

***ECOLOGICAL, OUTREACH, AND SUPPLY
SIDE INTEGRITY ISSUES ASSOCIATED WITH
PHYTOTECHNOLOGIES AND BROWNFIELD
REDEVELOPMENT***

A CANADIAN PERSPECTIVE

PRESENTED TO:

**USEPA APPLIED PHYTOTECHNOLOGIES
WORKSHOP**

CHICAGO, ILLINOIS

MARCH 4, 2003

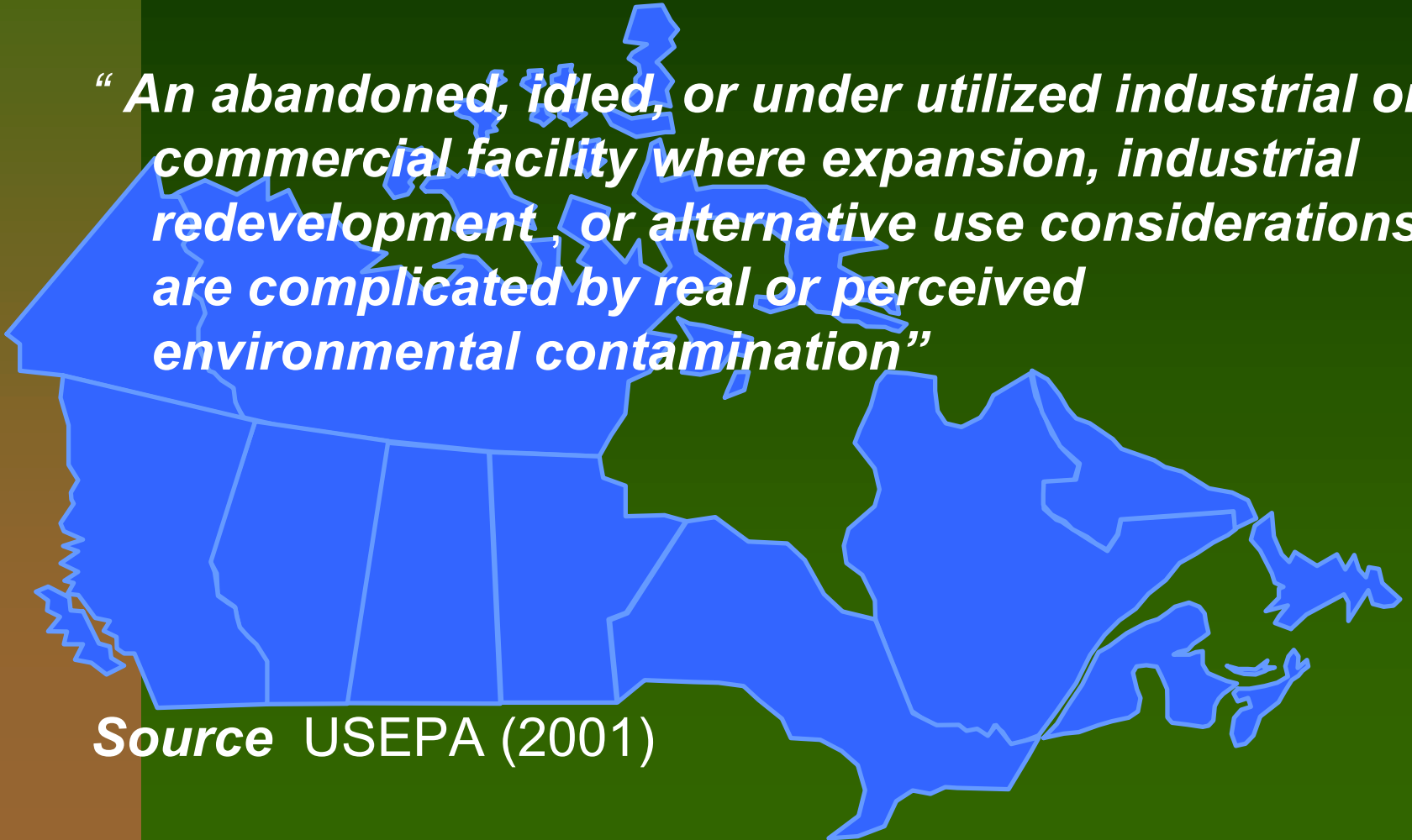
PURPOSE OF PRESENTATION

- **Outline extent of Brownfield contamination in Canada**
- **Introduce forces shaping and catalyzing Brownfield remediation and redevelopment**
- **Demonstrate environmental opportunities and challenges agenda associated with the use of phytotechnologies for Brownfield remediation / revitalization**
- **Share with you how Environment Canada is responding to opportunity / challenge agenda**
- **Set the stage for discussions of future R & D needs and priorities**

BROWNFIELD DEFINITION

“ An abandoned, idled, or under utilized industrial or commercial facility where expansion, industrial redevelopment , or alternative use considerations are complicated by real or perceived environmental contamination”

Source USEPA (2001)



TREMENDOUS NUMBER OF CONTAMINATED SITES IN CANADA

~ 75,000 to 90,000 petroleum contaminated sites in Western Canada

~ 5000 federal gov't contaminated sites

~ 10,000 abandoned mines with estimated \$6 billion clean up costs

~6000 abandoned mine tailing sites

~ 875 million tonnes of mining wastes capable of causing acid mine drainage

~185 million tonnes of radioactive tailings from uranium mines

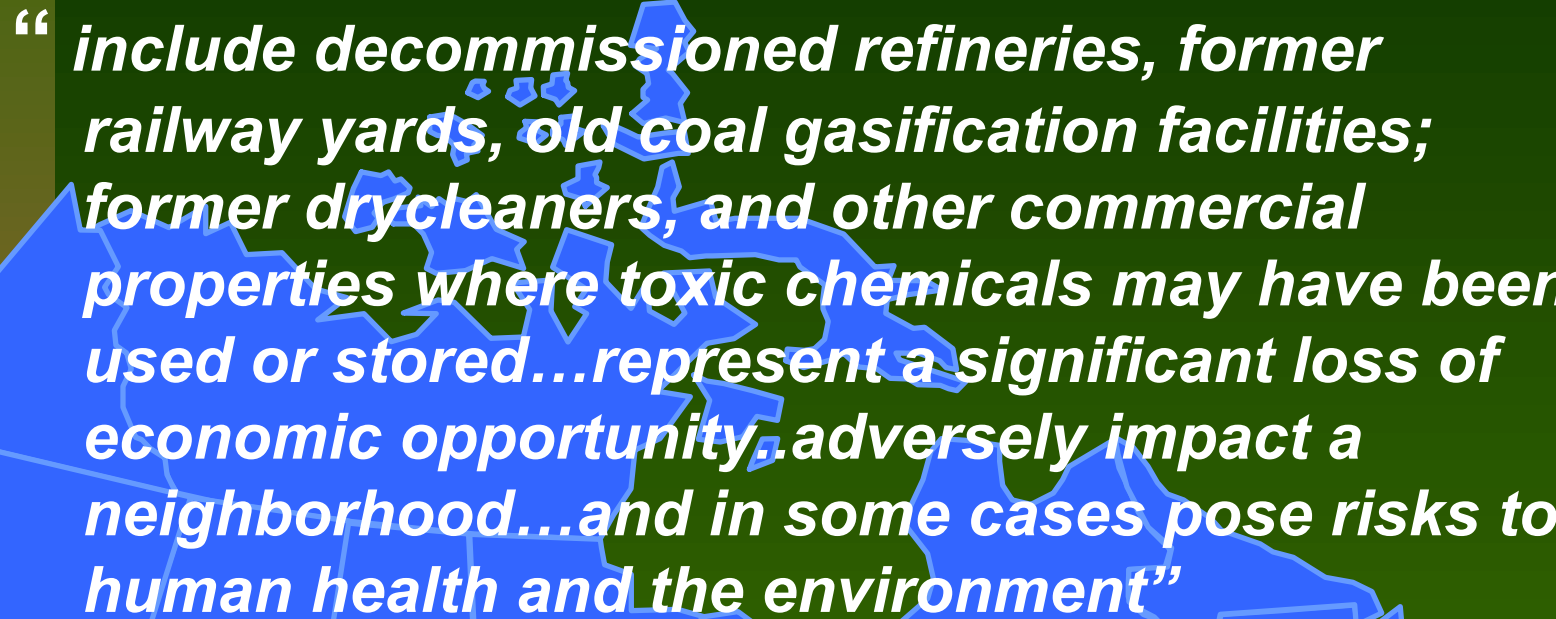
~30,000 provincial brownfield sites

Source CIELP (1995), Mining Watch Canada (2000) NCSWG (1998) (NRTEE 1999) (CCME 1997) (Pembina 2002) (Germida 2002) (NRTEE 2003)

NOT ALL BROWNFIELDS ARE CREATED EQUAL!

- **Top tier (15-20 %) have market values that greatly exceed the costs of remediation and do not remain abandoned for long periods of time**
- ***Bottom tier (15-20%) are properties where the cost of clean up far exceeds the value of land after remediation (utilizing traditional remediation tools)***
- ***Middle tier (60-70%) represents great challenge for Canadian remediation community (clean up costs high but so is potential for redevelopment particularly as many are previously serviced industrial sites)***

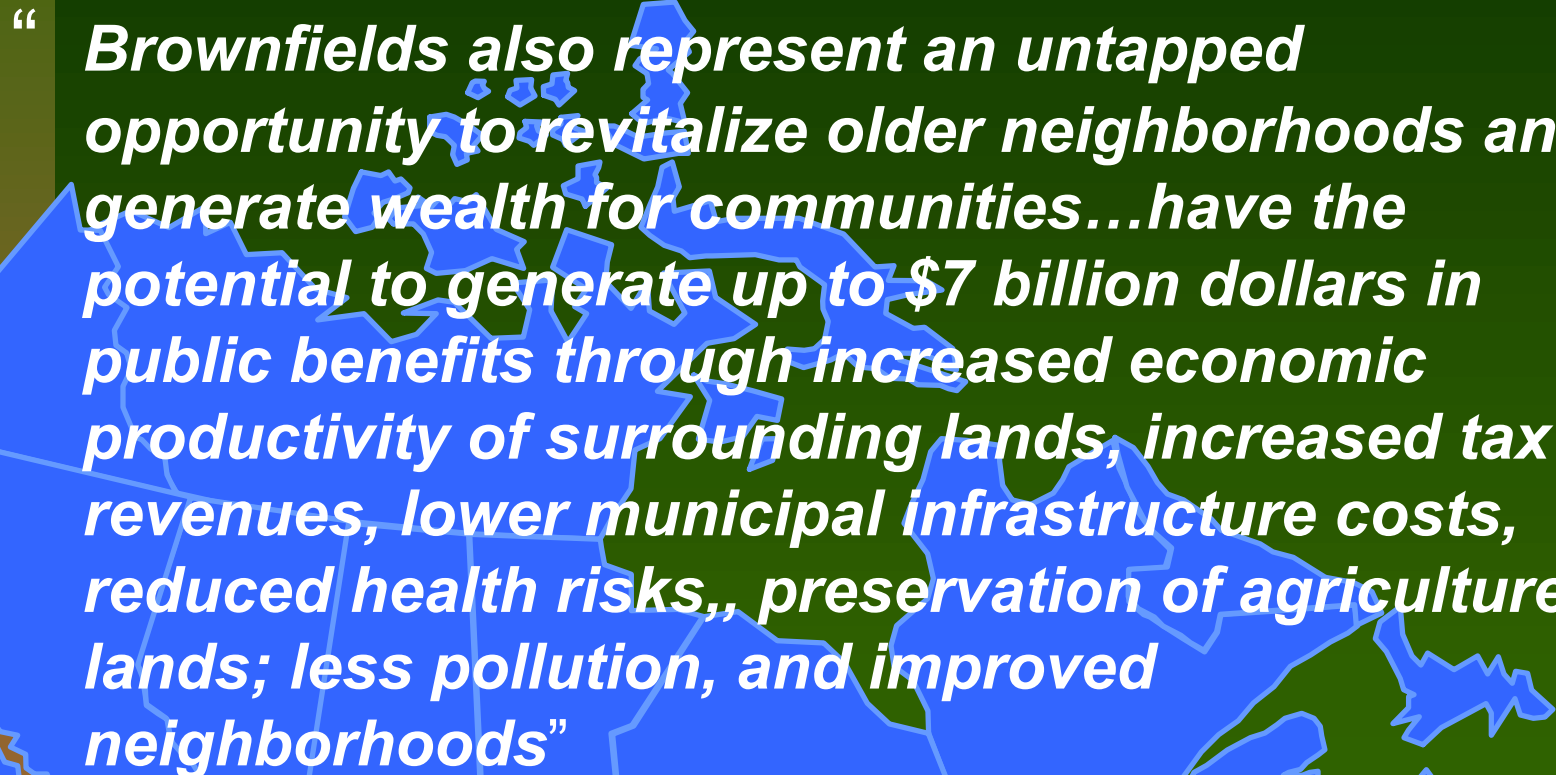
BROWNFIELDS DICHOTOMY



“ include decommissioned refineries, former railway yards, old coal gasification facilities; former drycleaners, and other commercial properties where toxic chemicals may have been used or stored...represent a significant loss of economic opportunity, adversely impact a neighborhood...and in some cases pose risks to human health and the environment”

Source (NRTEE 2003)

BROWNFIELDS DICHOTOMY



“ Brownfields also represent an untapped opportunity to revitalize older neighborhoods and generate wealth for communities...have the potential to generate up to \$7 billion dollars in public benefits through increased economic productivity of surrounding lands, increased tax revenues, lower municipal infrastructure costs, reduced health risks,, preservation of agriculture lands; less pollution, and improved neighborhoods”

Source Hara Associates (2003)

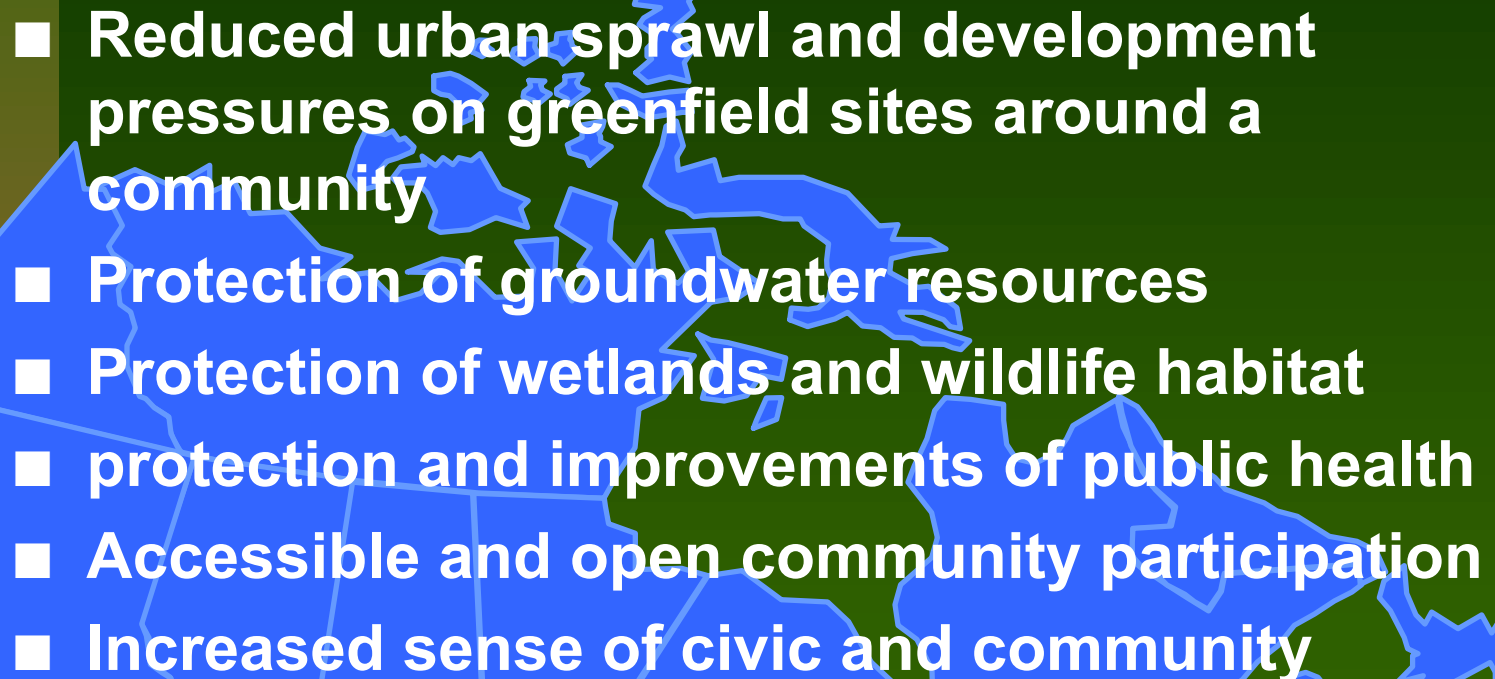
BENEFITS OF BROWNFIELDS REDEVELOPMENT

- Neighborhood, employment, and urban core revitalization
- Provision of affordable housing opportunities
- Improved aesthetic quality of the urban fabric
- Creation of parkland and public open space
- Improved public waterfront access
- Elimination of significant environmental hazards

Source NRTEE (2003)

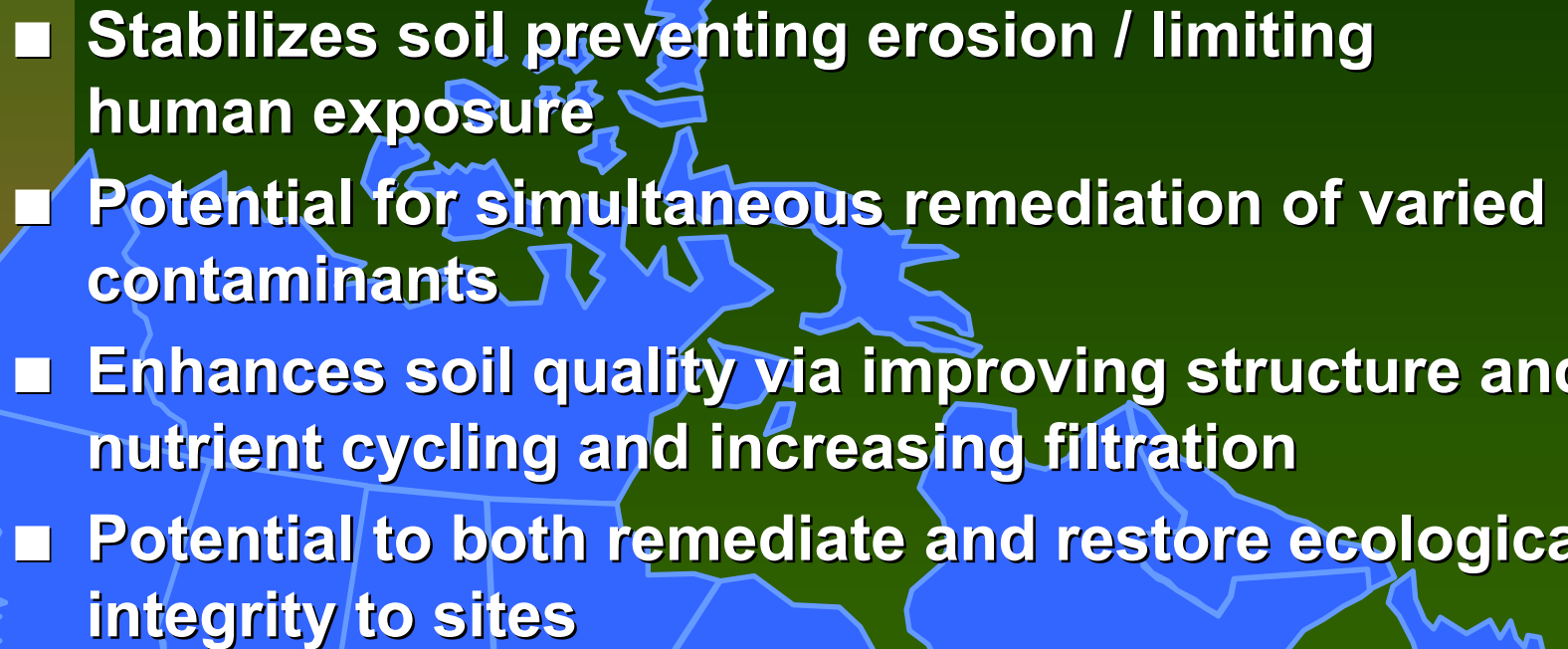
BENEFITS OF BROWNFIELD REDEVELOPMENT

(Cont.)

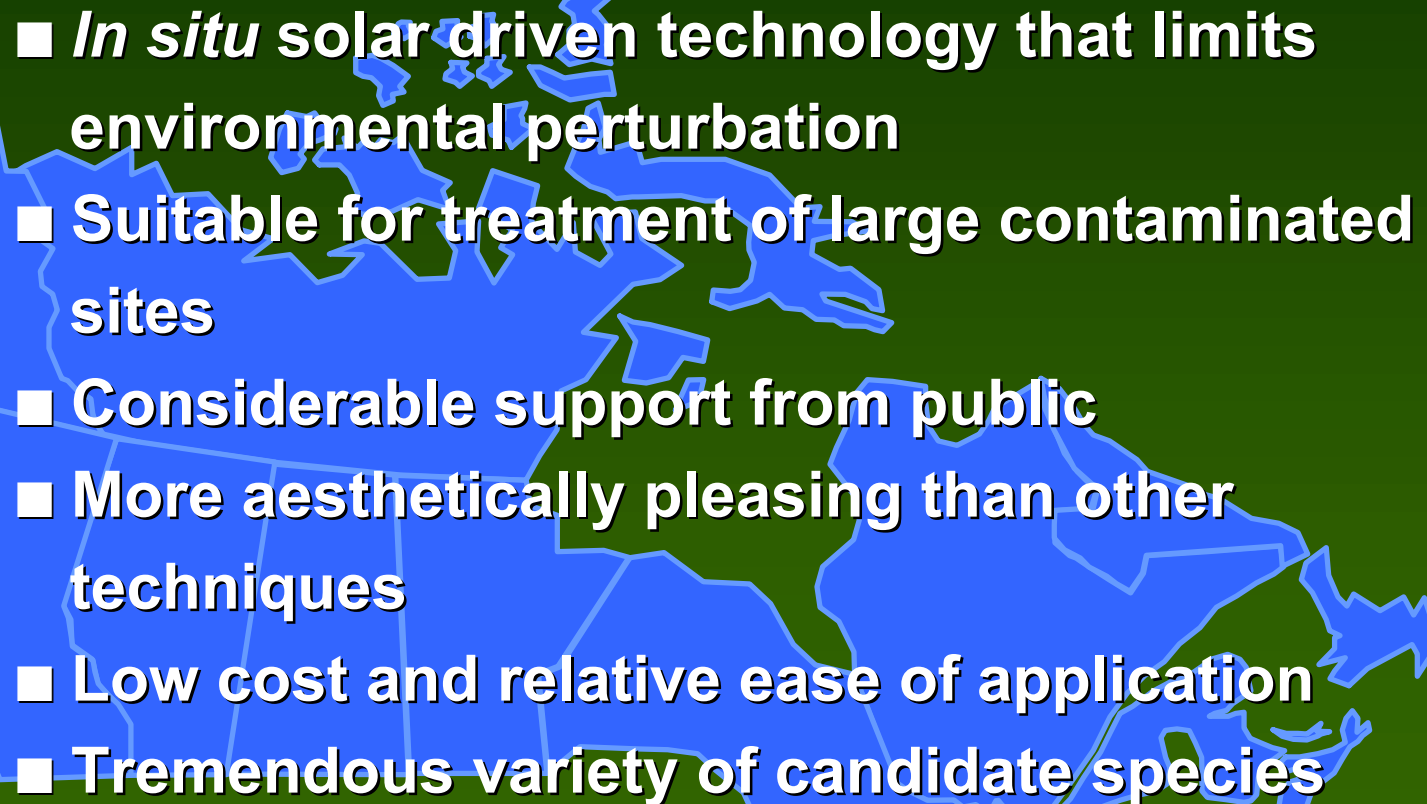
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- **Reduced urban sprawl and development pressures on greenfield sites around a community**
 - **Protection of groundwater resources**
 - **Protection of wetlands and wildlife habitat**
 - **protection and improvements of public health**
 - **Accessible and open community participation**
 - **Increased sense of civic and community**

Source (NRTEE 2003)

BENEFITS OF UTILIZING PLANT IN PHYTO - REMEDICATION / ECOLOGICAL RESTORATION

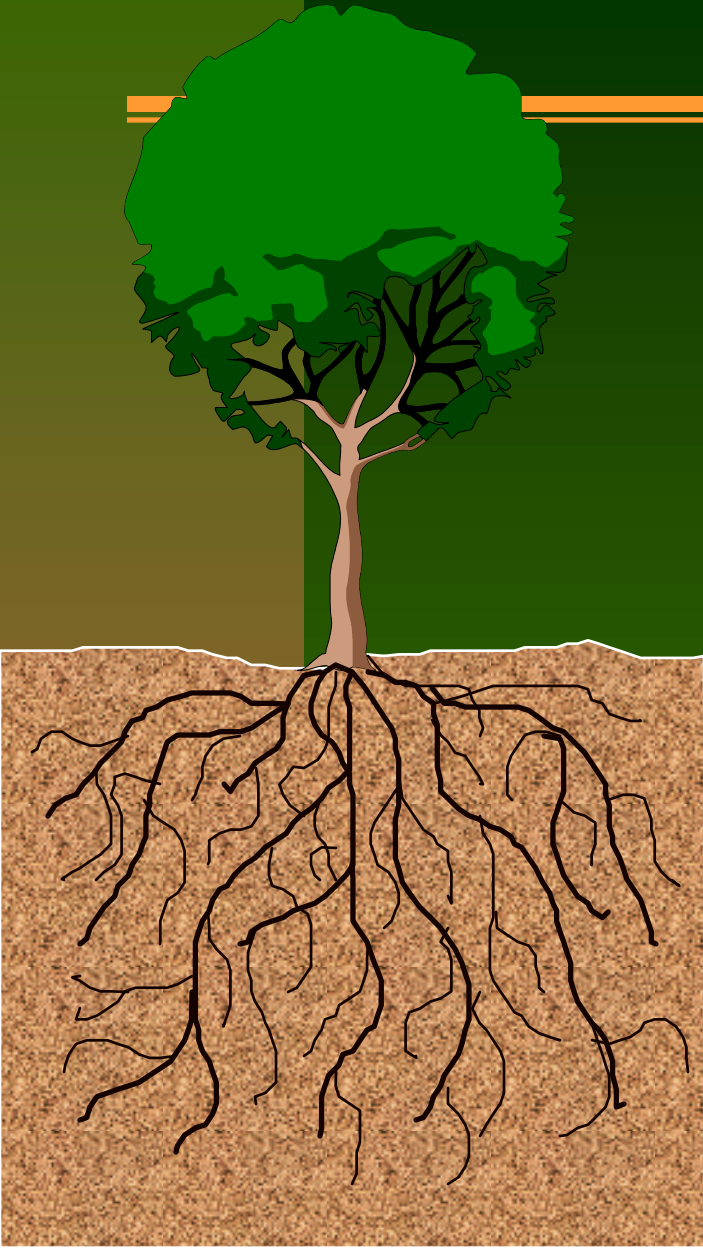
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- **Stabilizes soil preventing erosion / limiting human exposure**
 - **Potential for simultaneous remediation of varied contaminants**
 - **Enhances soil quality via improving structure and nutrient cycling and increasing filtration**
 - **Potential to both remediate and restore ecological integrity to sites**

BENEFITS OF UTILIZING PLANTS IN PHYTO - REMEDICATION / ECOLOGICAL RESTORATION

- 
- *In situ* solar driven technology that limits environmental perturbation
 - Suitable for treatment of large contaminated sites
 - Considerable support from public
 - More aesthetically pleasing than other techniques
 - Low cost and relative ease of application
 - Tremendous variety of candidate species

TREE-REMEDIATION

- ADVANTAGES -



- ① Perennial with long life spans,
- ② Extensive root mass and depth,
- ③ Large transpired roots,
- ④ Support growth of large number of soil microorganisms,
- ⑤ Potentially lowest cost plant type,
- ⑥ Keystone species in forest ecosystems,
- ⑦ Effective barriers to movement of contaminated groundwater,
- ⑧ Low maintenance.

WHY PHYTOREMEDIATION?

*Heavy Metals, Petroleum Hydrocarbons, Chlorinated Solvents
and Radionuclides*

◆ **LOW COST**

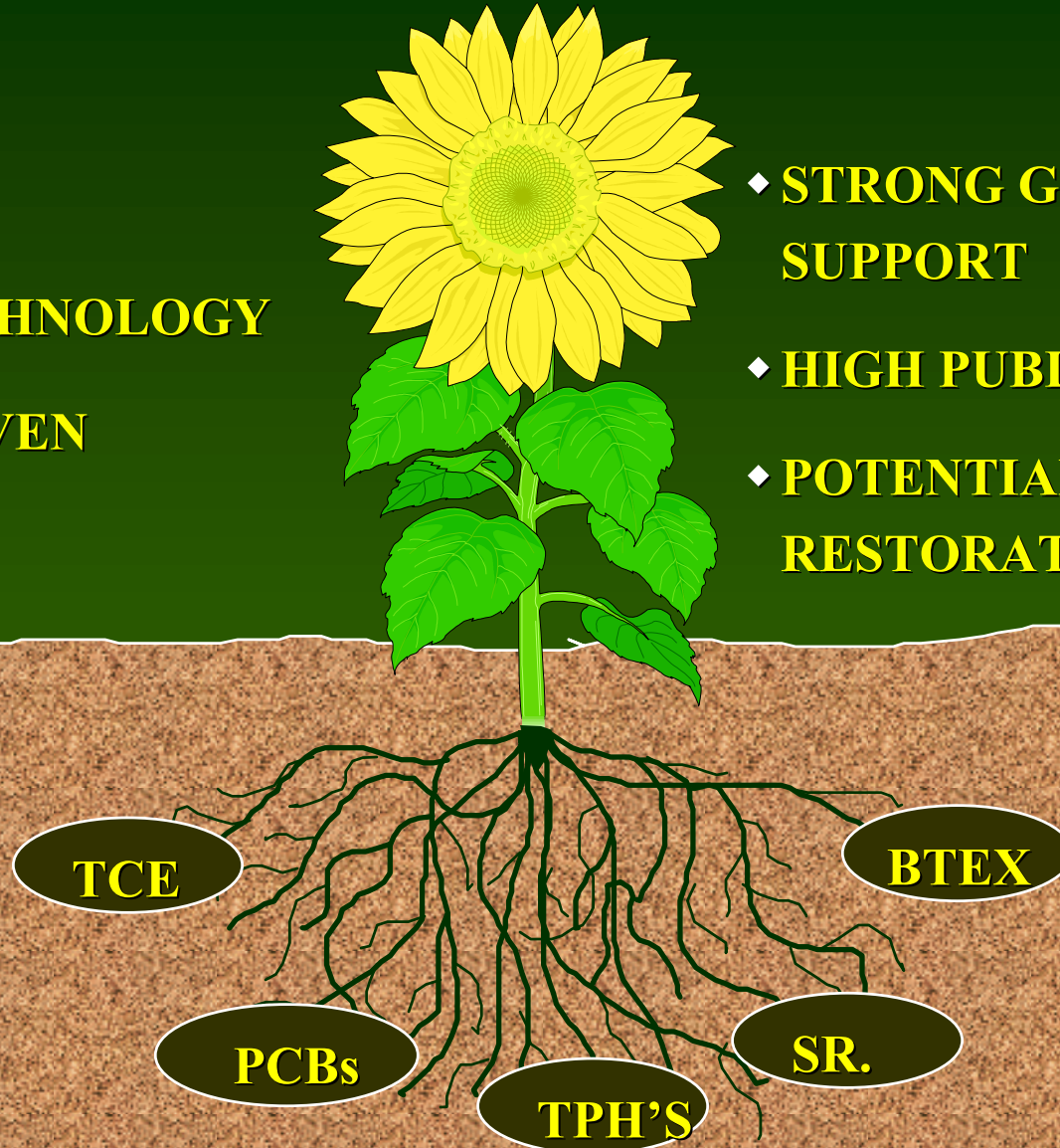
◆ **GREEN TECHNOLOGY**

◆ **SOLAR DRIVEN**


◆ **STRONG GOVERNMENT
SUPPORT**

◆ **HIGH PUBLIC SUPPORT**

◆ **POTENTIAL FOR
RESTORATION**



BROWNFIELD REDEVELOPMENT / PHYTOTECHNOLOGY UTILIZATION CONUNDRUM



“ If the benefits accruing from both use of phytotechnologies and for brownfield cleanup and restoration are both complementary, largely positive, and are so pronounced for the economy, society, and the environment, why are they not being utilized /cleaned up at a faster rate”?

IMPEDIMENTS TO BROWNFIELD REDEVELOPMENT

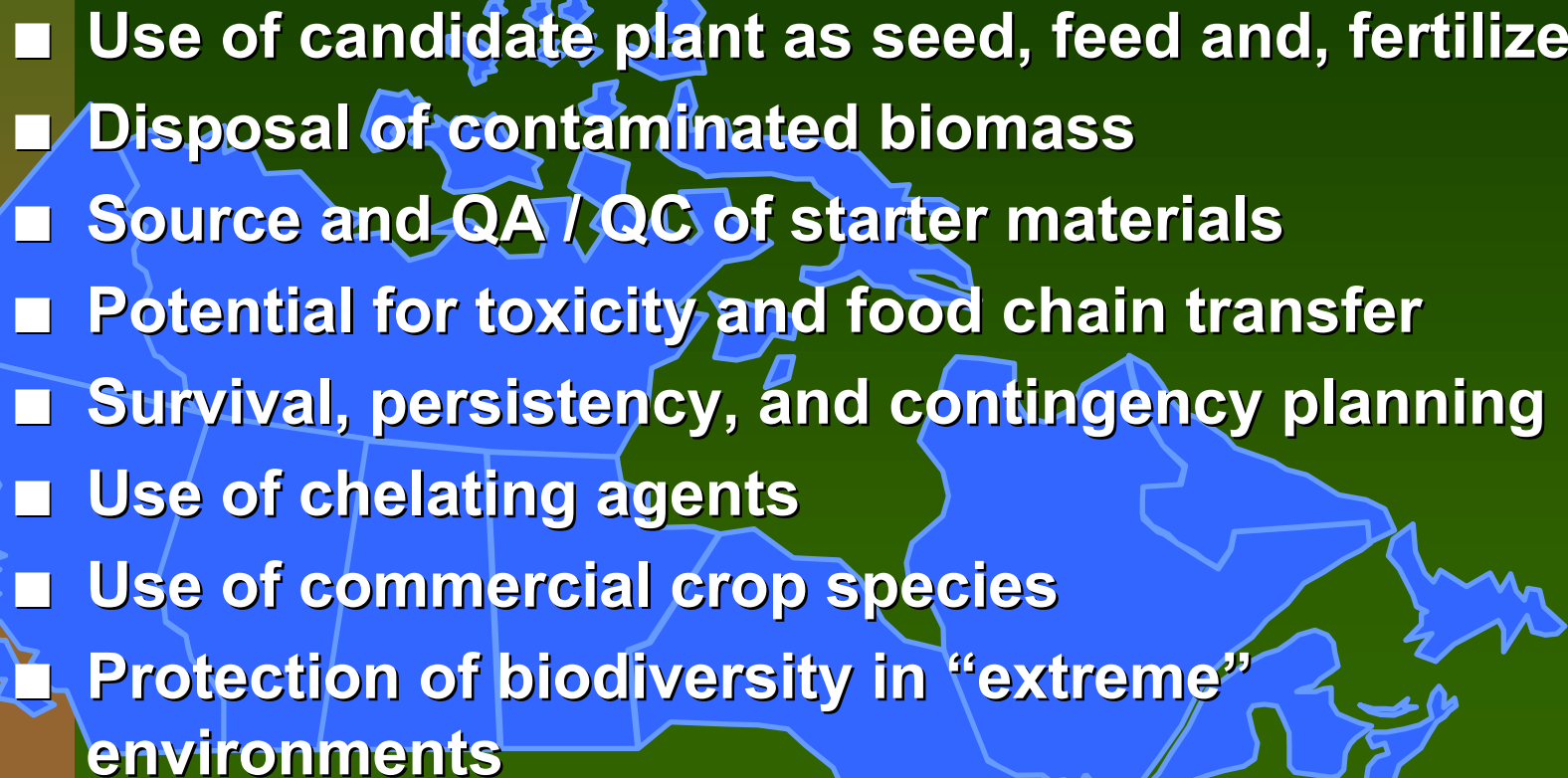
- lack of access to capital
- regulatory liability risk
- civil liability risk
- limited access to insurance protection
- stigma and risk perception
- ***regulatory uncertainty and delays***
- ***absence of low cost remediation technologies***
- ***limited awareness among decision makers of opportunities for redevelopment, best practices for remediation, or best available technologies***

Source (NRTEE 2003)


ISSUES RAISED BY PHYTOREMEDIATION / ECOLOGICAL RESTORATION

- Use of noxious weeds, poisonous plants, rare and endangered plants, alien species
- Use of species within the same genera
- Use of tree species and aquatic plants
- Genetically engineered cultivars
- Valuation, ownership, storage, protection, distribution, exploitation of biodiversity on contaminated sites
- Bioavailability and natural attenuation
- Risk of commercial exploitation

ISSUES RAISED BY PHYTOREMEDIATION / ECOLOGICAL RESTORATION

- 
- Use of candidate plant as seed, feed and, fertilizer
 - Disposal of contaminated biomass
 - Source and QA / QC of starter materials
 - Potential for toxicity and food chain transfer
 - Survival, persistency, and contingency planning
 - Use of chelating agents
 - Use of commercial crop species
 - Protection of biodiversity in “extreme” environments

ECOLOGICAL RESTORATION - POINTS TO CONSIDER (1)



“Ecological restoration is a science in its infancy and not surprisingly, still has teething problems... most of these stem from the need to understand extraordinary complex ecosystems... ecosystems are not more complex than you think, they are more complex than you can think!”

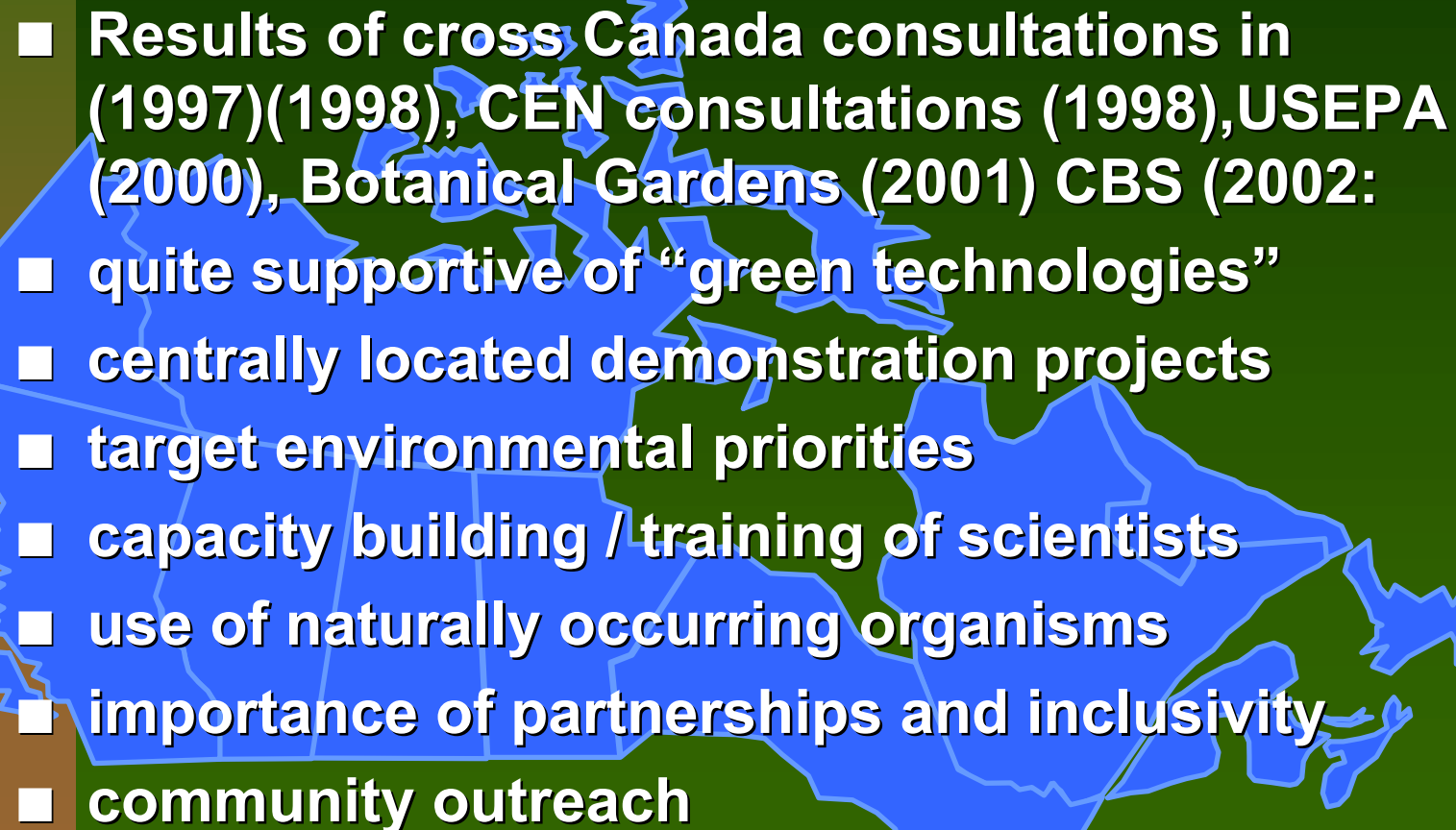
Source Niering (1997)

ECOLOGICAL RESTORATION- POINTS TO CONSIDER (2)

“ Unless we learn how to improve our understanding of how to restore ecosystems, we ought to be very careful about destroying them... where damage has already been done however, restoration is the only option, and each demonstration adds much needed information about the process of reconstruction”

Source American Academy for Advancement of Science (1997)

DERIVATION OF ENVIRONMENT CANADA ROLE IN PHYTOTECHNOLOGY DEVELOPMENT

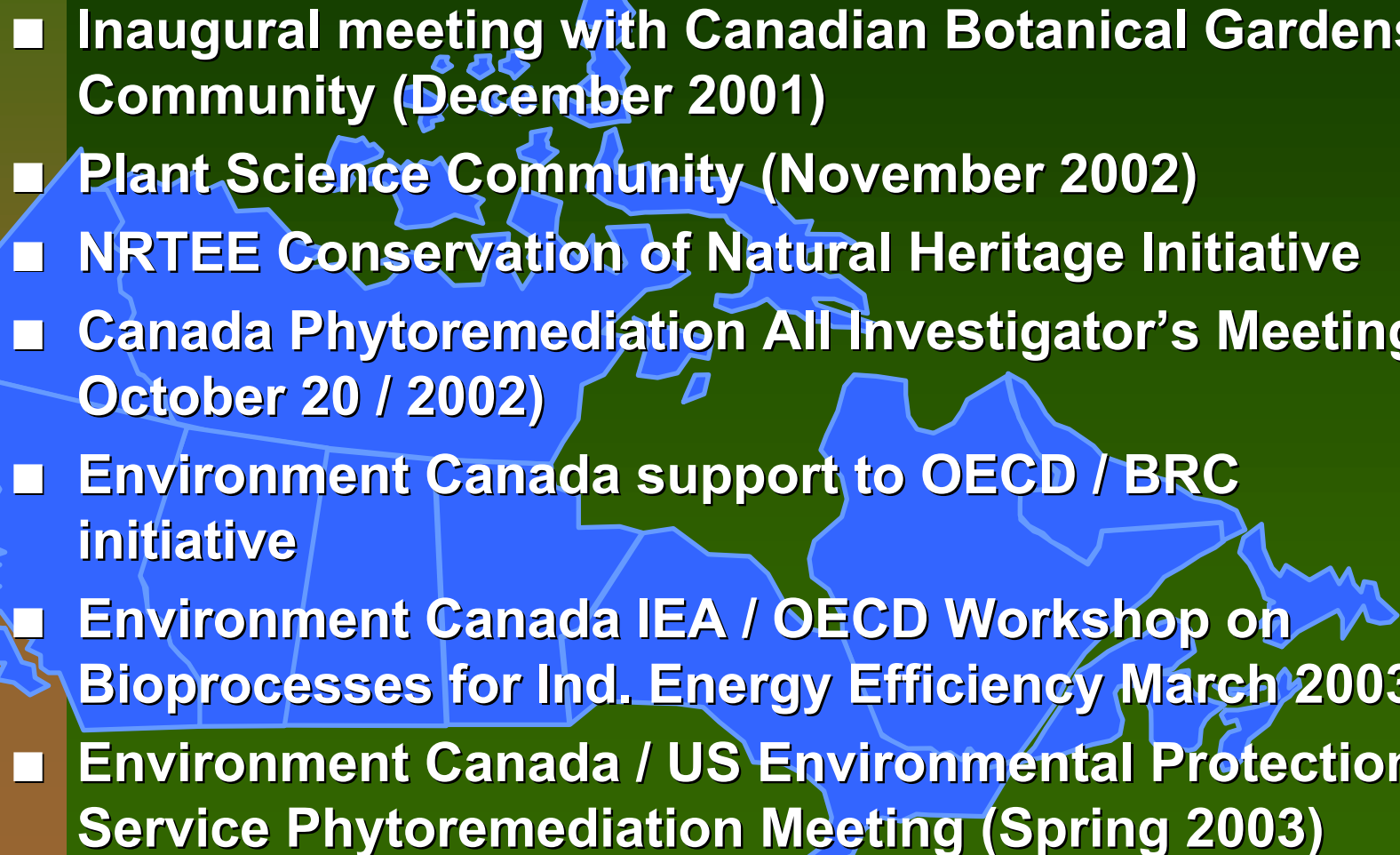
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- Results of cross Canada consultations in (1997)(1998), CEN consultations (1998), USEPA (2000), Botanical Gardens (2001) CBS (2002:
 - quite supportive of “green technologies”
 - centrally located demonstration projects
 - target environmental priorities
 - capacity building / training of scientists
 - use of naturally occurring organisms
 - importance of partnerships and inclusivity
 - community outreach

ENVIRONMENT CANADA RESPONSES

Partnerships, consultations, demonstration projects, capacity building and due diligence:

- Vegetative surveys (PHYTOPet, PHYTORem, PHYTONox, PHYTOChem, PHYTORad, PHYTOSolv)
- North American demonstration projects
- EC / USEPA Phytoremediation Workshop (2000)
- KEW Gardens Roundtable on Phytoremediation 2001
- UNEP responsible use protocols in development
- Forensic botany and contaminated sites
- Proposed collaboration on Green Legacy initiative
- Workshop with Ontario MOEE Standards Branch

ENVIRONMENT CANADA RESPONSES (2)

- 
- Inaugural meeting with Canadian Botanical Gardens Community (December 2001)
 - Plant Science Community (November 2002)
 - NRTEE Conservation of Natural Heritage Initiative
 - Canada Phytoremediation All Investigator's Meeting (October 20 / 2002)
 - Environment Canada support to OECD / BRC initiative
 - Environment Canada IEA / OECD Workshop on Bioprocesses for Ind. Energy Efficiency March 2003
 - Environment Canada / US Environmental Protection Service Phytoremediation Meeting (Spring 2003)

INDUSTRIAL AND ENVIRONMENTAL PLANT PROGRAM EVOLUTION - 1998

- **Development of an ten part plant based program focusing on :**
 - Identification of candidate phytoremediation cultivars
 - Ecological and supply side integrity of starter materials
 - Forensic ecology and botany in extreme environments
 - Due diligence and appropriate regulatory oversight
 - Potential of plant biotechnology techniques for enhancement
 - Protocols and strategic research
 - Limited small scale demonstration work
 - Community outreach / technology transfer
 - Plant germplasm storage, protection, distribution, access
 - International capacity building

PHYTOREMEDIATION

Plant-based Systems for Remediating or Restoring Petroleum Contaminated Sites



Jim Germida & Rich Farrell

germida@sask.usask.ca



PHYTOPET®

*A Database of Plants that Play a Role in the
Phytoremediation of Petroleum Hydrocarbons*

Look Up Phytoremediation Information By:

**Petroleum
Hydrocarbon**

**Plant Groups:
Phytoremediate
or Tolerate**

Individual Plant

**Mechanism of
Phytoremediation**

**Multiple
Queries**

Plant Details

References

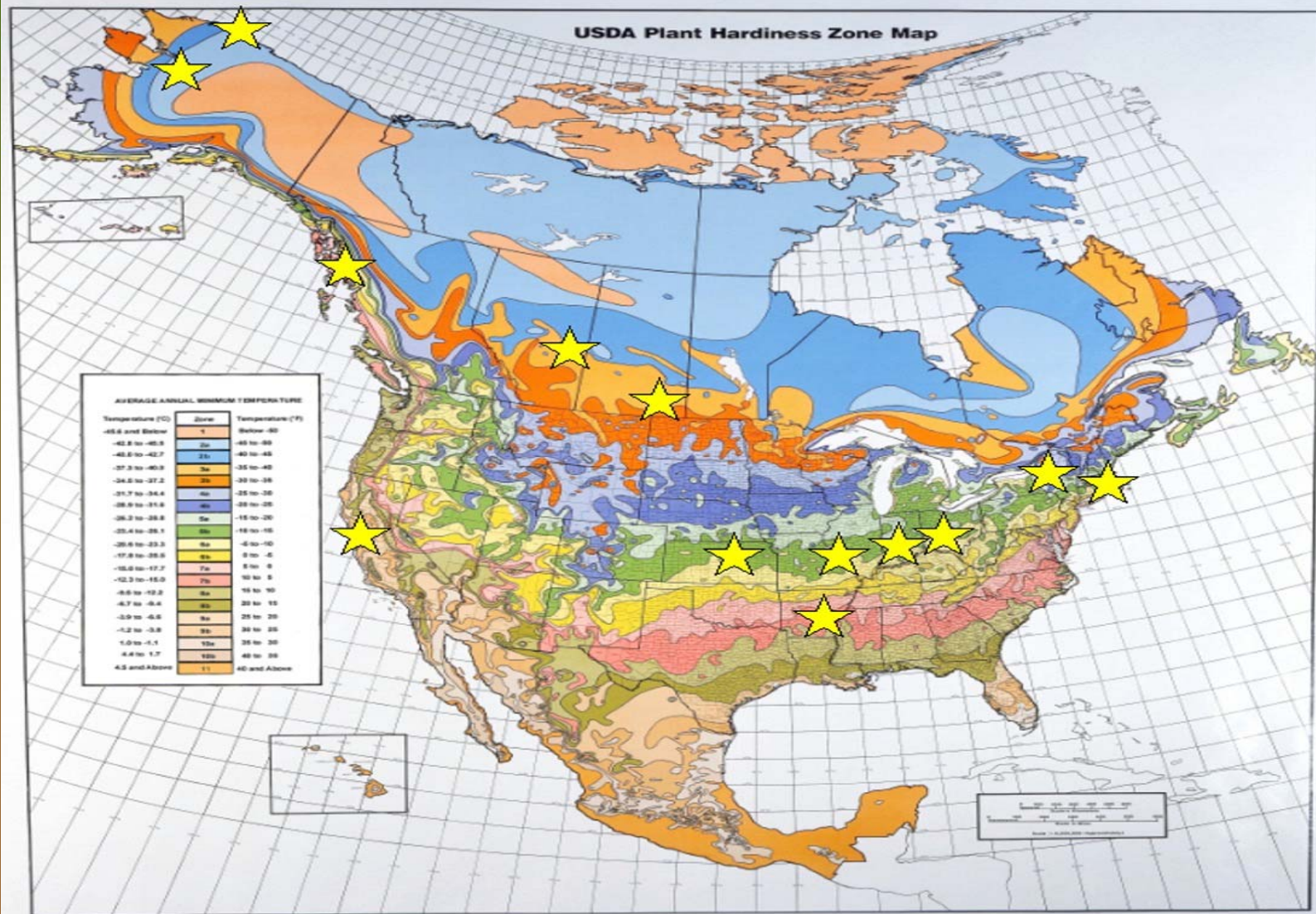
**Add / Edit
Information**

**About this
Database...**

**EXIT
PHYTOPET®**

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ENVIRONMENT CANADA / USEPA RTDF DEMONSTRATION SITES



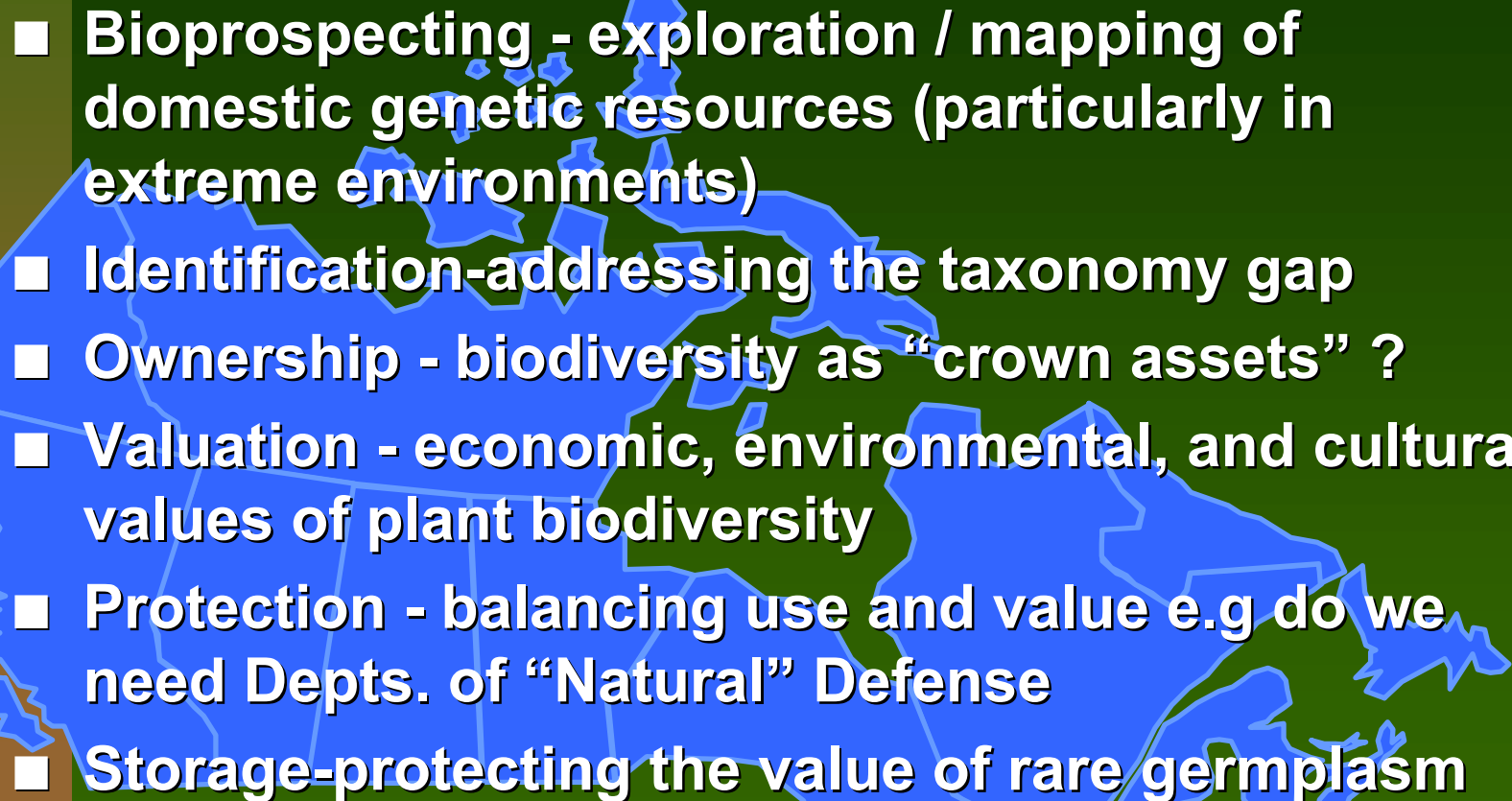
ENVIRONMENT CANADA SPONSORED PHYTOREMEDIATION OF METALS PROJECTS



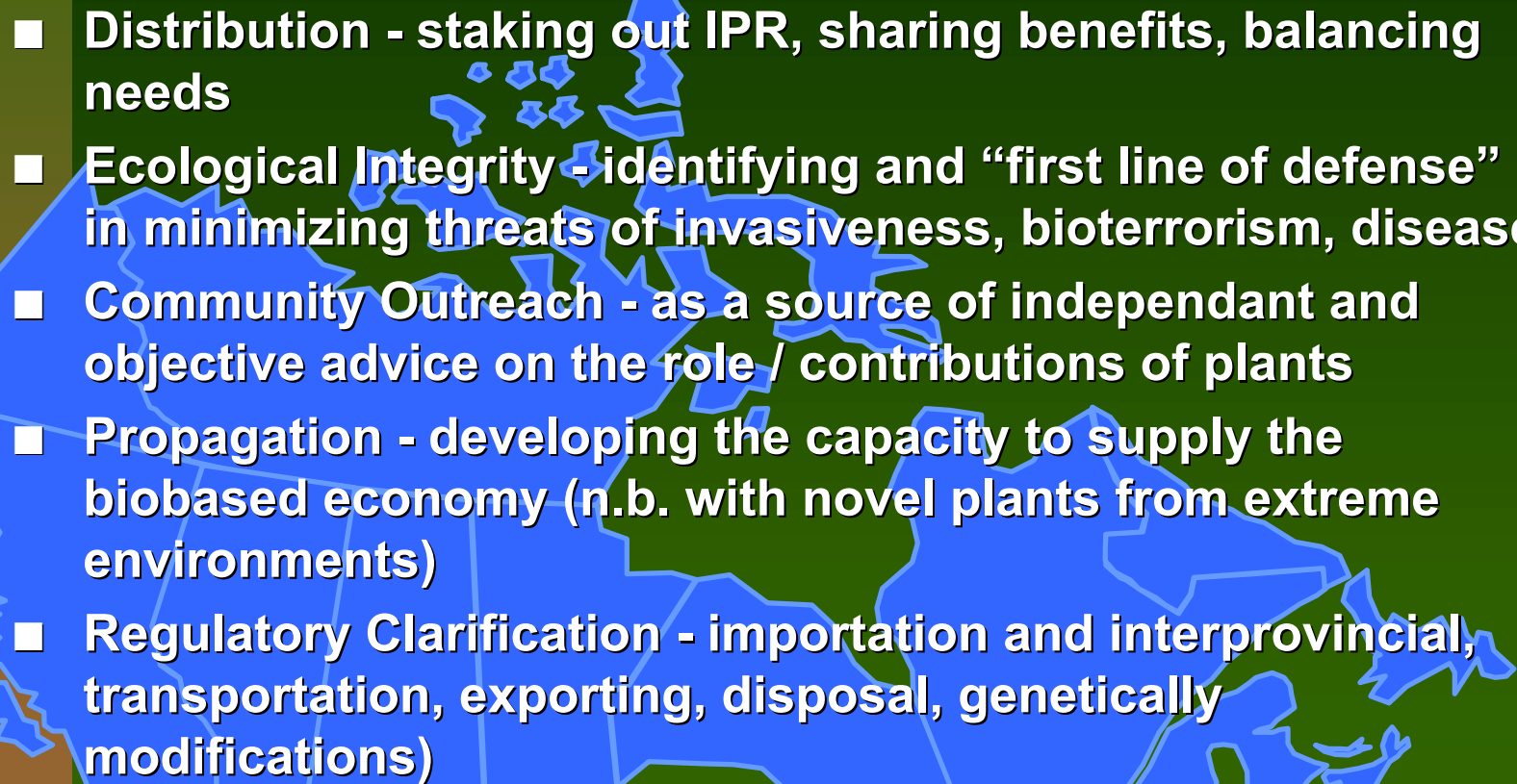
ENVIRONMENT CANADA SUPPORTED CONSTRUCTED WETLANDS RESEARCH



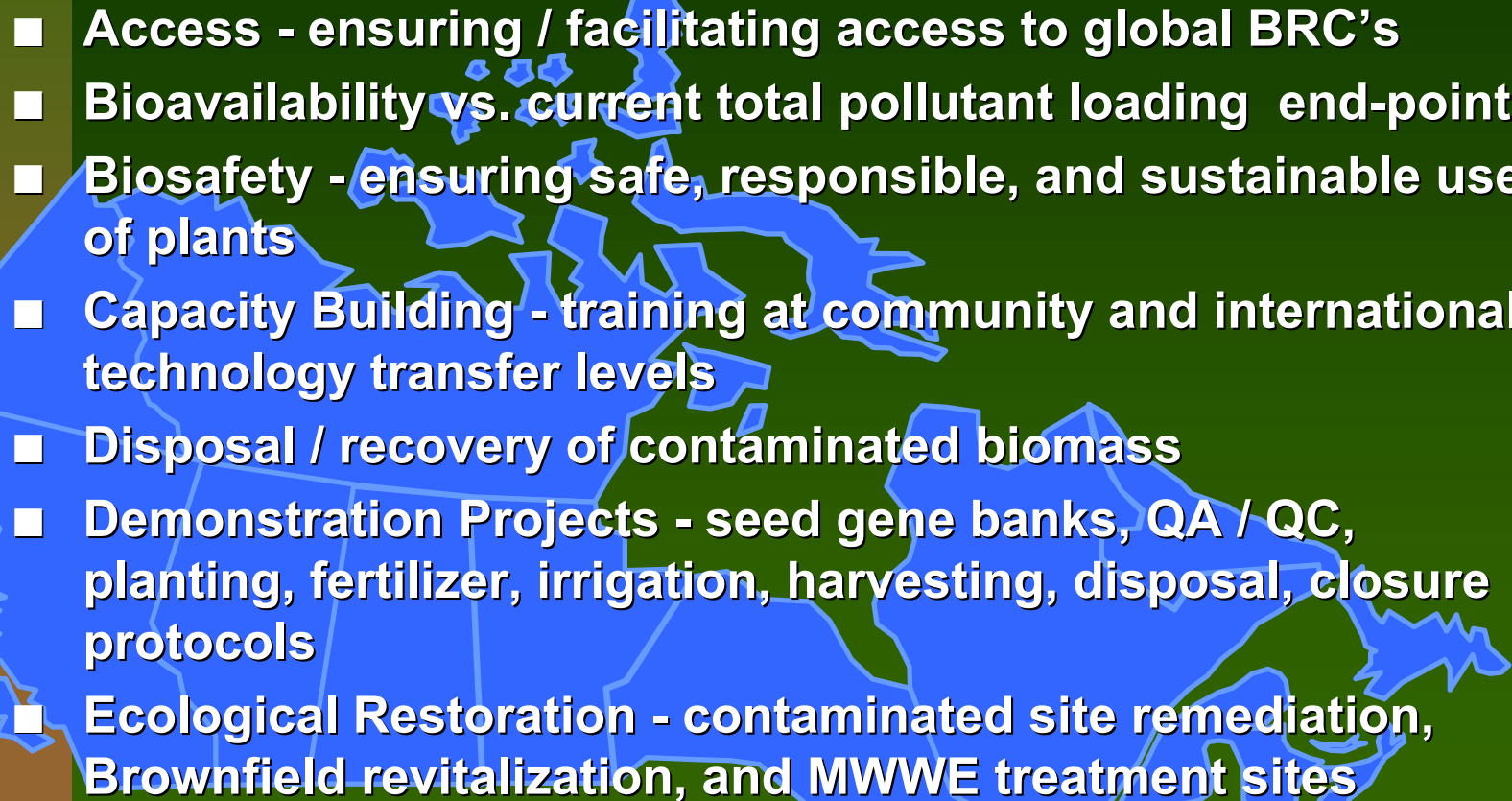
SPECIFIC FUTURE OPPORTUNITY AND CHALLENGE AGENDA FOR PLANT SCIENTISTS

- 
- **Bioprospecting** - exploration / mapping of domestic genetic resources (particularly in extreme environments)
 - **Identification**-addressing the taxonomy gap
 - **Ownership** - biodiversity as “crown assets” ?
 - **Valuation** - economic, environmental, and cultural values of plant biodiversity
 - **Protection** - balancing use and value e.g do we need Depts. of “Natural” Defense
 - **Storage**-protecting the value of rare germplasm

SPECIFIC FUTURE OPPORTUNITY AND CHALLENGE AGENDA FOR PLANT SCIENTISTS

- 
- **Distribution** - staking out IPR, sharing benefits, balancing needs
 - **Ecological Integrity** - identifying and “first line of defense” in minimizing threats of invasiveness, bioterrorism, disease
 - **Community Outreach** - as a source of independent and objective advice on the role / contributions of plants
 - **Propagation** - developing the capacity to supply the biobased economy (n.b. with novel plants from extreme environments)
 - **Regulatory Clarification** - importation and interprovincial, transportation, exporting, disposal, genetically modifications)

SPECIFIC FUTURE OPPORTUNITY AND CHALLENGE AGENDA FOR PLANT SCIENTISTS

- 
- **Access** - ensuring / facilitating access to global BRC's
 - **Bioavailability** vs. current total pollutant loading end-point
 - **Biosafety** - ensuring safe, responsible, and sustainable use of plants
 - **Capacity Building** - training at community and international technology transfer levels
 - **Disposal / recovery of contaminated biomass**
 - **Demonstration Projects** - seed gene banks, QA / QC, planting, fertilizer, irrigation, harvesting, disposal, closure protocols
 - **Ecological Restoration** - contaminated site remediation, Brownfield revitalization, and MWWE treatment sites

CLOSING COMMENTS

- There are no “single problems” in Brownfield redevelopment / ecological restoration in North America
- There are no “single solutions” for Brownfield redevelopment / ecological restoration in North America
- Selected Brownfield sites represent unique opportunities to showcase the potential for plants in site remediation, restoration, and revitalization as well as accelerate selected site clean - up and reutilization

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