

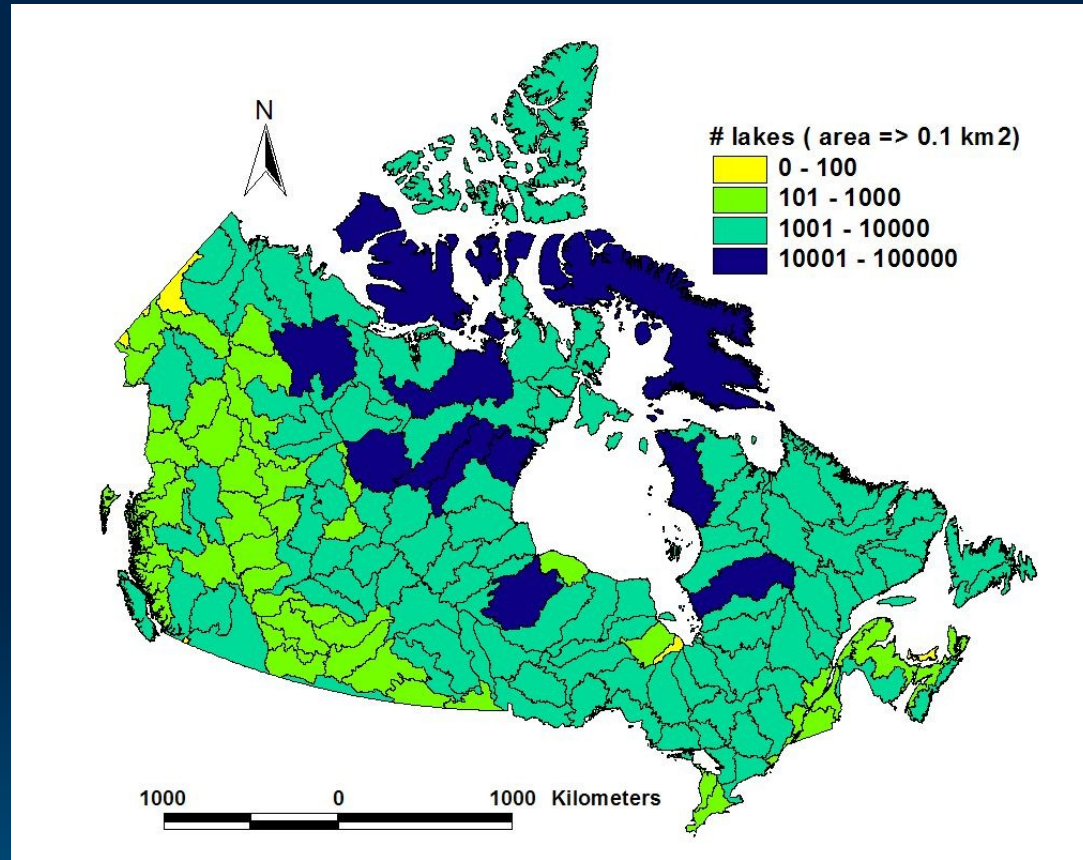
# The Present Status and Future Prospects of Canada's Freshwater Ecosystems: Battle Between Conservation and Use

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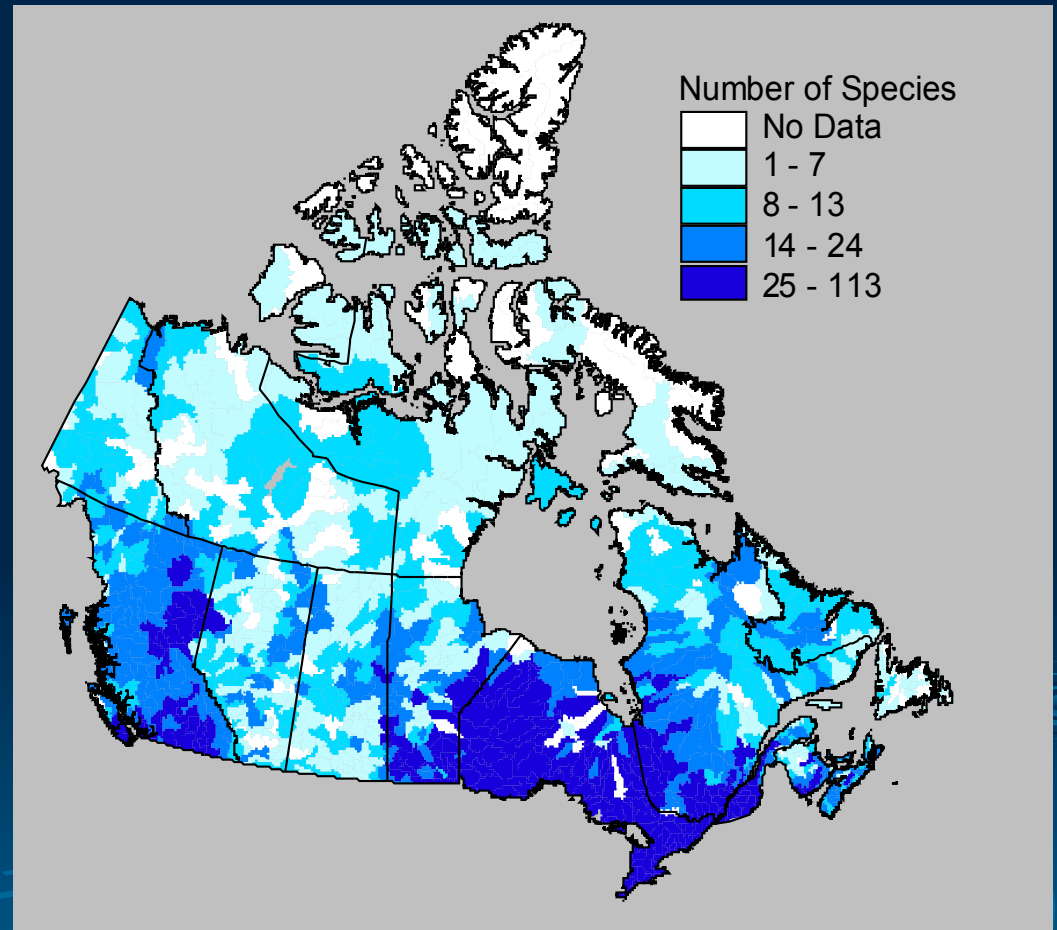
# Canada's freshwater ecosystems

- 9% of freshwater runoff
- The largest share (25%) of global lake resources
- 40% of all large (>100km<sup>2</sup>) lakes
- Profligate users of freshwater
- Domestic water use 350 L/day (UN recommends 50)
- Ecological footprint 7.6 ha (global average 2.2, WWF)



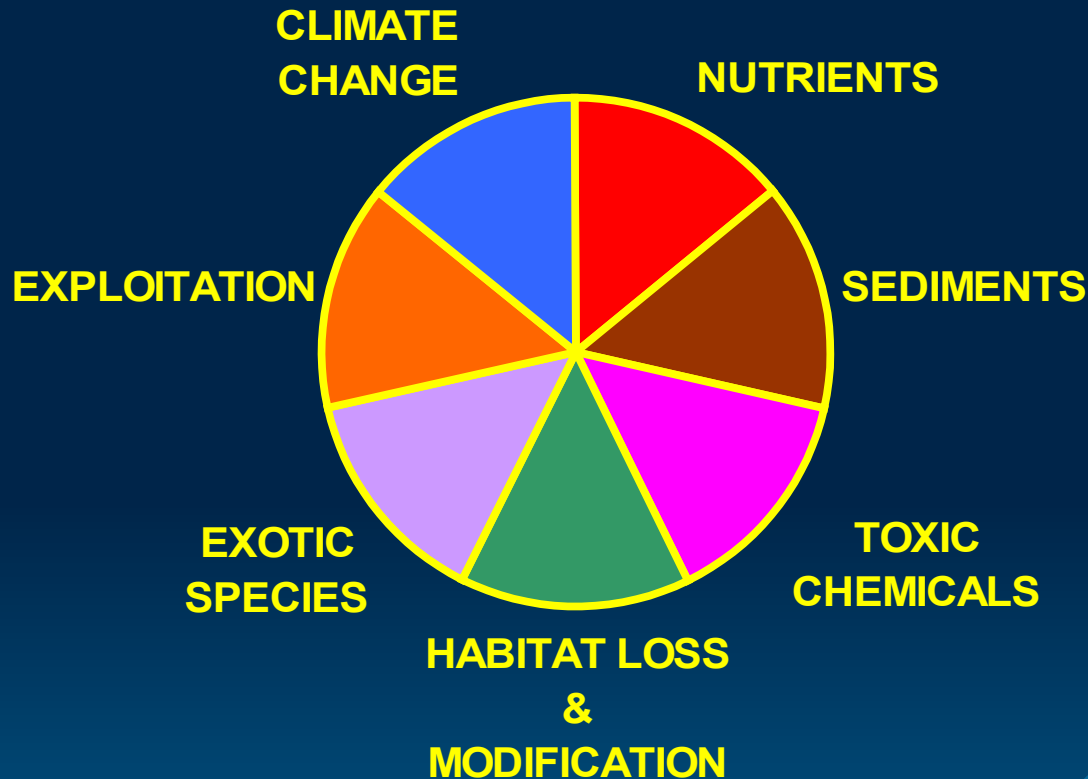
# Freshwater biodiversity

- Canada has a fish species richness that is linked to temperature, the supply of freshwaters, and colonization since the last glaciation
- Many fish species are prized in sport, commercial and subsistence fisheries



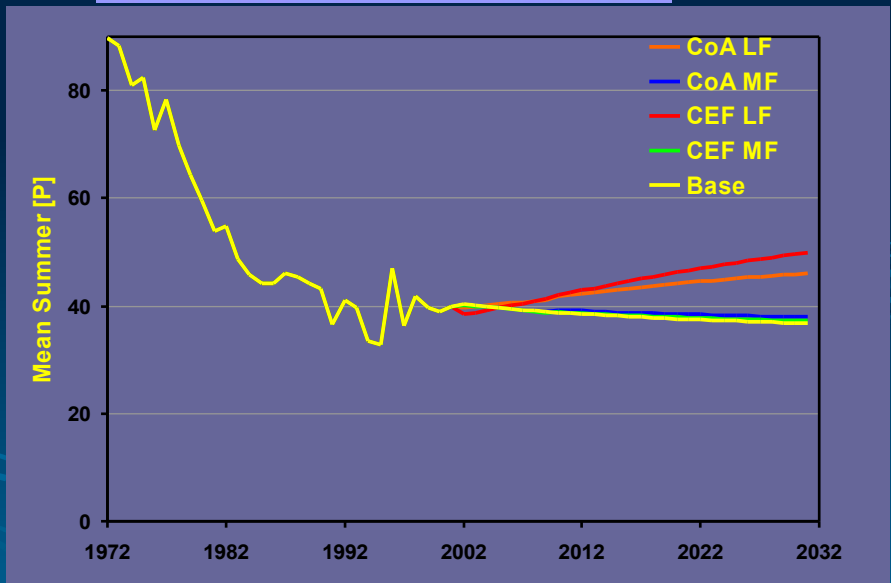
Chu *et al* CJFAS 60:624-34 2003

# Seven Deadly Stresses



# Nutrients

- Phosphorus was controlled in the 60-80s by concentration limits (intensity) in new STPs but now growth and resistance to new public sector investment are starting to erode that success
- Nitrogen is still an increasing problem (farming & transport)
- In 1999 only 40% of our municipal population had tertiary treatment and 21% had primary or none
- In the Bay of Quinte, full use of current STPs with recent low flows will see [P] rising again and further urban growth will exacerbate the situation



Upper Bay of Quinte, Summer [P]

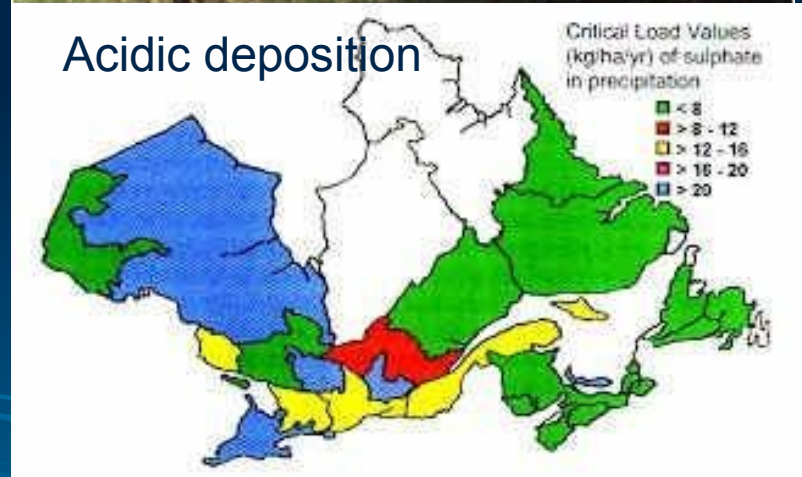
# Sediments



- Soil erosion due to agriculture, deforestation, urban development, mineral extraction
- Nutrient enrichment, habitat alteration and loss, contamination, direct effects on biota

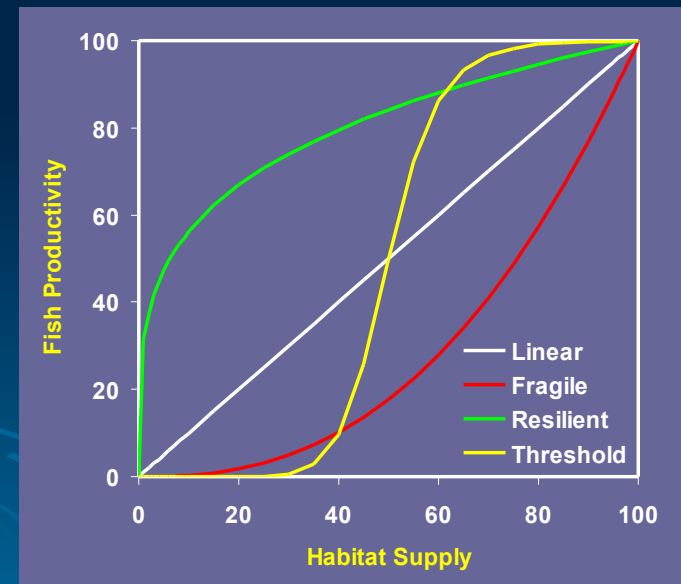
# Toxic Chemicals

- Many have been banned but more linger on in freshwater ecosystems
- Even greater numbers have yet to be addressed
- New ones are being created all the time



# Habitat Loss & Modification

- Loss and modification are the norms for development in Canada; fragmentation is also a major problem
- The majority of human activities involve a net loss of productive capacity of habitat
- Habitat loss the #1 reason cited for extinctions in fish
- The form of the habitat:fish link is often poorly known but threshold is more likely than linear





# Exotic Species



Ecological Corp of Engineers

# Exploitation



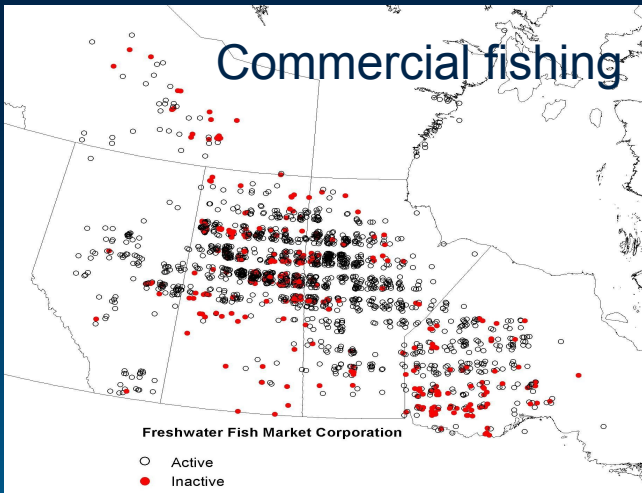
Irrigation



Domestic waste



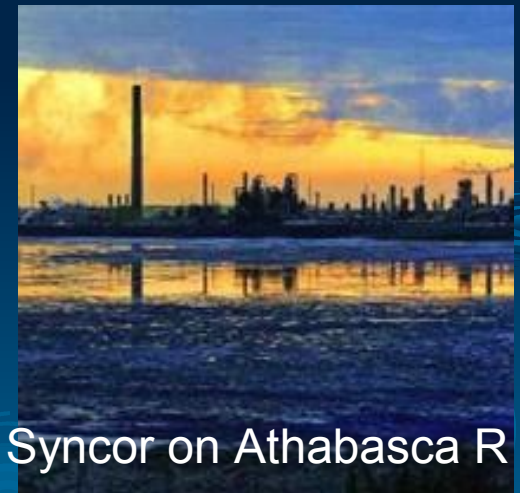
Eastmain 1 – Hydro-Quebec



Commercial fishing



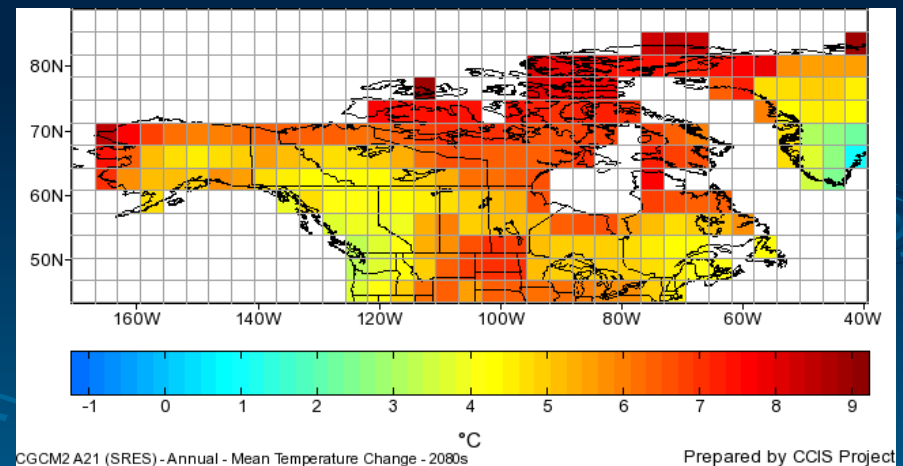
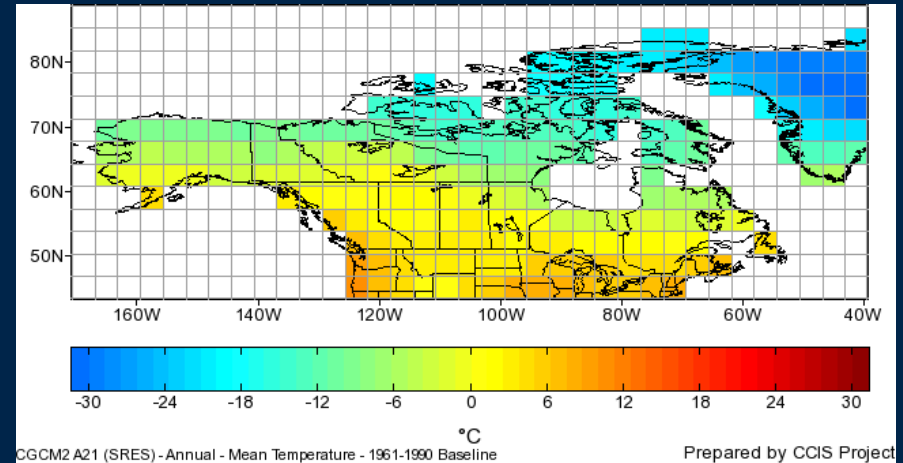
Groundwater



Syncor on Athabasca R

# Climate Change

- This is already occurring and will shift all ecosystem reference points
- New temperatures, hydrologies, landscapes, species compositions
- +2 °C maybe too much for many ecosystems and species (WWF)



# Stress management strategies

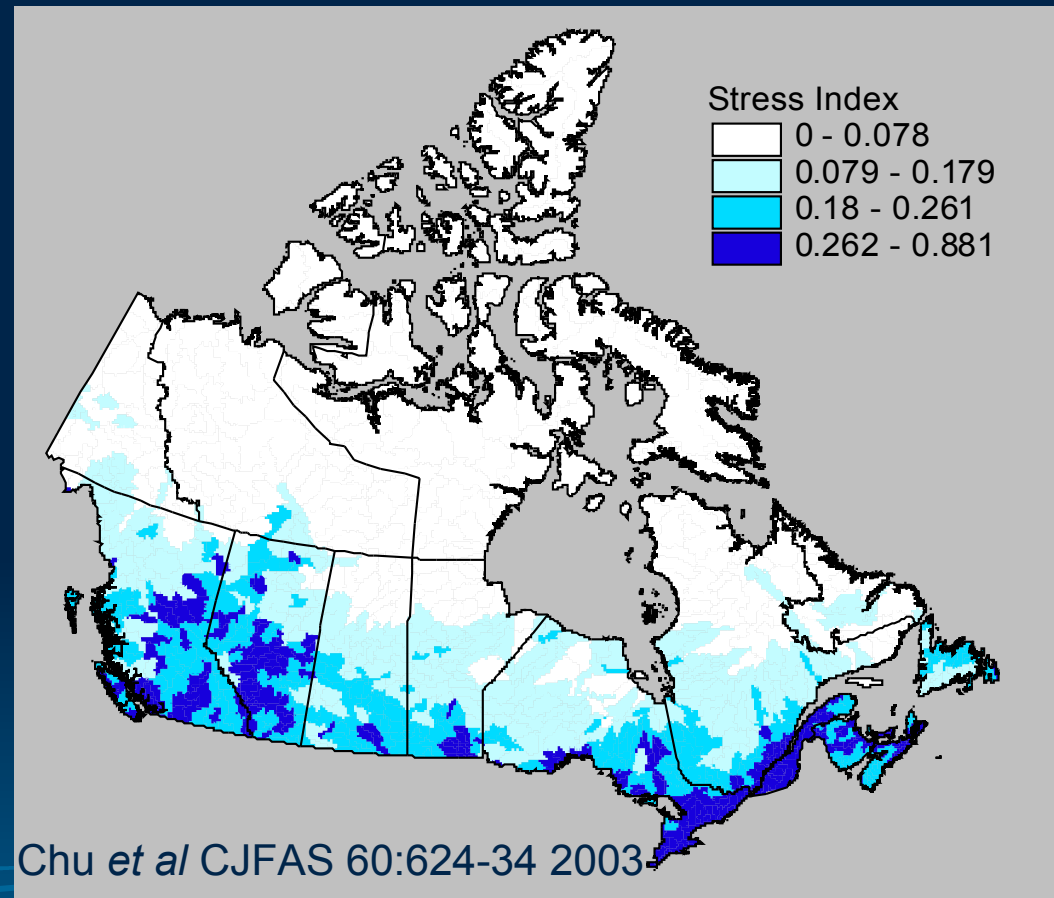
- Two basic approaches: “intensity” and “load”
- Intensity – rate-limited usually linked to some other activity, e.g., phosphorus was controlled by concentration limits but STP flow rates are allowed to increase without limit
- Load – absolute limit on output, e.g., most toxic chemicals (Hg, PCBs, CFCs, etc.) are to be phased out completely
- Load limits should be the preferred strategy as long as human population and activities keep increasing

# Management Examples

Stressor	Control Method	Success?
Phosphorus	“Intensity”	Temporary
CFCs (Ozone Layer)	“Load”	Beginning to work
SO2/NOX (Acid Rain)	“Load”	Yes, when done
Habitat	“Intensity”	Failing
Exotic species	“Load”	Yes, if ever done
Exploitation	“Intensity”	Failing
GHG (Climate Change)	“Intensity”??	Failing so far??

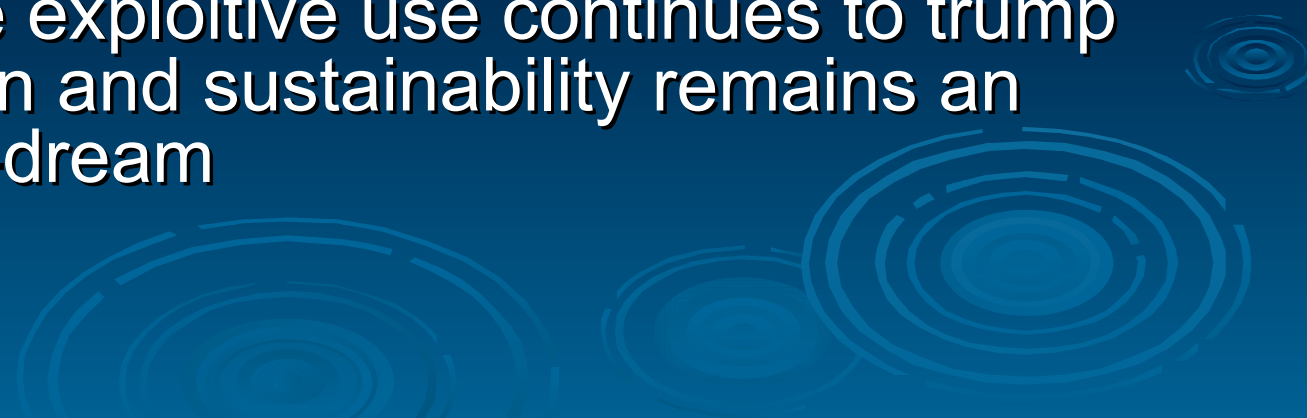
# Anthropogenic stress

- Combined human population and settlement, agricultural and industrial stresses are increasing
- Stress on ecosystems is increasing as population grows, and spread further into the hinterland as resources are extracted and exploited
- Climate change and resource extraction stresses are exacerbating this situation with greater impacts in the North



Ehrlich's equation:  $\text{Stress} = \text{Population} * \text{Activity} * \text{Intensity}$

# The Battle Lines Are Drawn

- Water resources are the main focus of attention, not freshwater ecosystems and their ecological services
  - Fisheries are the main focus not fishes (biodiversity, ecological services)
  - Resources to be exploited or turned to human needs are the focus, not natural self-sustaining ecosystems
  - Everywhere exploitive use continues to trump conservation and sustainability remains an empty pipe-dream
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# Freshwater services

- Ecological:
- Hydrological and climatic regulation
- Transport and cycling of materials
- Primary production
- Habitat for biodiversity
- Anthropogenic:
- Drinking water
- Domestic, industrial, agricultural supplies
- Hydropower
- Waste disposal and assimilation
- Transportation corridors



# Fish services

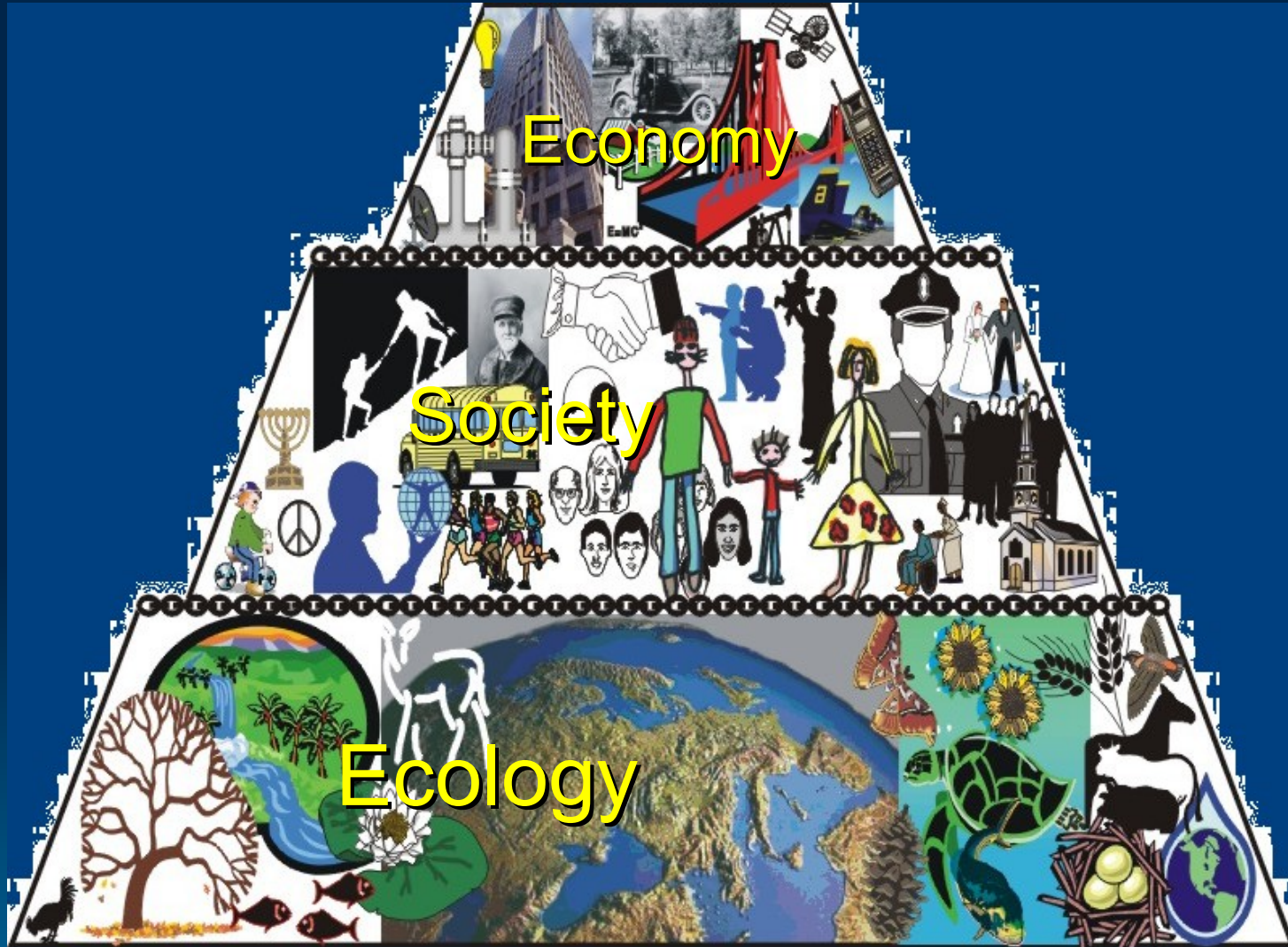
- Ecological:
- Regulation of energy and nutrient cycles
- Maintenance of biodiversity
- Linkages within and between ecosystems over space and time
- Transport of materials and energy
- Anthropogenic:
- Food production and stock for aquaculture
- Biological control
- Recreation, aesthetics and culture
- Evolutionary, historical and ecological knowledge
- Assessment of ecosystem health

# Vulnerabilities

- **Freshwater**
- Further fragmentation and disruption of stream and river drainage networks
- Loss of streams, rivers and lakes
- Decrease of ecosystem regulatory and maintenance services and further declines in ecosystem resilience
- Loss of biodiversity
- Every ecological phenomenon is being affected now
- **Fish**
- Extirpation and extinction of many existing species-at-risk
- Many more valued species will be put at risk even if not legally listed by the federal minister
- Deleterious selection processes due to excess exploitation
- Increased disturbance of trophic structures and energy/material flows

“Stresses increase the vulnerability of ecological services”

# Ecosystem pyramid



# Cumulative ecosystem change options

- Prevention

- Limit our stress loads on ecosystems
- Humans appear to lack the collective will to act though individuals are often strongly motivated

- Mitigation

- Impacts on humans can often be resolved with ingenuity and technology but rarely equitably
- Growth\*intensity usually leads to short term benefits


- Adaptation

- Humans have shown themselves to be remarkably resilient and resourceful though highly destructive
- Ecosystems and species can adapt to some extent but are long-term products of evolution
- Transitional disturbances often lead to losses

# Human (mal-)adaptation options

- **Water**
  - Increase exploitation of water for hydro-electricity, agricultural and urban irrigation, effluent disposal, drinking water
  - Continue infill and alteration of aquatic habitat to advance anthropogenic development activities
  - Divert waters regionally and internationally to meet human use demands
  - Abundance seems to foster abuse
- **Fisheries**
  - Continue over-exploitation of existing stocks
  - Increase exploitation of other stocks
  - Stock to supplement natural stocks
  - Introduce new fishery stocks
  - Accept increased biotic invasions and their impacts
  - Expand industrial aquaculture of food fish
  - Economic and social concerns outweigh ecological reality

# Key Ecosystem Issues

- Failure to recognize that ecological services are an essential prerequisite of all anthropogenic services
  - Ecological services are vulnerable while there are usually costly substitutes for lost anthropogenic services
  - Responses to perceived problems usually involve increased levels of water and fisheries (ab-)use
  - There are few “load”-based limits on freshwater resource exploitation
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# Tools and Rules

- The federal government has strong potential powers in the Fisheries, CEA, CEPA, and Species-At-Risk Acts to conserve and protect the country's fish and fish habitat (freshwater plus ...) but the will to act has been missing...
- Legal decisions have confirmed that conservation should trump use, and yet ...
- Ecosystem conservation principles indicate that some freshwater habitats should be set aside to ensure future availability (ecologically sustainable use)

# Conclusions

- Without aggressive “load” prevention measures to prevent runaway ecosystem degradation, current mitigation and mal-adaptation actions amount to acceptance of further losses and degradation
- Human adaptability and the rapidity of modern development have undermined awareness of our total dependence on natural ecosystems, especially freshwaters, and led society to under-appreciate the degree to which every aspect of our lives is being radically altered by cumulative ecosystem change.
- This situation has resulted from a collective indifference to, sometimes defiance, and often a neglect of, ecological essentials
- The future prospects do not look good at present



# The Responsibilities of Scientists

- **Research**

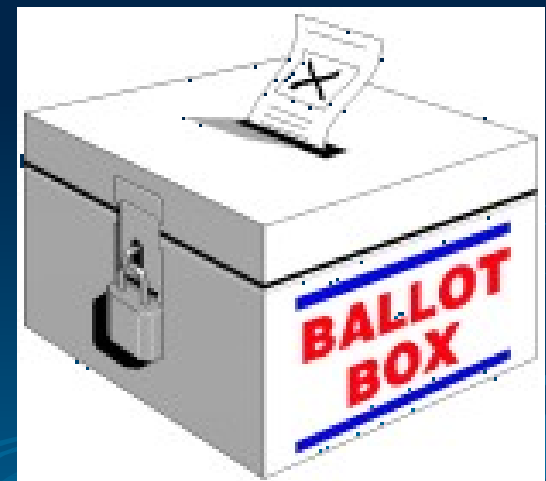
- Pay more attention to documenting and understanding the effects of human stressors on freshwater ecosystems

- **Education**

- Help ensure that all children receive frequent outdoor nature experiences
- Be a source of reliable scientific knowledge in your family, community

- **Politics**

- Vote; Join a political party and work to improve its environmental policies
- Don't let non-science/ nonsense go unchallenged





We need to start behaving as if we intend to stay