receiving a response to these comments, and to future engagement with the Ministry of the Environment, as the responsible authority, with respect to next steps in reducing the release of contaminants from mining operations and remediating the harm from releases to date.

Sincerely,
Brennain Lloyd
Northwatch

Response:

Thank you very much for the comments submitted on behalf of Northwatch concerning the Sudbury Ecological Risk Assessment (ERA). We recognize the time and effort required to read the Technical Reports in order to provide meaningful comments. Responses are provided below to the Northwatch comments using the same order of subject matter as appeared in your submission.

Page 2, last paragraph, of submission

The approaches and methods used in both the HHRA and ERA were very conservative and considered protective of both human and ecological health. In no situation were the most contaminated samples eliminated, nor were less protective standards employed in either study.

General

It is standard risk assessment practice to identify uncertainties with the data and available information. Any study will have uncertainties but they are rarely documented as part of the study report. It is important in risk assessment to acknowledge uncertainties and evaluate the impact that these uncertainties could have on the overall risk estimate. This was done in the ERA. The risk assessment was conducted to over-estimate, not under-estimate, risk (that is, to be protective). A risk assessment is designed to be able to make conclusions and recommendations in the face of uncertainty. Readers not used to reviewing a list of uncertainties in a report may reasonably conclude that they represent limitations. However, any outstanding issues that should be addressed could be considered during risk management, which in the case of the ERA is the Biodiversity Action Plan being developed by the City of Greater Sudbury and supported by the two mining companies, Vale Inco and Xstrata Nickel, as well as additional studies related to the ERA are being sponsored directly by the mining companies.

We agree that it would have been helpful to define the terms re-greening, reclamation, risk management, restoration and remediation in the ERA because these terms are not always used in the same way. For our purposes, we define these terms as follows:

- Re-greening – activities such as application of lime and fertilizer, and active planting, to promote the growth of plants. The main difference between re-greening and restoration is that re-greening may not result in a natural, self-sustaining ecosystem.
- Reclamation – synonymous with restoration
- Risk Management – analogous to “risk-based decision-making” which is defined in the glossary. Risk management may be a generic term referring to any action taken to reduce risk (e.g., methods used to decrease chemical concentrations in the environment [such as soil removal] and methods used to eliminate exposure pathways [such as paving]). In some jurisdictions, risk management only refers to methods used to eliminate exposure pathways. Actions taken to remove sources of chemicals are referred to as remedial actions or remediation.
- Restoration – actions taken to make the environment whole. Restoration goes beyond remediation to include activities such as restocking, habitat rehabilitation, etc. (Suter, 2007[1])
- Recovery – the extent of return of a population, community or ecosystem process to a condition with valued properties of a previous state (Suter, 2007)
- Remediation – Actions taken to reduce risks from contamination, including removal or treatment. In some jurisdictions, remediation refers only to methods used to decrease contaminant concentrations (e.g., soil removal) whereas risk management refers to the placement of physical barriers to decrease or remove exposure (e.g., land use restrictions, fencing, paving)

Ministry of the Environment (MOE) Tables A, B and F are available on the MOE web site. Currently, Tables A, B and F have been replaced by Tables 2, 3 and 1, respectively. The Table 2, 3 and 1 standards may be found at: http://www.ene.gov.on.ca/envision/gp/4697e.pdf The explanation that the values are the same can be found at http://www.ene.gov.on.ca/envision/gp/4706e.htm.

[1] Suter, G.W. II. 2007. Ecological Risk Assessment. Second Edition. CRC Press. Boca Raton, FL.

Chapter 1 – Introduction

The approach of responding to the four study objectives was considered a clear and logical approach to preparing the report. Different methods were used to assess the different study Objectives which covered different ecological receptors. Chapter 6 of the ERA tries to bring the information together.

The definition of "acceptable" risk is perhaps not clearly provided in the report. For Objective #1 any impact to the natural vegetation was documented and those impacted communities were considered to be "at risk" from future natural recovery. For the wildlife assessment, "acceptable risk" is inherently included in the assessment endpoints and Toxicity Reference Values (TRVs) used in the study approach which are intended to be protective of wildlife populations.

The effects of SO_2 emissions were clearly considered in Objective 1 of the ERA in that impacts to the vegetation were likely due to historical SO_2 emissions in combination with other stressors. Current levels of SO_2 emissions are not considered to likely impact natural vegetation.

Aquatic and terrestrial ecological risk assessments are frequently conducted separately, due to the requirement for different types of data. Not conducting an aquatic ERA does not negate the results of the terrestrial ERA. The focus of the Sudbury Soils Study was the elevated level of metals in soil and their associated terrestrial ecological risks. The Technical Committee agreed that the emphasis of the ERA was the terrestrial environment. The ERA completed by the SARA Group fulfilled the scope as identified by the Sudbury Soils Study Technical Committee.

In recognition of the importance of the aquatic environment in the Sudbury area, and in response to the ERA, the two mining companies have committed to continue supporting research and monitoring activities at the Freshwater Co-op Unit at Laurentian University.

Chapter 2 – Problem Formulation

The COCs were selected using Table A or B. The qualification that these tables apply when soil pH is between 5 and 9 is a requirement of the MOE guidelines, and not something we stipulated. When soil pH was < 5.0 then we referred to Table F (background concentrations).

Because the purpose of the ERA was to evaluate risks associated with smelter emissions, chemicals should be present across the study area to be considered COCs. No chemicals were excluded due to this criterion for either the ERA or HHRA.

The terms "presence" and "survival" are used commonly in ERA assessment endpoints. These terms reflect the important characteristics of organisms that are to be protected.

Chapter 3 – Evaluating Objective #1.

A summary of Chapter 3 is provided in the overall Executive Summary at the front of the report in pages ES-6 to ES-12.

It was, and remains, our position that standard toxicity data from the literature were not directly applicable to Sudbury, in that much of the literature data were based on exposure to single metals, neutral soil pH and to plant species generally not relevant to Sudbury. Therefore with respect to Objective #1, we conducted extensive field studies and laboratory toxicity testing using Sudbury soils to try to address some of these limitations of the published literature.

The study approach chosen was to collect an extensive amount of data in the field at fewer sites (22) versus less data at more sites. There are trade offs with both approaches. The use of 18 field sites is actually large considering the vast amount of information collected at each site. There was no intention to exclude sites from the "common" area of the 3 smelters, only to have a minimum of 5-6 test sites associated with each smelter.

The number of Reference sites for the study is considered appropriate, that is, one Reference site per smelter. Relative proximity to the smelters is important to have sites with similar ecological, climate and geological conditions as the test sites. Having Reference sites with soil metal levels at or below background ensures they have not been impacted by metal deposition from the smelters, thus reducing a great deal of uncertainty in the evaluation.

It is easy to state that more Reference sites would have been preferable, and difficult to dispute that more is better. The important fact is that the results of the assessment determined that the plant community at each test site was either moderately or significantly impacted by smelter emissions and other historical stressors. This provided sufficient basis to help launch the Biodiversity Action Plan. It is very unlikely that having more reference sites would change the study conclusions or risk management decisions

Regarding the effort to find test sites with a pH between 4 and 5, the study was designed to be representative of the majority of forested areas in Sudbury. There are some isolated pockets where the pH is above 5 (water slurry method), but the majority of the area has natural soils with a pH that is below 5.

A pH of less than 5 is often cited as being limiting to plant growth. Below pH 5 is also outside of the limits for the MOE screening table, Table A, which was used for COC selection. When designing a field program it is necessary to define some variables to allow for comparability between sites. As a result soil pH was chosen as a variable that was used as a basis for site selection in the study design. We selected sites to have a similar pH level so they were comparable.

A clarification on the methods used to determine pH is needed to answer the last part of this comment. Two methods were used to measure pH: water slurry and calcium carbonate. Both of these methods are well established in the scientific community and each has advantages and disadvantages associated with its use. The water slurry method yields the pH closest to the pH of soil solution in the field so this was the method used for site selection. The calcium carbonate method is widely used by soil scientists but the addition of the salt lowers the pH by about 0.5 pH units compared to the water method. Table 3.17 in the ERA gives a range of the pH (water slurry) in all samples and it can be seen that they range from 4.04-4.88. The pH values listed in Tables 3.13 to 3.16 are all calcium carbonate (this is listed in the table under the column pH).

It is true that the Sudbury region is the transitional zone between the boreal forest and the Great Lakes St Lawrence forest regions. This was part of the reason why reference sites were selected to the north, east and west of the study area. This means that within the reference sites all possible site diversity for a healthy forested community in the Sudbury region should be represented.

All test sites were available to the SARA Group and the companies fully cooperated with the field personnel. However, 2 of the sites were on private property managed by the two mining companies. For safety reasons outside visitors or researchers must have some on-site training in company health and safety procedures, or be accompanied by a company employee or supervisor. Since the litter decomposition study was being conducted over a long period of time (one year) and we utilized local students to retrieve samples on a regular basis, it was decided to omit those two sites from routine sampling. We are confident that the study results were not jeopardized by this decision.

It is true that a great diversity of sites (including wetlands, fens, bogs, barrens and grasslands) all exist in the Sudbury area. However, the 2004 field study was not designed to be characterization of the vegetation that exists in the Sudbury region. Instead, it was designed as a comparative study where as many variables as possible were equilibrated and the outstanding variable was the concentration of metal in the soils. To have included each of these different site conditions in the selection of sites would have further complicated what is already a difficult puzzle. Instead the opposite approach was taken: decrease the variables as much as possible so that it is possible to determine the role of metals in the vegetation (or lack of) that exists at the site.

The conclusion regarding Objective #1 is very significant, although on the surface it may seem simplistic and an understatement. The impacted landscape has previously been attributed to a wide range of stressors that the ERA also acknowledges. This report clearly documents that metal levels in soil (not just sulphur emissions or tree cutting) has contributed to these impacts. It also concludes that metal levels are contributing to the prevention of natural recovery. While this latter fact has been thought to be part of the problem and implicitly addressed by some of the re-greening activities (ie. liming), it has never been clearly documented and examined in a methodical scientific fashion. Furthermore, the companies that commissioned the ERA have accepted these results and acknowledged, from the outset of the study, the smelters as a source of these metals.

Chapter 4 – Evaluating Objectives #2 and #3

It is standard practice in ERA to use available site-specific data, combined with models and data from the literature, to estimate risks. The models themselves are based on considerable toxicological data for the chemicals of concern. The effects assessment is primarily based on literature. However, the database of literature reviewed to develop Toxicological Reference Values (TRVs) for the effects assessment was extensive (see ERA report Appendix F). Any assessment will require simplifying assumptions. It is important in risk assessment to acknowledge uncertainties and evaluate the impact of these uncertainties on the overall risk estimate. This was done in Section 4.4 of the ERA. In some instances, data with medium or high uncertainty may not have a significant influence on risk estimates (e.g., surface water concentrations, related to wildlife exposures). The risk assessment was conducted to over-estimate, not under-estimate, risk (that is, to be protective of wildlife). A risk assessment is designed to be able to make conclusions and recommendations in the face of uncertainty. Any outstanding issues that need to be addressed can be considered in the future.

Chapter 5 – Aquatic Problem Formulation

As stated in the ERA report, one of the goals of any future detailed ERA for aquatic life would be to determine the scope of the assessment. The current ERA report made recommendations based on the assumption that the goal of an aquatic ERA would be to evaluate impacts from smelter emissions (not mining). These recommendations are only recommendations. Any future study will need to consider the data gaps required to complete the assessment. In response to the ERA, Vale Inco and Xstrata Nickel have committed to funding additional aquatic studies with the Freshwater Co-op Unit of Laurentian University.

Surface water directly receiving input or effluent from a mine operation are regulated and studied separately under provincial regulations for discharge Certificates of Approval as well as Environmental Effects Monitoring under the federal *Fisheries Act.*

Chapter 6 – Conclusions and Recommendations

We agree that it would have been helpful to define the terms re-greening, reclamation, risk management, restoration, recovery and remediation in the report because people don't always use these terms in the same way. We provided definitions under General responses above.

Vale Inco and Xstrata Nickel acknowledge their responsibility to follow up on the results of the ERA. The next steps that will deal with risk management include follow up studies, monitoring, re-greening and restoration activities that will be undertaken by many groups including Laurentian University, the Freshwater Co-op Unit, the Ontario Ministry of the Environment, Vale Inco, Xstrata Nickel, VETAC and others. In addition, the City of Greater Sudbury has initiated the Biodiversity Action Plan, with support from the mining companies. For more information on the Biodiversity Action Plan, please visit www.greatersudbury.ca/biodiversity.

Regarding the suggestion that more reference sites are necessary for the ERA please refer to our response under Chapter 3 above.

The statement that a self-sustaining forest ecosystem tends to have 50 or more plant species was based on the information collected in this study and analysis of the data. It is applicable to the Sudbury study area and was developed as a guideline for comparing reference sites to test or impacted sites.

Public involvement and decision making

The Ontario Ministry of the Environment (MOE) was involved at all stages of the ERA and participated in all decisions with full acceptance of their regulatory responsibilities.

As you are aware significant efforts were made to present the results of the ERA to the public and to make the study process available for comment and review. The large scientific technical reports (both ERA and HHRA) were summarized in two "reader friendly" Summary Reports to boil down the key methods and results into a shortened version. The study results were also presented in 3-4 page *Update* Newsletters.

The PAC meeting of May 12, 2009 included a public presentation by two of the study authors and was held to provide another opportunity, separate from the release date, for the public to ask questions.

Although the Sudbury Soils Study is now officially complete, the City of Greater Sudbury and the mining companies have initiated the Biodiversity Action Plan in response to the ERA results. Additional studies related to the ERA are being sponsored directly by the mining companies. The leaders of the Biodiversity Action Plan were also involved with the Sudbury Soils Study and listened to the concerns with the public consultation process. In response, the approach used to engage the public for the Biodiversity Action Plan did involve smaller focus groups, workshops and site tours. If Northwatch, or any other group, is interested in discussing the results of the ERA you are welcome to contact any of the former Technical Committee members. For information on the Biodiversity Action Plan, anyone can contact Dr. Stephen Monet, Manager of Environmental Planning Initiatives with the City of Greater Sudbury at Stephen.monet@greatersudbury.ca. For more information on the Biodiversity Action Plan, please visit www.greatersudbury.ca/biodiversity.

Again, we thank Northwatch for their detailed review of the ERA report and continued interest in the Sudbury Soils Study. We encourage members of the group to become involved with the Biodiversity Action Plan which will continue to evolve in response to public input over the coming years.