Sustainable Re-vegetation: A Multi-disciplined Approach

Sébastien Marquis; Tim Boudreau

ROCHON ENVIRONMENTAL

Atlantic Reclamation Conference, Wolfville NS, October, 2014

Re-vegetation Projects

Re-vegetation: Multi-Faceted vs. Single

Multi-faceted Approach

- Different, indigenous plant varieties
- Already acclimated to local conditions
- Requires detailed design & monitoring

Single Approach

- Single plant variety (e.g., sodding, hydro-seeding, saplings)
- Typically from nursery or sterile, hybrid stocks
- May or may not top dress
- Apply and leave process (hope for the best)

Re-vegetation Sustainability Challenges

- **Contaminants presence / absence**
- **Current ecosystem present**
- **Parasites, pests, disease, bad fungal attack**
- **Climate / Seasonality**
- **Geography / Topography**
- **Geology / Hydrogeology**

If planned for in advance, the effects of these can be diminished

SINGLE (simple) APPROACH

ADVANTAGES

- Can be used in hard-to-reach places
- Completed quickly; fast service
- Rapid land stability
- Often seems acutely cost-efficient

DOWNSIDES

- Quick vegetation may be unhealthy
- shallow-rooted = slumping
- No growth monitoring
- High probability of losses due to pest, disease, weather
- May not be cost-efficient in long-term

MULTI-DISCIPLINED APPROACH

ADVANTAGES

- Greatly improved survival rates
- Seed propagation often at year-1
- Natural colonization of other biological assemblages
- increased biodiversity
- Monitoring plan
- Often cost-efficient in long-term

DOWNSIDES

- Complex planning
- Plant collection/sowing
- Establishment can be slower
- Seems expensive in the short-term (hard sell to clients)

Multi-faceted Approach Considerations

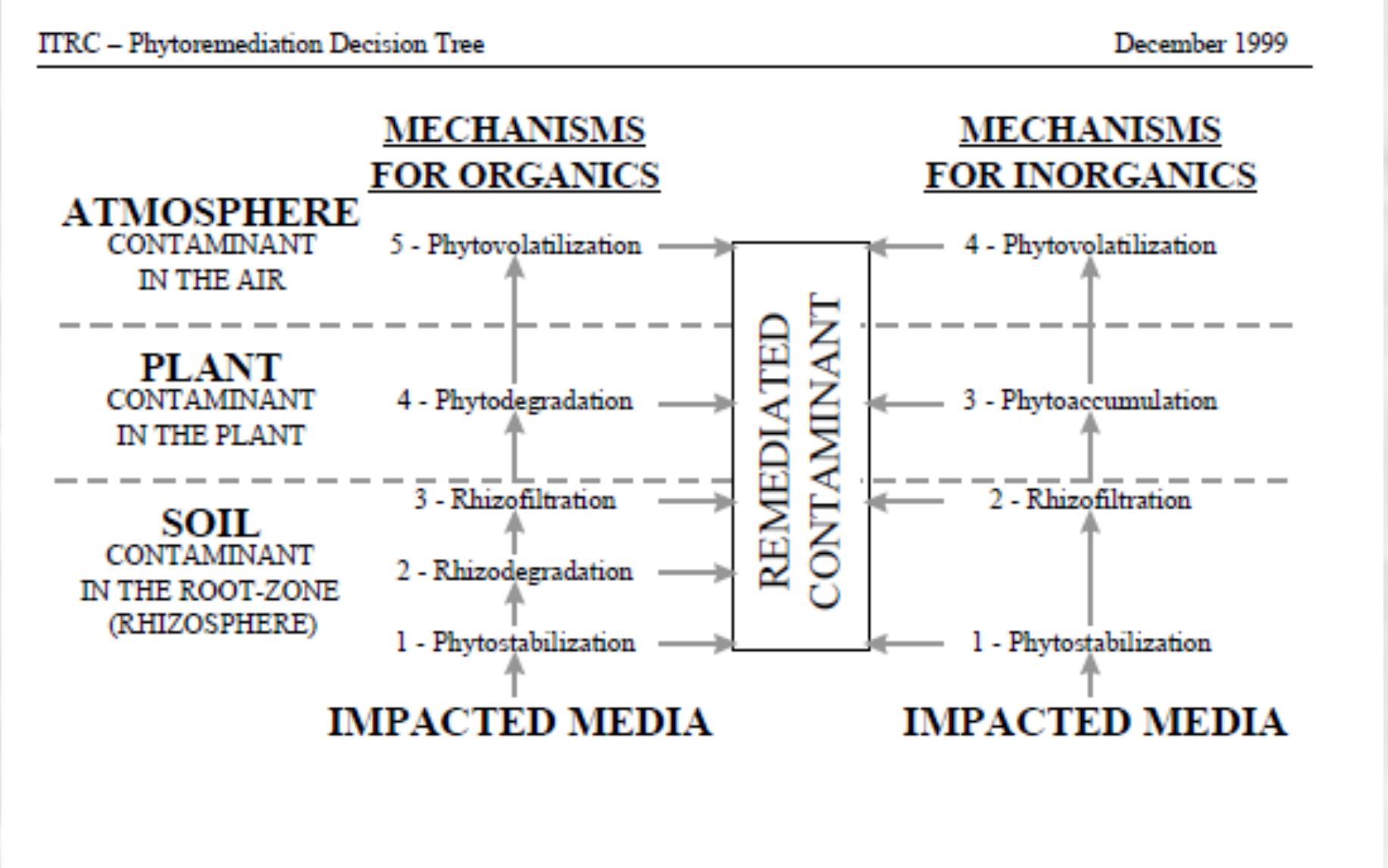
Soil Preparation

- *Soil type*
- *Moisture / drainage*
- *Fertility / dterility*
- *Soil condition (pH, etc)*
- *Organic content*
- *Insect WEB*
- *Mycelium presence/ absence*

Botanical Selection

- *Relevant habitats*
- *Remedial approach (decision tree)*
- *Local, indigenous species*
- *Need for phytoremediative species*
- *Species hardiness*
- *Pollinators*
- *Introducing foraging wildlife*
- *Biological indicators*
- *Collection and planting / sowing*

Re-vegetation Tools (phytoremediation)

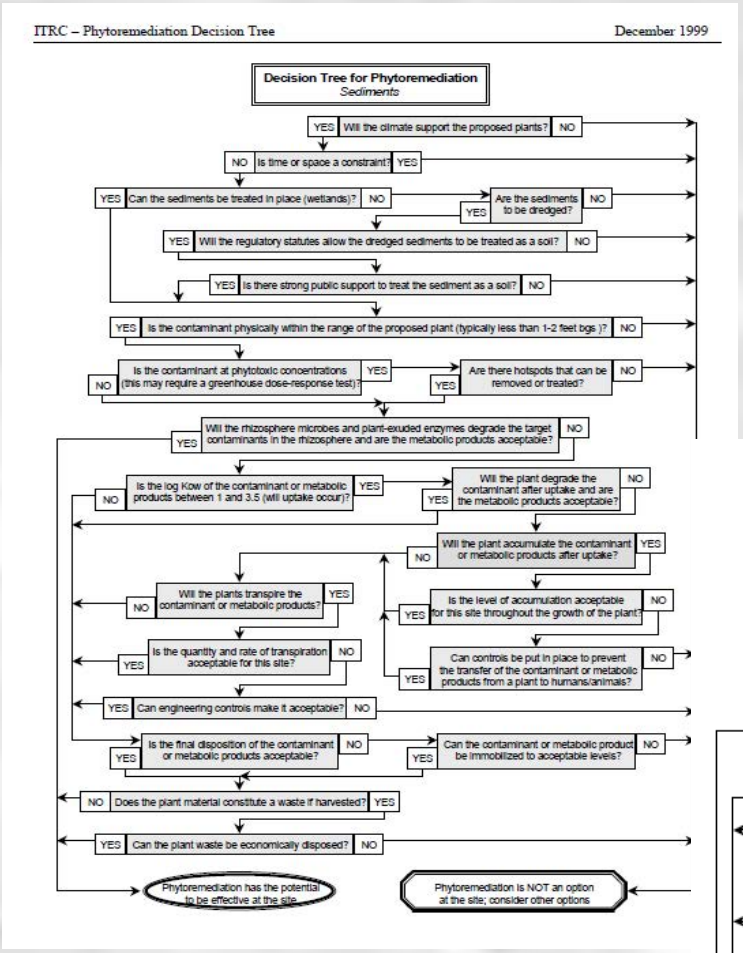


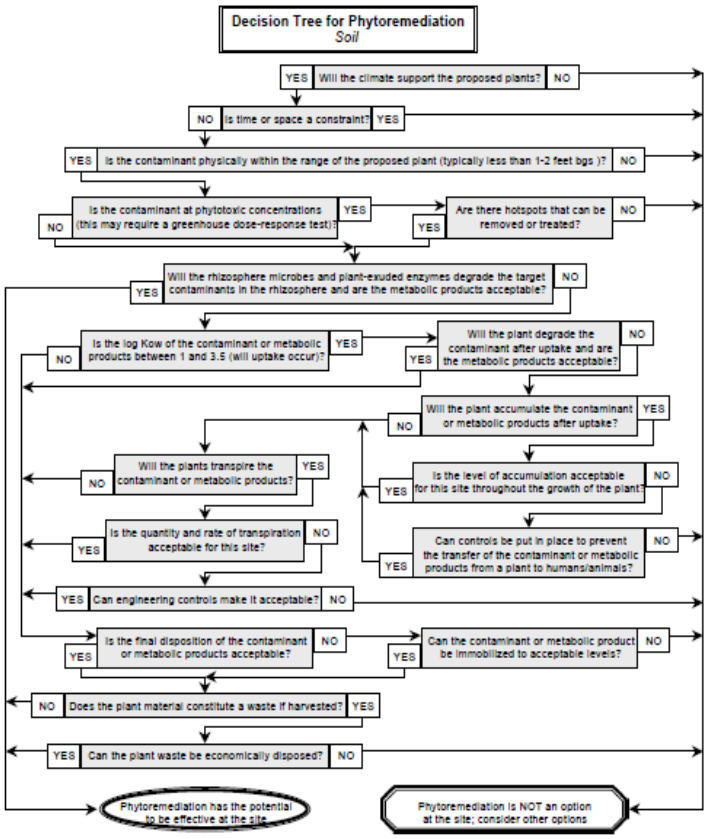
Phytoremediation Tools

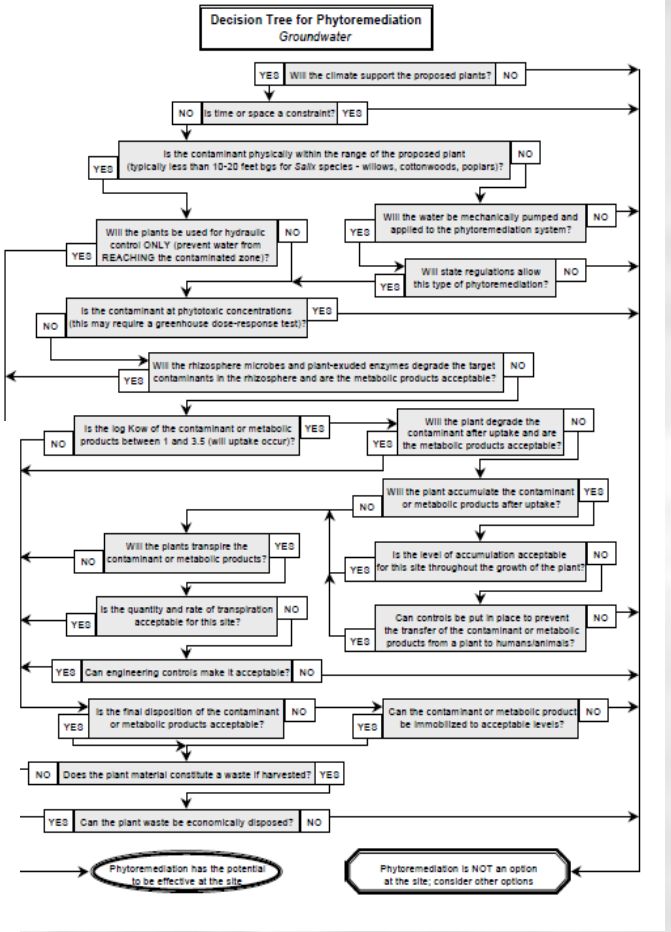
Table 1-1: Types of Phytoremediation for Organic Compounds

Type of Phytoremediation	*Process Involved*	*Contaminant Treated**
1 – Phytostabilization	Plants control pH, soil gases, and redox conditions in soil to immobilize contaminants. Humification of some organic compounds is expected.	Expected for phenols, chlorinated solvents (tetrachloromethane and trichloromethane), and hydrophobic organic compounds
2 - Rhizodegradation, phytostimulation, rhizosphere bioremediation, or plant-assisted bioremediation	Plant exudates, root necrosis, and other processes provide organic carbon and nutrients to spur soil bacteria growth by two or more orders of magnitude. Exudates stimulate degradation by mycorrhizal fungi and microbes. Live roots can pump oxygen to aerobes and dead roots may support anaerobes.	Polyaromatic hydrocarbons, BTEX, and other petroleum hydrocarbons, perchlorate, atrazine, alachlor, polychlorinated biphenyl (PCB), and other organic compounds
3 - Rhizofiltration or contaminant uptake	Compounds taken up or sorbed by roots (or sorbed to algae and bacteria)	Hydrophobic organic chemicals
4 - Phytodegradation or phytotransformation	Aquatic and terrestrial plants take up, store, and biochemically degrade selected organic compounds to harmless byproducts, products used to create new plant biomass, or byproducts that are further broken down by microbes and other processes to less harmful products. Reductive and oxidative enzymes may be used in series in different parts of the plant.	Munitions (TNT, DNT, HMX, nitrobenzene, picric acid, nitrotoluene), atrazine, halogenated compounds (tetrachloromethane, trichloromethane, hexachloroethane, carbon tetrachloride, TCE, tetrachloroethane, dichloroethane), DDT and other chlorine and phosphorus based pesticides, phenols, and nitrites.
5 - Phytovolatilization	Volatile organic compounds are taken up and transpired. Some recalcitrant organic compounds are more easily degraded in the atmosphere (photodegradation).	Chlorinated solvents (tetrachloromethane and trichloromethane), organic VOCs, BTEX, MTBE

Re-vegetation Decision Trees







The Case Study

Land and Swamp Reclamation Overview

Project Details

- Trucking oil spill contaminated 2 habitats a Meadow (2,600m^2) and Swamp (900m^2)
- Remedial Action: creation of a Wetland and Meadow after bulk contaminant removal
- Geology: mineral-rich (Al, Fe, Mn, Zn) soil, low organic content
- Re-vegetation design included phytoremediation (treatment of residuals)
- Implemented in Autumn
- $480,000 cost for reclamation and monitoring phase

Site-Specific Botanical Selections

Terrestrial
8 plants,
4 trees,
3 fungal types,
4 seed varieties

Table 3: Wetland Botanical Function and Enumeration (May 2011).

Common Name	*Latin* Name	General Function(s)	Individual Counts Cell 1	Cell 2	Cell 3
Terrestrial					
Red-Osier dogwood	*Cornus sericea*	Land stabilization, HC segregation	8	6	2
Black spruce	*Picea mariana*	Land stabilization, hydraulic control	8	5	18
Yellow and grey birch	*Betula alleghaniensis, B. populifolia*	Land stabilization, hydraulic control	1	2	3
Atlantic goldenrod	*Solidago arguta*	Metals remediation, salt resistance	64	44	51
Goose-tongue plantain	*Plantago maritime*	Soil enhancement, hydraulic control	-	23	15
Evening Nightshade	*Solanum spp*	Swale stabilization	5	8	10
Wild carrots	*Daucus carota*	Metal/HC remediation, stabilization	64	22	20
Sweet fern	*Comptonia peregrina*	Hydraulic control, berm stabilization, metals remediation, nutrients	9	5	3
Mycological plugs	*Boletus spp., Conocybe spp., Amanita spp.*	Fungal and bacterial enhancement of virgin soils, bioremediation	360	200	200
Rye, clover, fescue seed-stock	*Secale cereale, Trifolium*	Land stabilization, phytoremediation	15 lbs.	10 lbs	10 lbs
Riparian					
Willow	*Salix spp.*	Bank stabilization, HC remediation	26	19	24
Bulrush	*Scirpus validus, S. fluviatilis, S. campestris*	Hydrocarbon remediation, salt resistance, bacterial enhancement	21	12	-
Soft Rush	*Juncus effusus*	HC remediation, bank stabilization	-	5	16
Aquatic					
Duck Potato	*Sagittaria lancifolia*	WQ, bio-monitor	-	13	5
American water plantain	*Alisma subcordatum*	Metals/HC remediation, WQ	9	25	12
Ribbon Grass	*Vallisneria americanai*	WQ, bio-monitor	3	32	12
Ribbon grass seed stock	" "	" "	-	2 Lbs	
Cattails	*Typha spp*	Hydrocarbon remediation, bacterial enhancement, silt recovery, WQ	41	-	62
Water lily	*Nuphar variegatum*	Metals phytoremediation, WQ	-	19	9
Bur-reed	*Sparganium americana*	WQ, bacterial enhancement	5	5	
Aquatic water milfoil	*Myriophyllum sibiricm*	WQ, hydrocarbon segregation	popul	popul	popul
Bladderwort	*Urticularia vulgaris*	Mosquito control, WQ	popul	popul	popul
Plant Total			264	245	262
Plant Total plus fungal counts			624	445	462

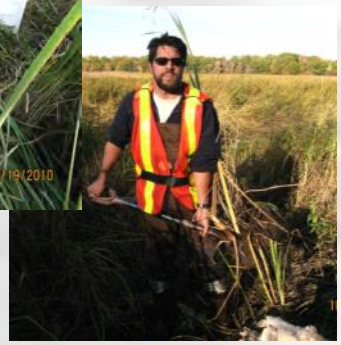
Multiple Activities

Soil Reinstatement and Landscaping

Mycelium Inoculation

Seed Sowing

Indigenous Plant Collection



100m radius

Planting / Sowing

1 Acre = 4 Men, 7 Days

Naturally Sustainable Evolution

Monitoring

Day 0

8 Months

16 Months

Naturally Sustainable Evolution

Terrestrial Ecosystem

Implementation

8 Months

20 Months

Aquatic and Riparian Ecosystems

Added Benefits

Natural biota colonization

Aesthetics / recreational use

Biological Balance

Sustainable bio-remediation

CONCRETE RESULTS

ANY QUESTIONS?

ROCHON ENVIRONMENTAL