Ontario's Freshwater Ecosystems and Climate Change: Impacts and Responses

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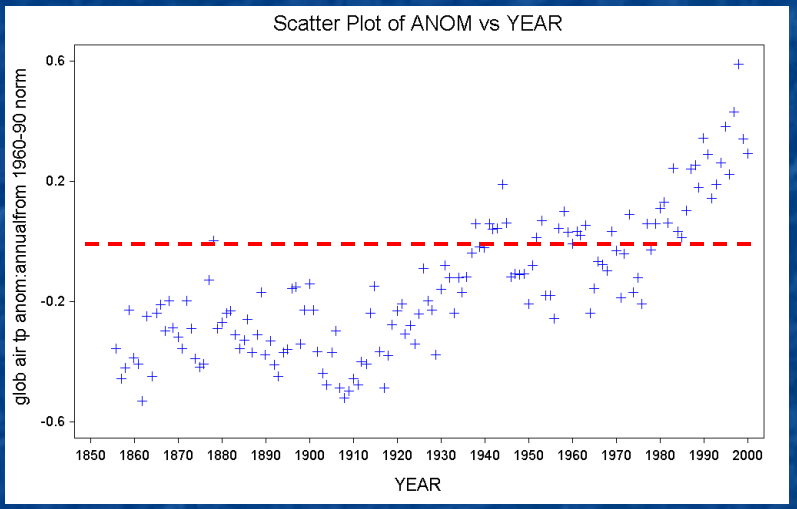
Outline

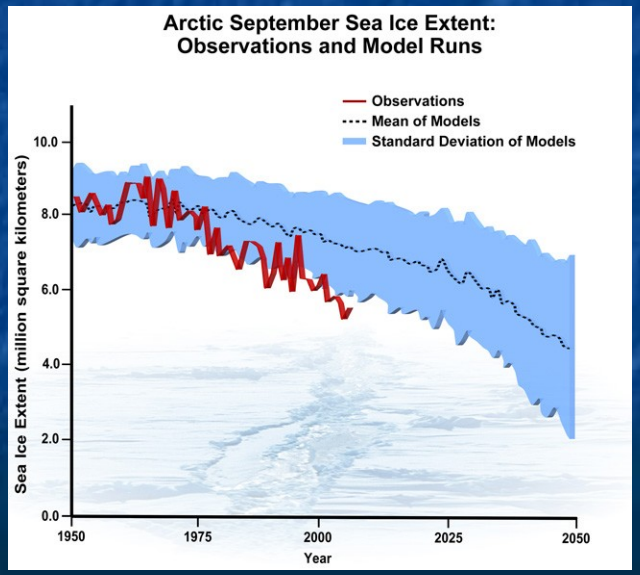
- Climate Change in Ontario
- Freshwater Ecosystems
- Biological Impacts
- Future Options and Choices
- Ecosystem Stewardship

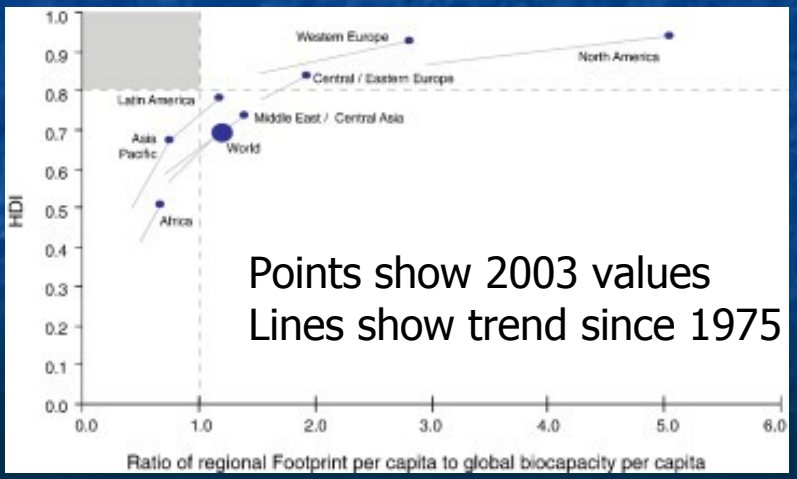
With thanks to Brian Shuter, Cindy Chu, Nigel Lester, Sapna Sharma

Global Ecosystem Change

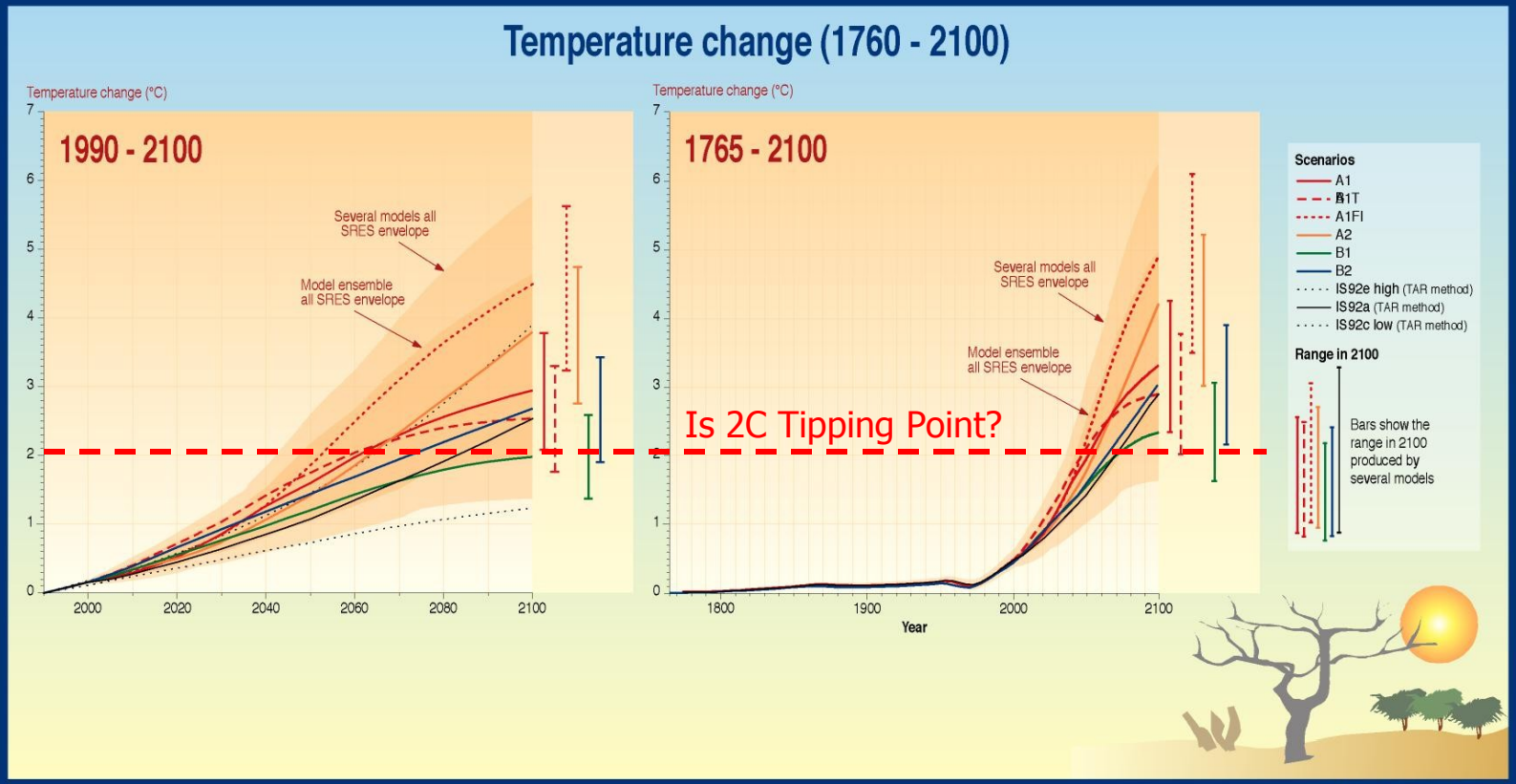
- The Earth's temperature is rising as GHG levels increase (IPCC 2001)
- Arctic ice cover disappearing faster than predicted!
- Human footprint exceeds Earth's carrying capacity (Moran et al. Ecol Econ 2007)







Global Ecosystem Change



WG1 TS FIGURE 22

IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

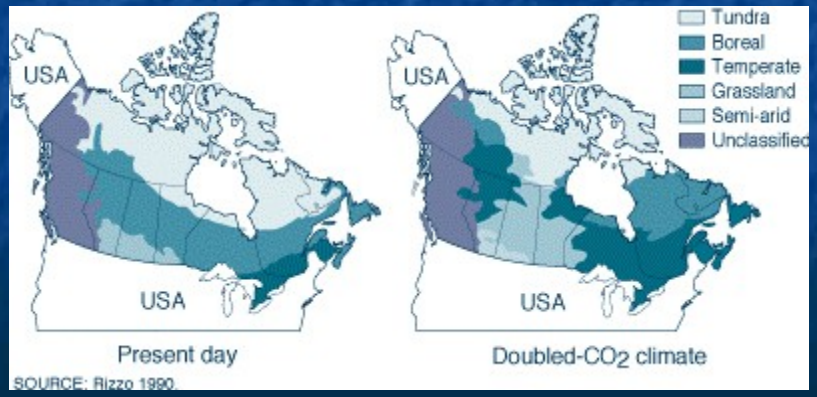
Climate Change in Ontario by 2100

- Temperature
  - ➔ Increases of 2 to 4 ºC
  - ➔ More in summer than winter
- Precipitation
  - ➔ 10 to 20 % increase
  - ➔ Decrease in summer
  - ➔ Less snow cover
  - ➔ Earlier snowmelt
  - ➔ Increased variability
- Runoff
  - ➔ "*Rule of thumb*" – A 10 % increase in rain is needed to offset each 1ºC of warming
  - ➔ More evapo-transpiration and less runoff
- Seasons
  - ➔ Warmer, wetter winters
  - ➔ Hotter, dryer summers

"It may be sooner than 2100 judging by the weather of recent years"

Landscape changes

- Ecozones will shift northwards as mixedwood plains replace boreal, and boreal replaces tundra
- This will affect human settlements and uses

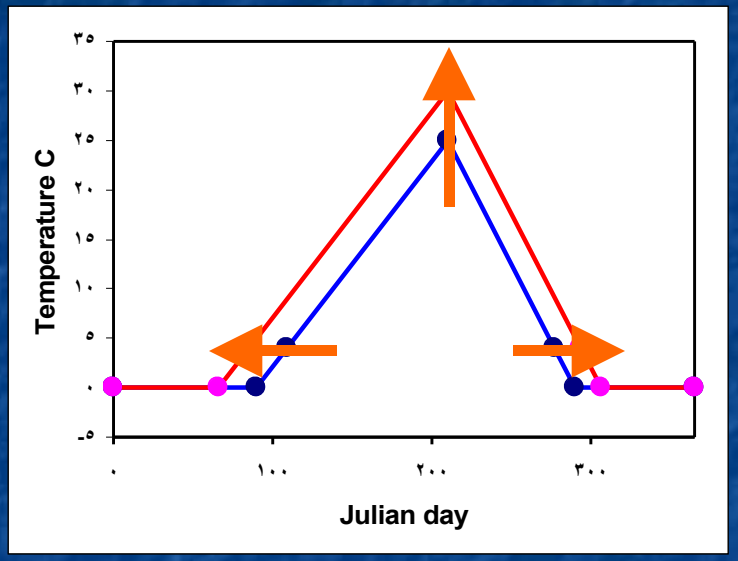


Changes in Streams & Rivers

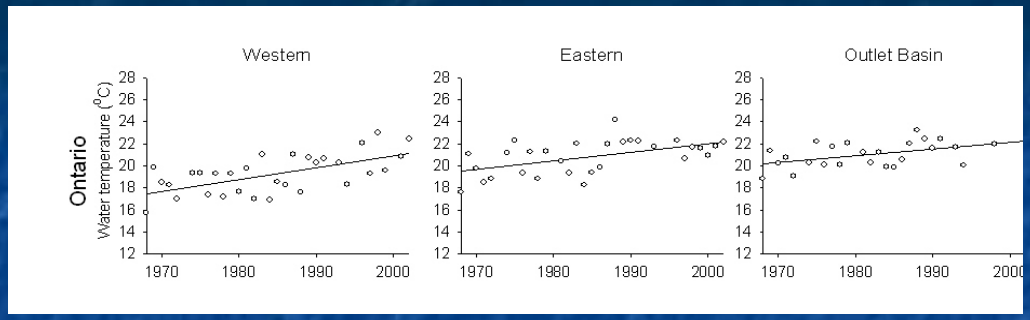
- Lower base flows and, longer term, less cold and cool waters as groundwater warms
- More evaporation from areas behind dams and in in-stream lakes
- Increased erosion due to more extreme flows (high and low), affecting sediment flux and dams
- Shifts in channel morphology
- Increased coldwater habitat fragmentation during summer low flows coupled with higher temperatures

Changes in Lakes

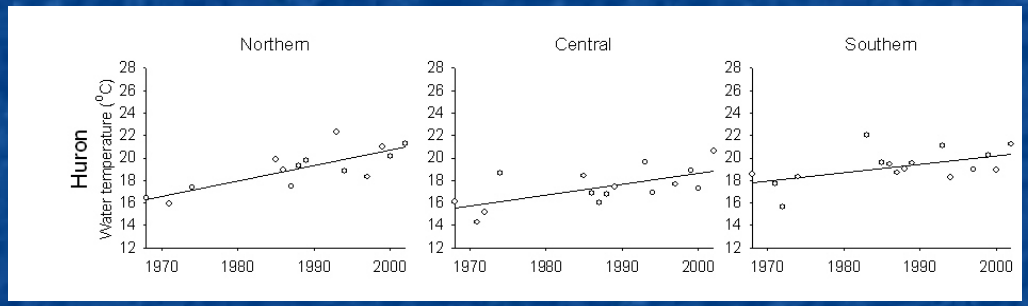
- Increased summer surface water temperatures
- Longer ice-free and stratification periods
- Lower water levels (up to 2.5 m in GLs)
- Reduced ice-cover and ice thickness
- Less winter anoxia but more summer anoxia



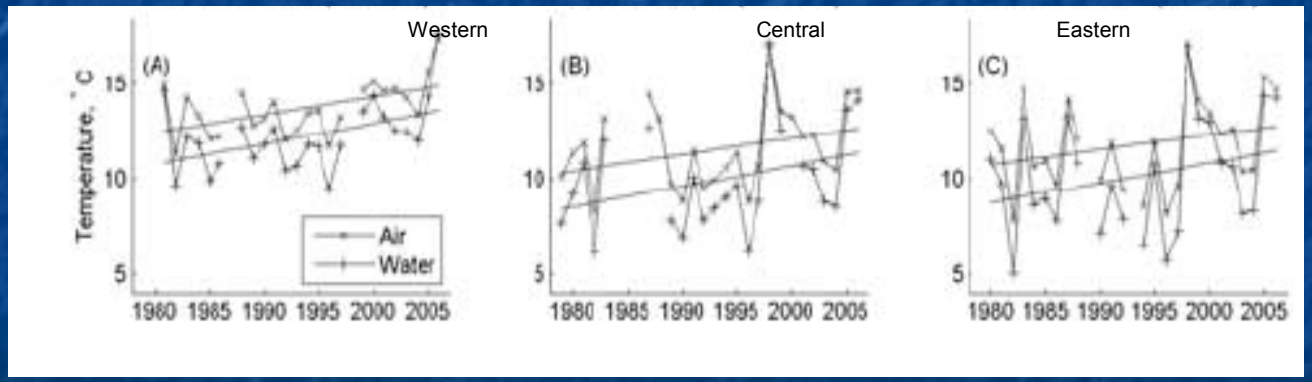
Summer Mean Surface Temperature Versus Year by Basin For 3 Great Lakes



ONTARIO
1970-2000
Summer Surface Water Temps

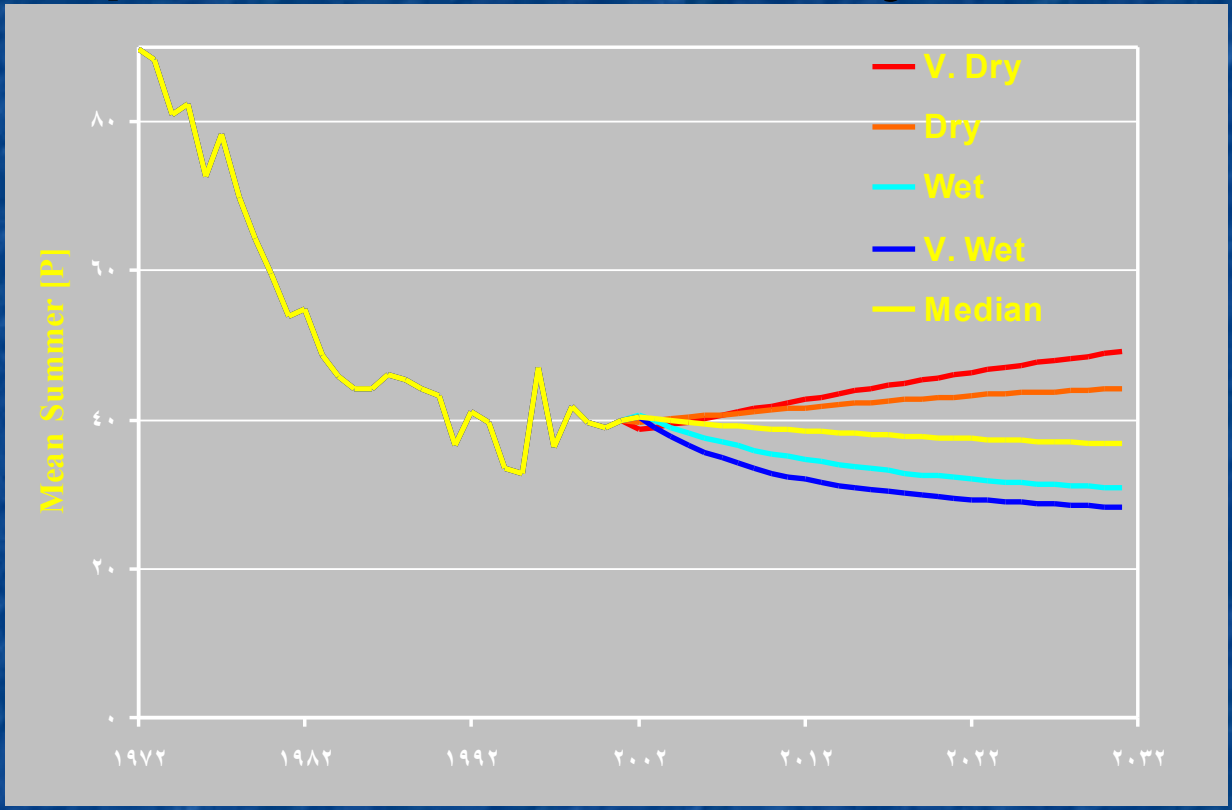


HURON
1970-2000
Summer Surface Water Temps



SUPERIOR
1980-2005
Summer Temps: Air & Surface Water

Phosphorus in the Bay of Quinte

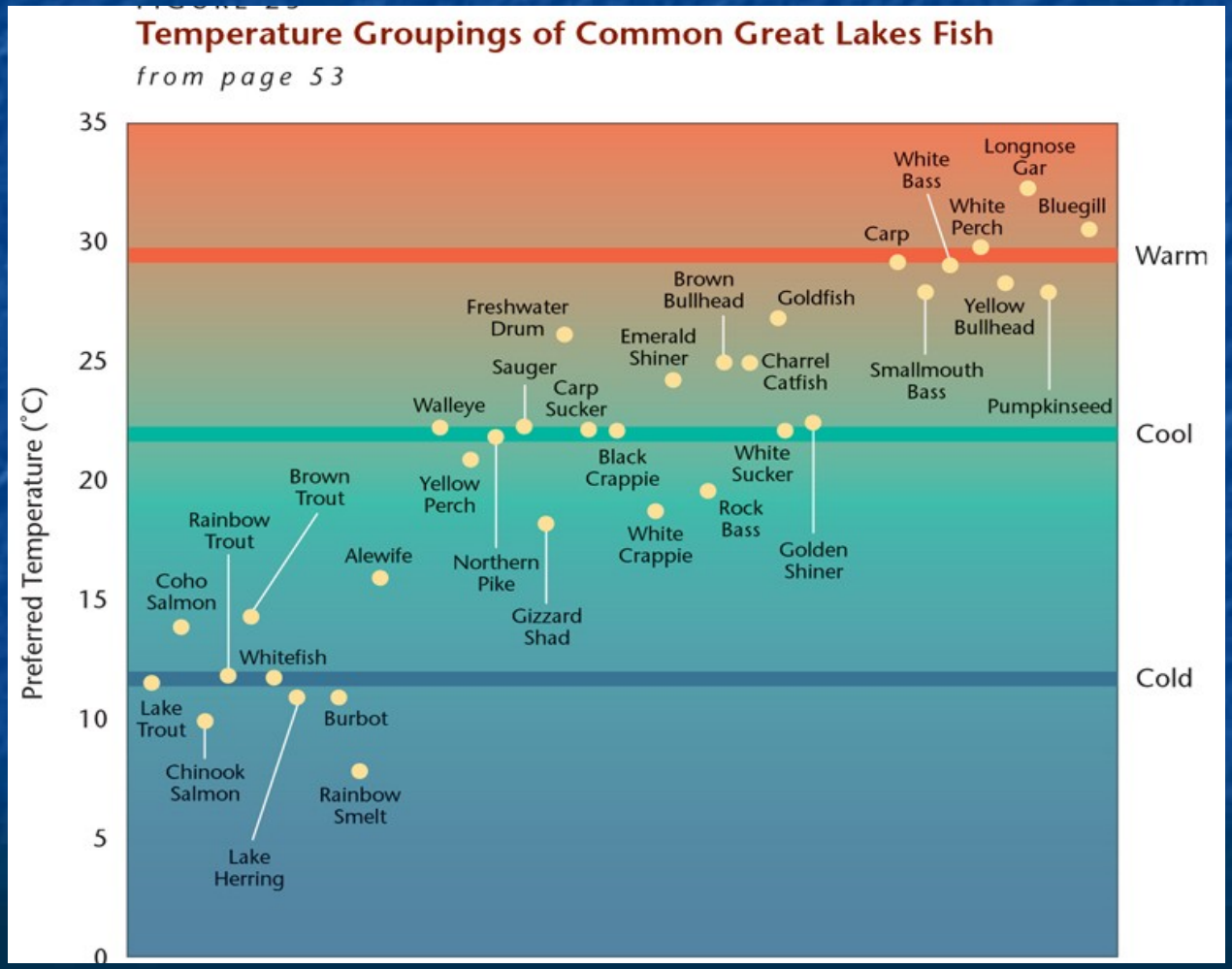


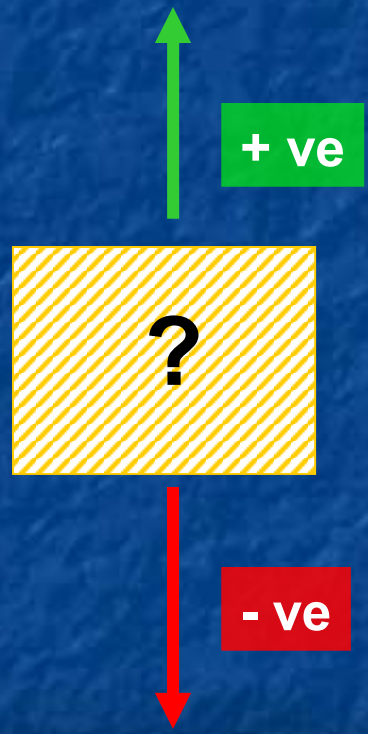
- 10, 25, 50, 75, 90 percentiles of 1972-2001 flows
- Lower flows are more prevalent in recent years
- Situation will be worse if current STP capacities are reached

Biological Impacts

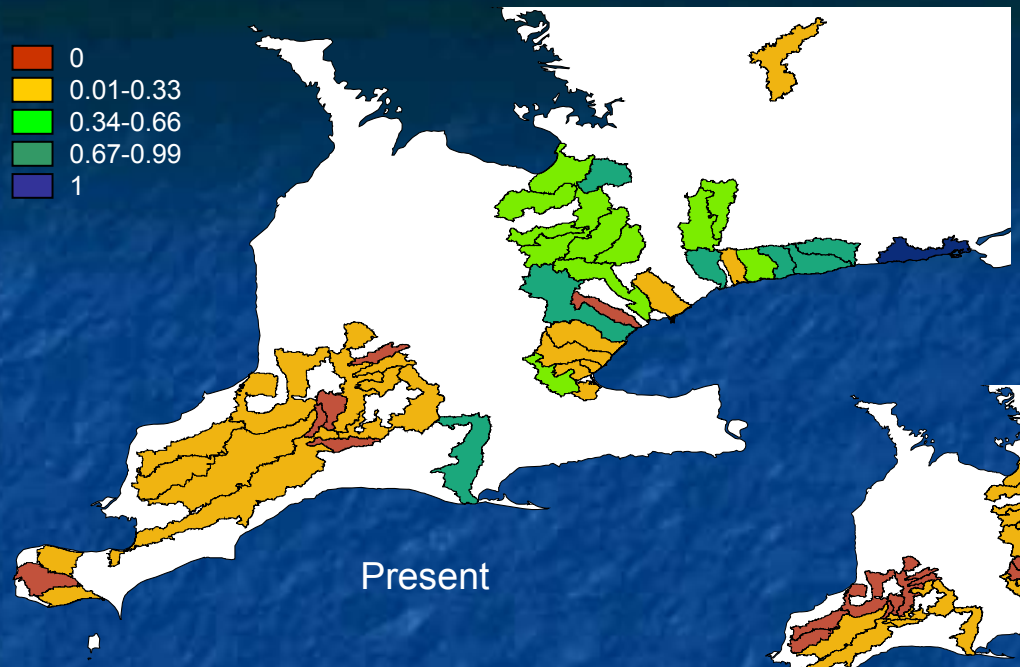
Climate Change Impacts on Fish Ecology	Consequences for Fisheries
Changes in **overall fish production** in a particular aquatic ecosystem	Changes in **sustainable harvests** for all fish populations in the ecosystem
Changes in relative **productivity of individual fish populations** in a particular aquatic ecosystem	Changes in **sustainable levels of exploitation** that can be directed against the fish populations of the ecosystem
Large-scale **shifts in geographic distribution** of species	Changes in **mixture of species** that can be sustainably harvested within specific regions. Changes in **location** of profitable fishing grounds
Small-scale **shifts in the spatial distribution** of members of a specific population	Change in **sustainable harvest** for the population Change in **efficiency of fishing gear**, leading to change in sustainable levels of fishing effort

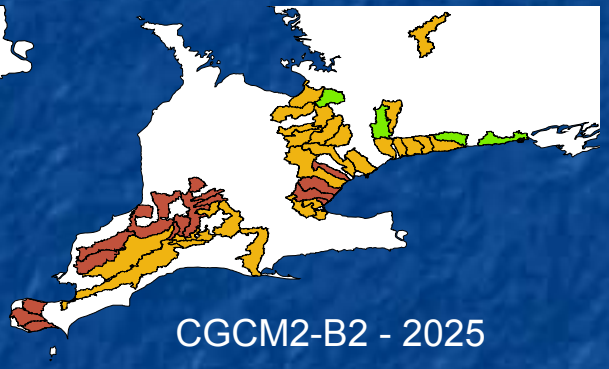
Impacts depend on thermal preferences

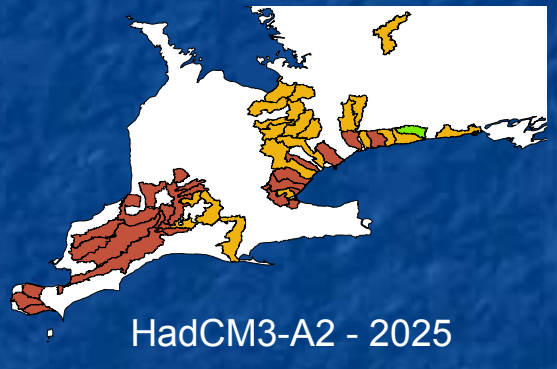


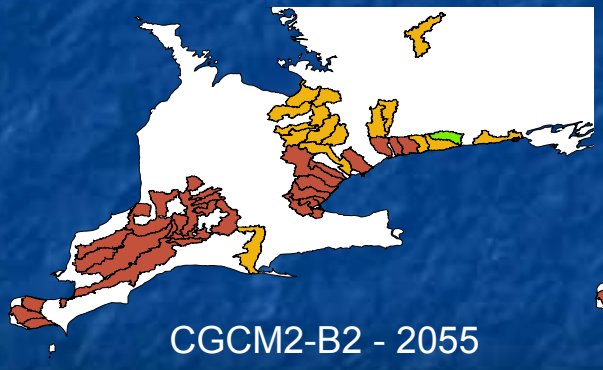


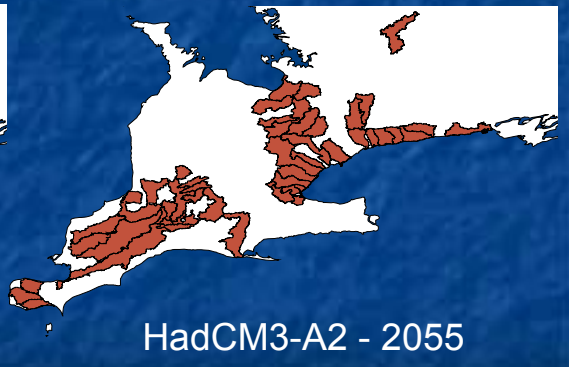
Southern Ontario Stream Fishes







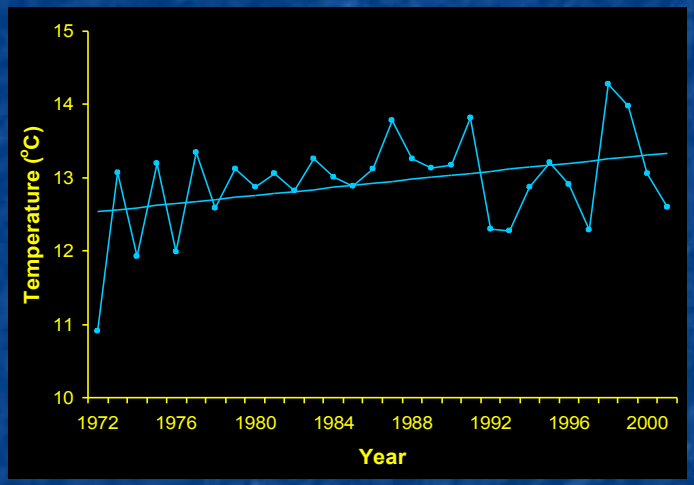


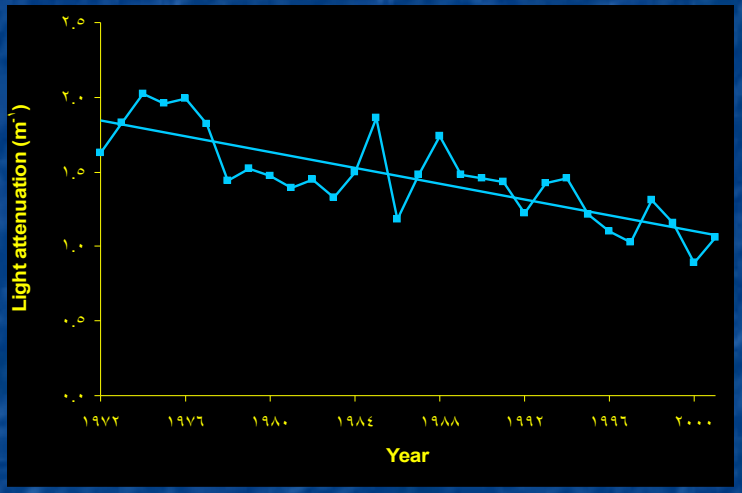


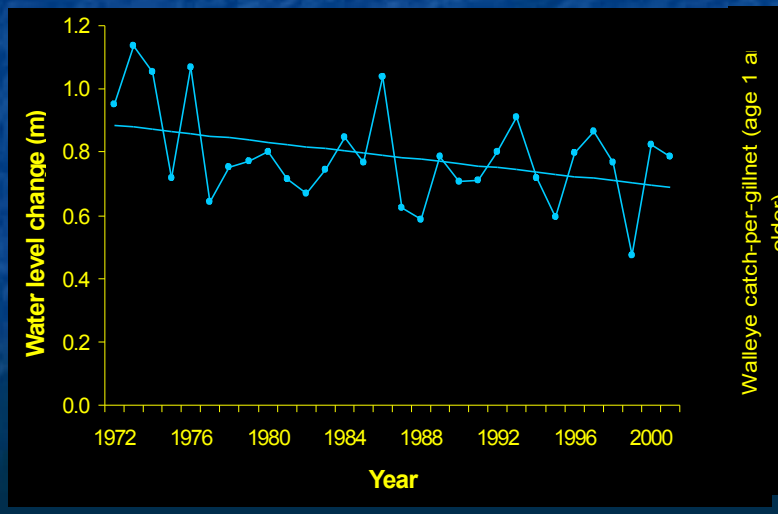
Proportion of sites in 43 southern Ontario watersheds having coldwater fishes currently and under the Canadian Global Climate Model 2 (CGCM2) B2 and Hadley Centre Climate Model 3 (HadCM3) A2 climate scenarios.

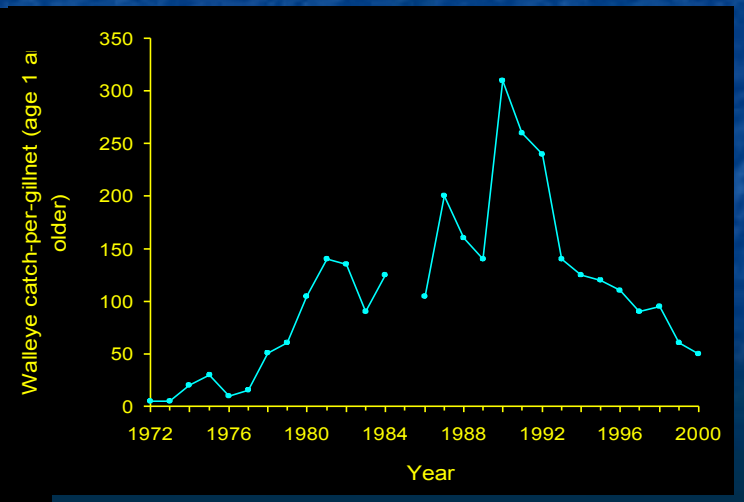
* Cindy Chu et al, 2007 In Press. Diversity and Distributions

Bay of Quinte Walleye



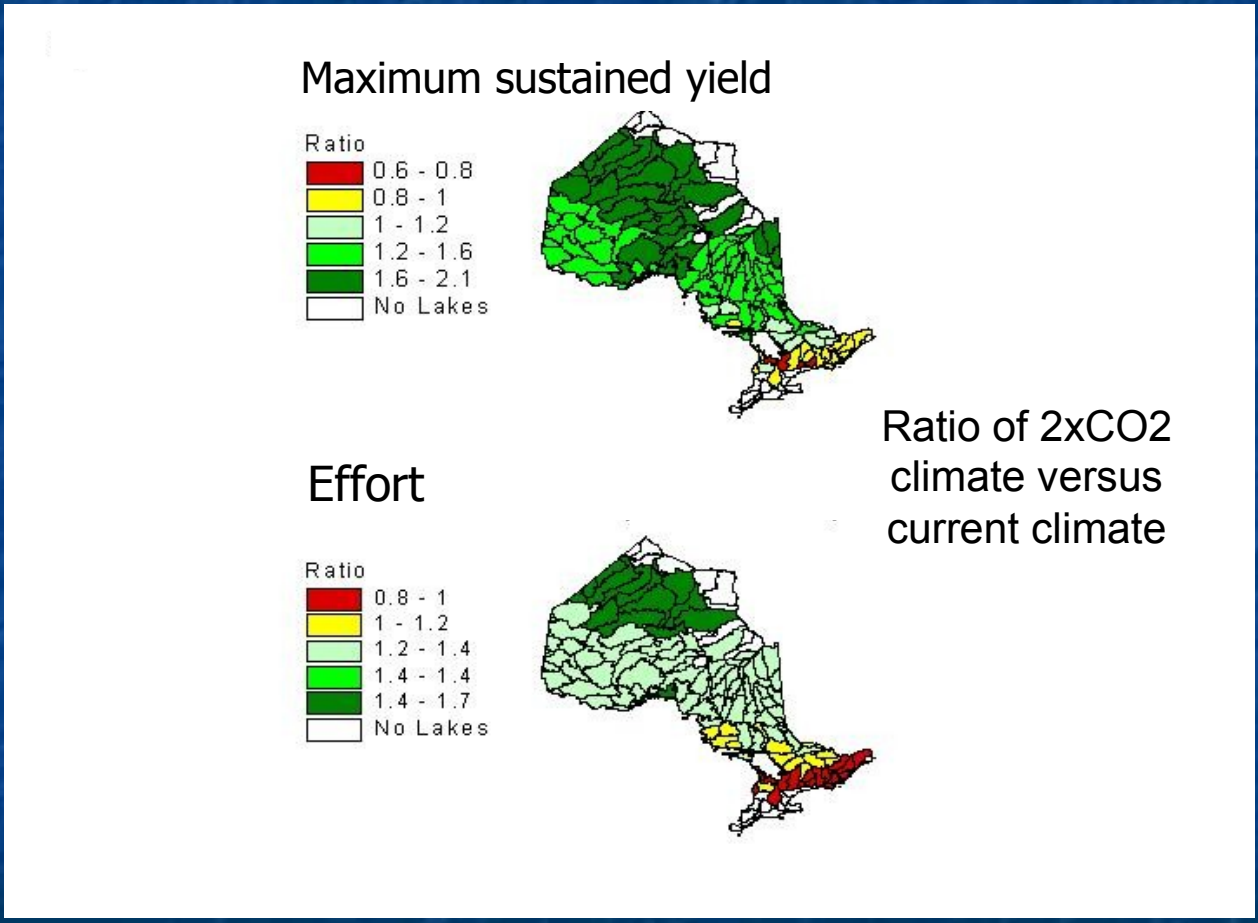






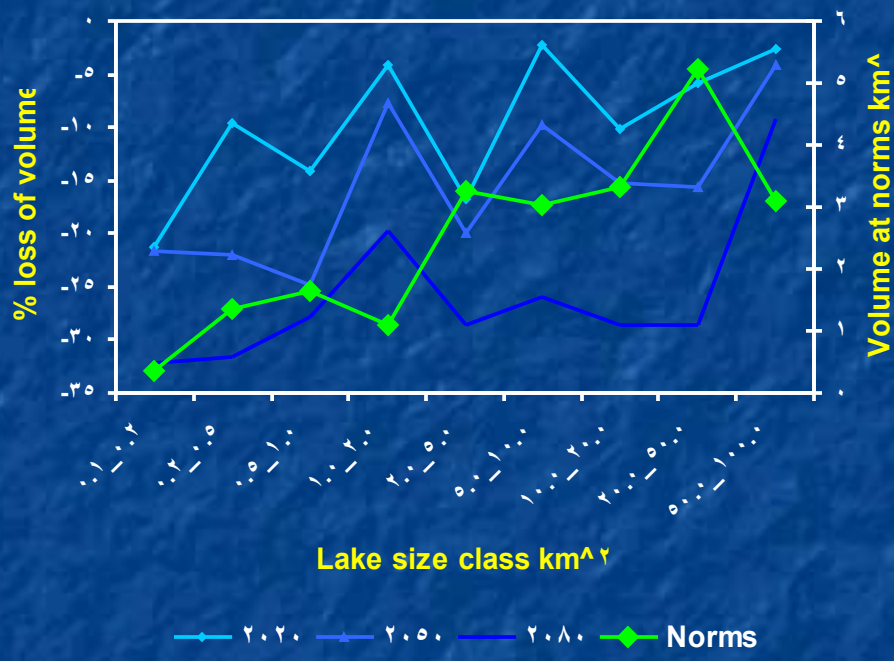
Chu et al 2004

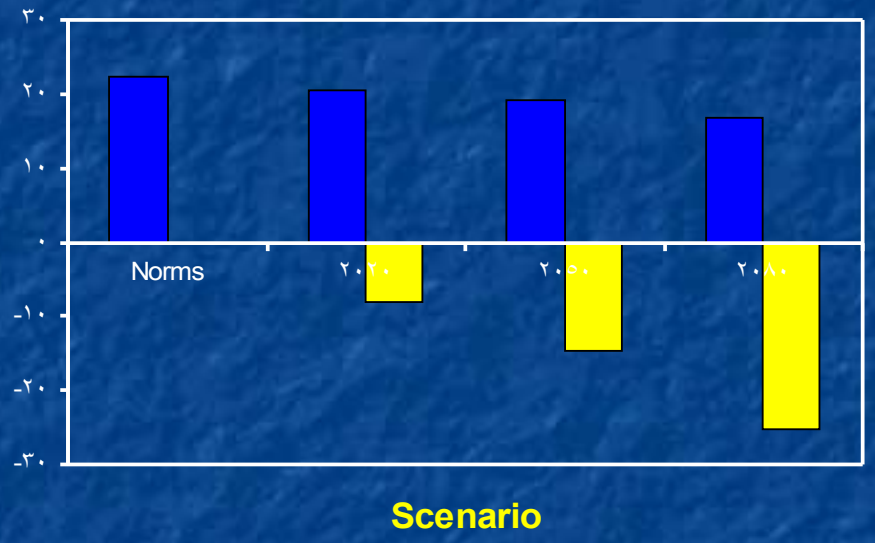
Inland walleye (sander) Lakes



- Projected equilibrium production and effort ratio in walleye lakes by TWS 2xCO2 vs. 1xCO2 climate scenarios in Shuter et al 2002 Proc (based on Lester et al TOHA model linking walleye production to degree days and water clarity)

Ontario lake trout resources

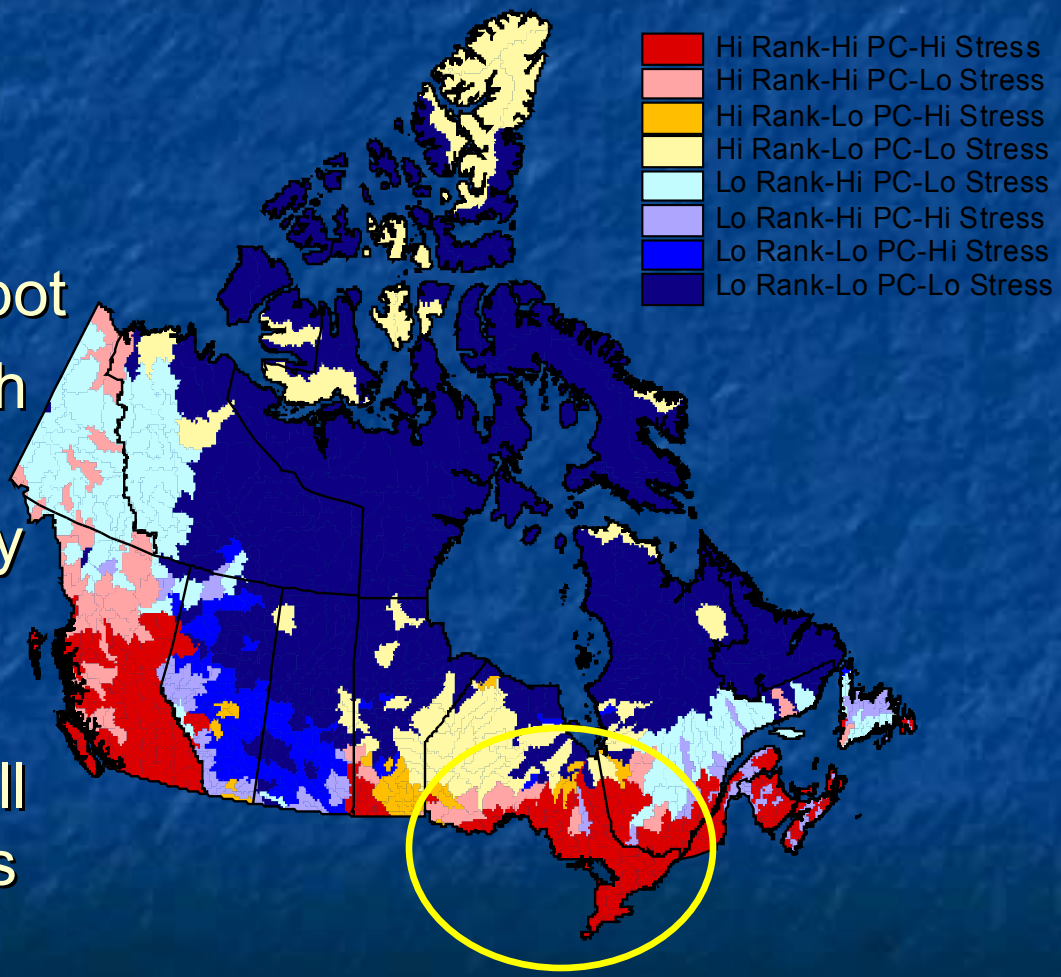




Midsummer thermal volume in the 8-12 C range
Inland lake trout lakes (area <=100 km2) in Ontario secondary watersheds
CCAF #968 Minns/Shuter et al. CLAM – Canadian Lakes Assessment Model

Biodiversity*Capacity*Stress

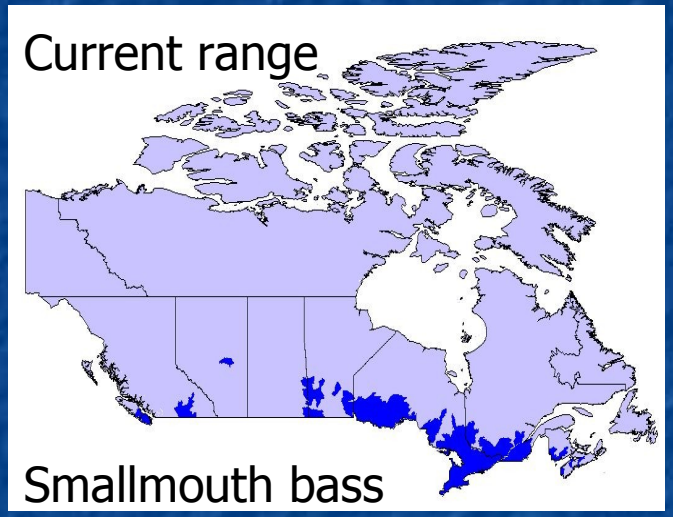
- Southern half of Ontario is a conservation hotspot
- Overlap of high fish biodiversity rank, productive capacity and human stress levels
- Climate change will add to the stresses

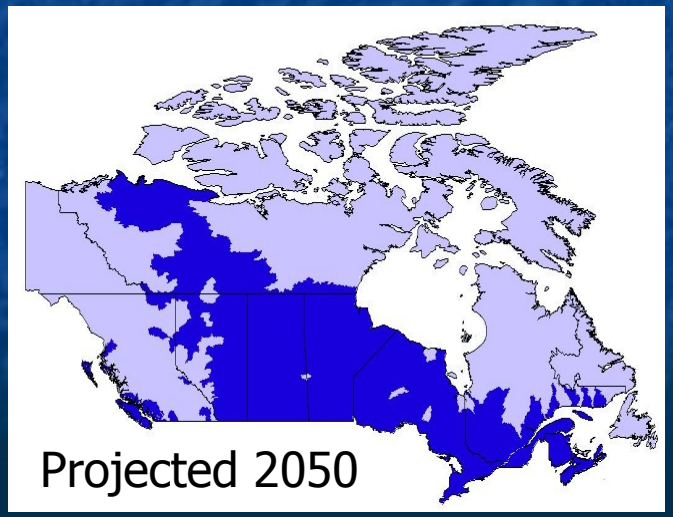


Chu et al CJFAS

Invasive species

- Smallmouth bass have already invaded many areas in Ontario since the 1930s' introductions
- There are many warmwater species, like bass, present in the Great Lakes basin poised to expand northward with climate change
- Competition and predation from invaders will increase problems for cold and cool native species
- Humans will likely continue to aid invasions to "improve" fisheries without regard to native species or ecosystem consequences





"The economy is a wholly owned subsidiary of the environment"

Ecosystem Pyramid

Quotation attrib. Gaylord Nelson

Think of freshwaters as a templet for ecosystems not as a commodity

- Climate trends
  - ➔ Hotter with both winter floods and summer droughts
- Demographic trends
  - ➔ Population growth in the Golden Horseshoe; outward expansion of suburbia; “paving paradise”
- Economic trends
  - ➔ Rising energy prices and post-peak oil; increasing local demand for recreation; continued de-industrialization
- Ecosystem trends
  - ➔ Human adaptation plans are generally based on **increased** management and exploitation of freshwaters
- “Sustainable Development” is a profound oxymoron

Future Choices and Options

- Prevention (Time is fast running out)
  - ➔ We need GHG reductions of 50-80% soon
- Mitigation (Making the best of it)
  - ➔ Trends toward the lowest common denominator
- Adaptation (Humans not ecosystems)
  - ➔ Ecosystems are not as adaptable as humans
- Do Nothing (Current government policy!)
  - ➔ We need more action and less politicking

Ecosystem Stewardship

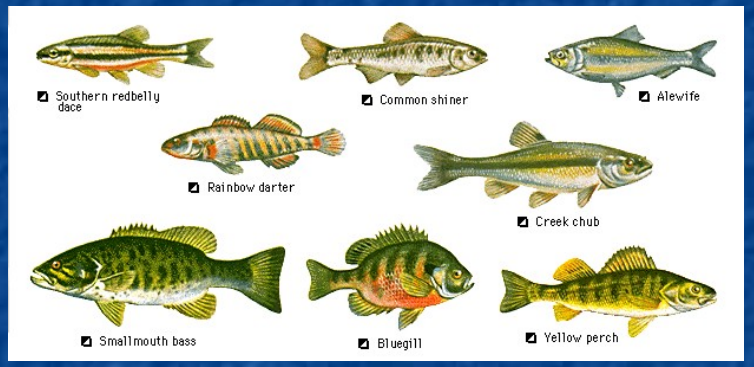
- As many first nations groups have indicated, humans are not owners of the Earth but rather stewards, or guardians.
- Most environmental agencies have good mandates and legislation to support actions to conserve and protect ecosystems but often lack the will to act.
- As individuals we are still beset by the difficult inner conflicts between comprehending the scope and severity of the problems we face with climate change and making the life-style choices which will undoubtedly make our lives less easy and comfortable though perhaps more fulfilling and meaningful.

Agency Stewardship Actions (1)

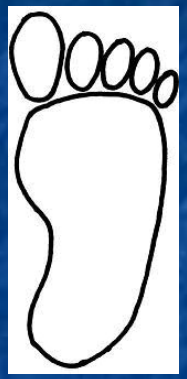
- Watersheds
  - ➔ A network of upland 4° reserves
  - ➔ Reforestation
  - ➔ Cap or reduce imperviousness and groundwater extraction
  - ➔ Limit or reduce network fragmentation
  - ➔ Block inter-basin water transfers
- Shorelines
  - ➔ Cap or reduce hardening and infilling
  - ➔ Restore and protect coastal wetlands
  - ➔ Limit development levels around lakes

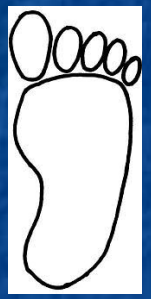
Agency Stewardship Actions (2)

- Fishes
  - ➔ Implement conservation and restoration plans for species-at-risk and biodiversity
  - ➔ Reduce sources of potential invasive species (bait buckets, live imports for food, trans-oceanic access to Great Lakes)
- Fisheries
  - ➔ Promote catch-release fishing
  - ➔ Reduce fishing access to limit effort (why is fishing allowed in national and provincial parks?)



Individual Stewardship Actions





- Life-style choices
  - ➔ Reduce your carbon and energy footprints
  - ➔ Consume less “stuff”; try the 100 mile diet
- Be informed and knowledgeable
  - ➔ Know your ecosystems and the issues
  - ➔ Share what you know with your community
  - ➔ Play your part in the democratic process
- Children and grand-children
  - ➔ Tackle the “nature-attention deficit”
  - ➔ They will inherit the consequences of the actions (or inaction?) of the next 5-10 years