Harnessing Natural Processes:

Effective strategies for reclamation of drastically disturbed sites

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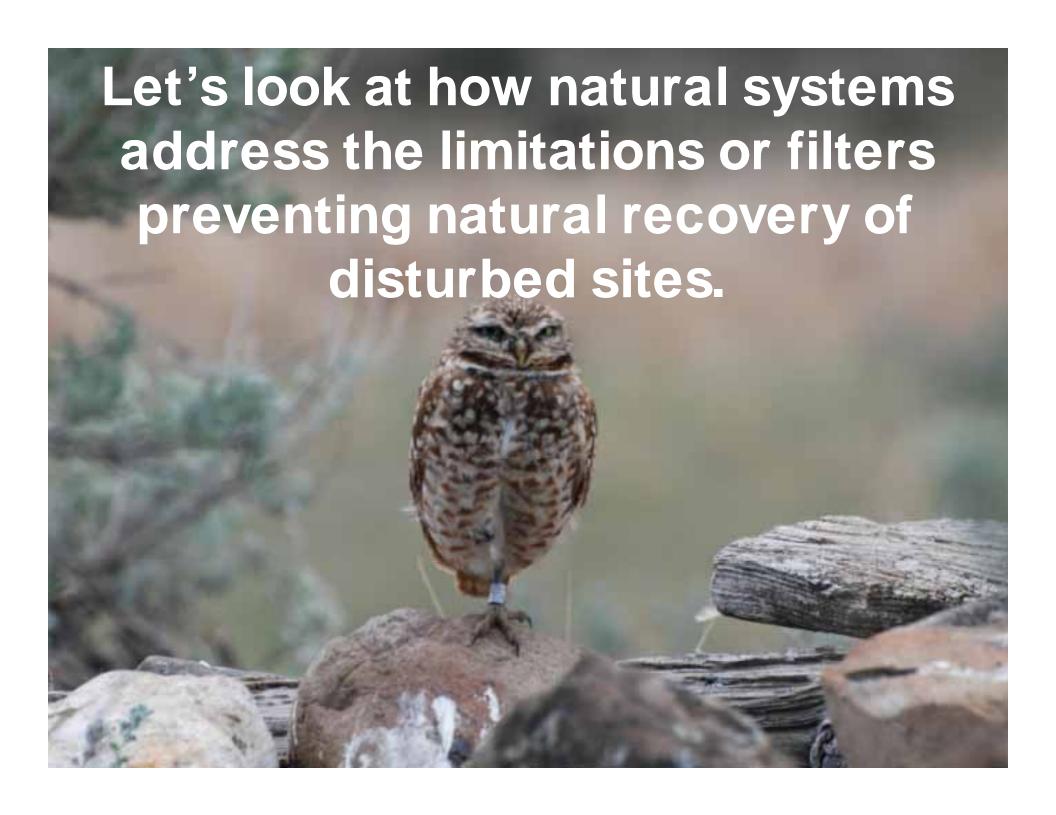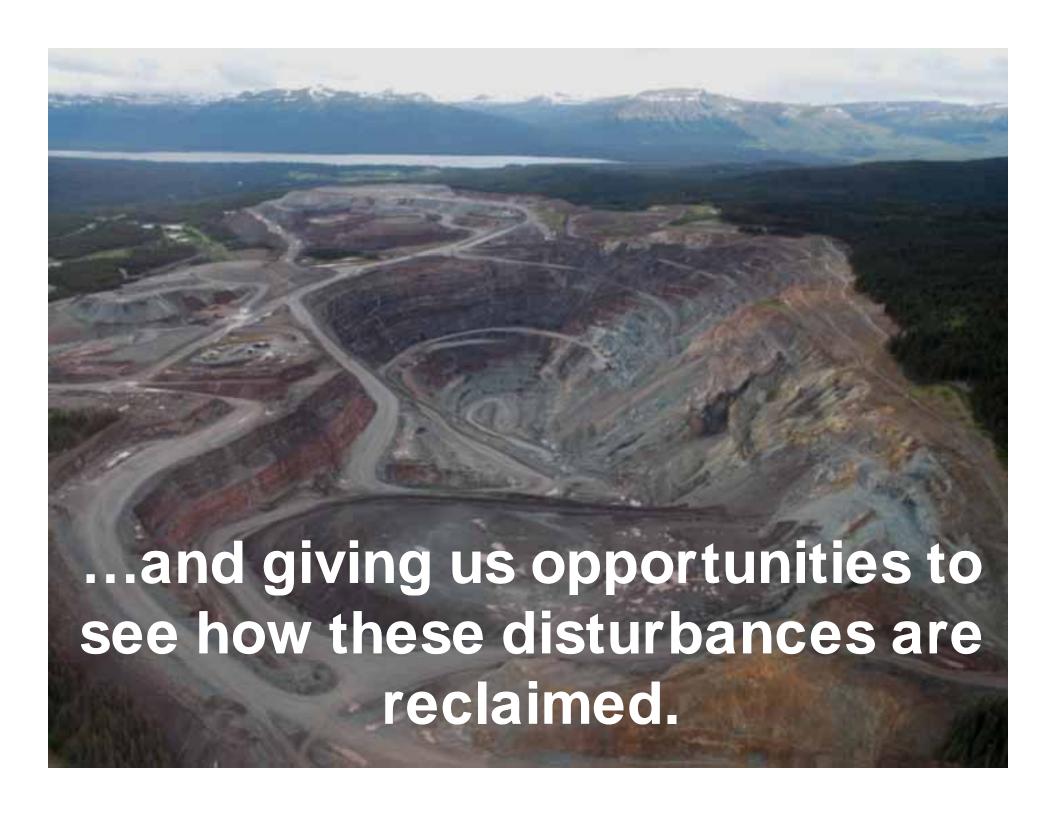**Polster Environmental Services Ltd.**

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

Damage can be extensive...

...and may entail permanent ecosystem changes.

Our conversion of vast tracts of the earth's surface to alternative, simplified ecosystems that do not give us the goods and services that were formerly available creates opportunities for restoration.

What role does restoration play in re-establishing the critical goods and services provided by natural ecosystems in an urban context?

Can we use natural processes to deal with storm water or can we use landscaping treatments to replace lost habitat?

Let's look at how natural systems address the limitations or filters preventing natural recovery of disturbed sites.

Continental glaciation created huge landscape disturbances…

…making some of our largest disturbances look small…

...and giving us opportunities to see how these disturbances are reclaimed.

Insects can turn a healthy green forest into a stand of dead pine.

What is the role of humans in restoration of a "natural" disturbance?

Natural events such as fires can damage extensive areas.

Somehow natural processes serve to restore even the most degraded sites – How does this happen?

Natural landslides...

Frank Slide

Over time natural processes "restore" these sites

Pockets of organic soils provide sites for seeds

By looking at natural solutions to revegetation we can develop effective restoration systems

Can we apply these natural restoration processes to human disturbances?

Fine textures at the top, free draining in the middle, larger rock at the bottom

By pushing the fine textured materials over the face we can eliminate the limitations of the coarse substrate.

What about erosion?

What natural processes can protect against erosion?

First of all what is erosion?

Universal Soil Loss Equation
X = RKSLCP

Where:

X = the computed soil loss in tons (dry weight) per acre from a given storm period

R = the rainfall erosion index

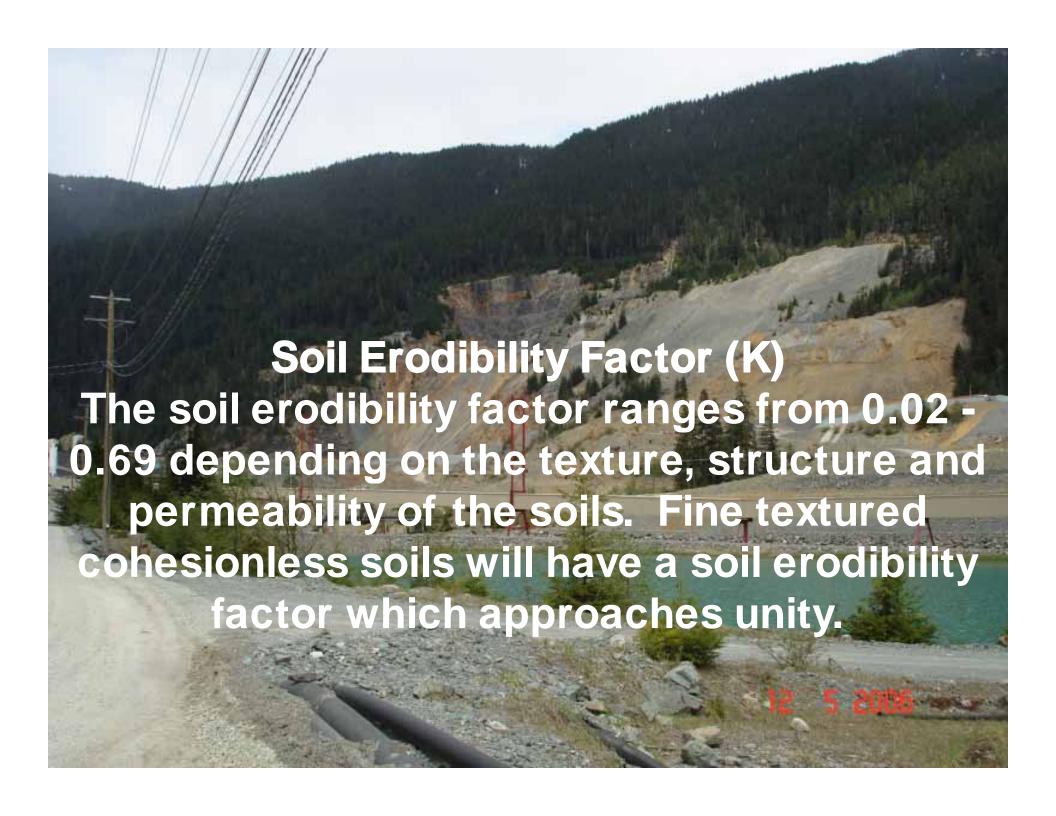K = the soil erodibility index

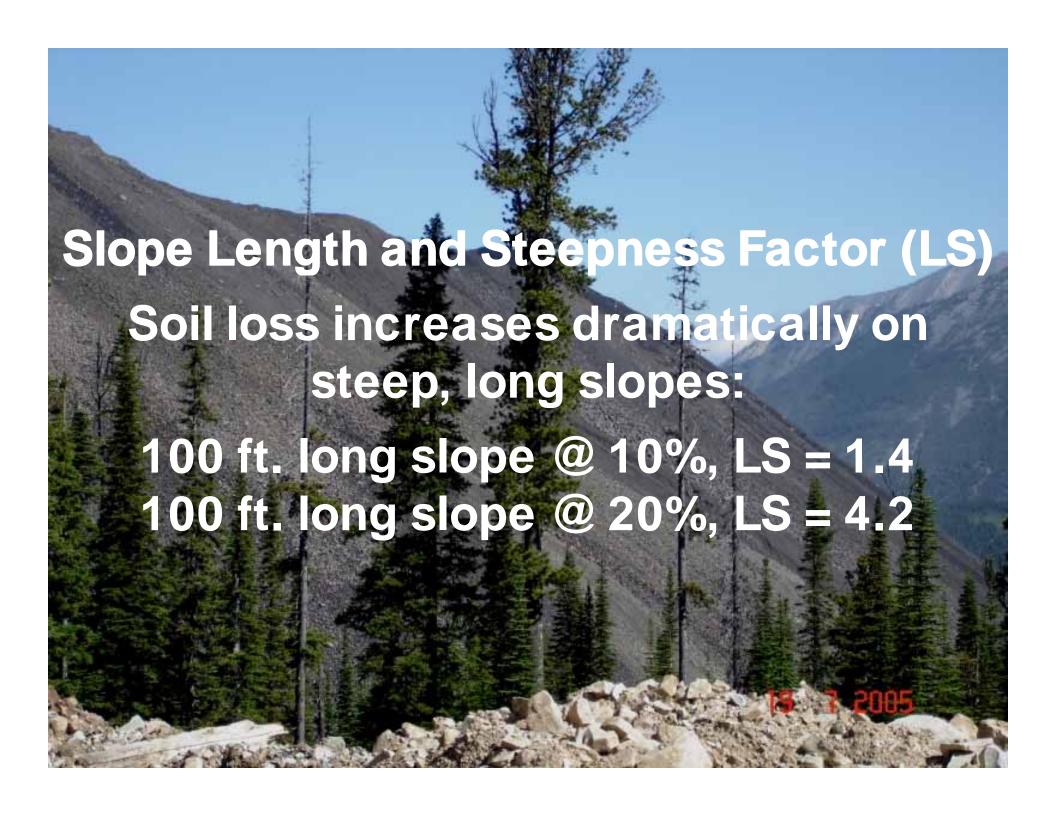S = the slope gradient factor

L = the slope length factor

C = the cropping (vegetation) factor
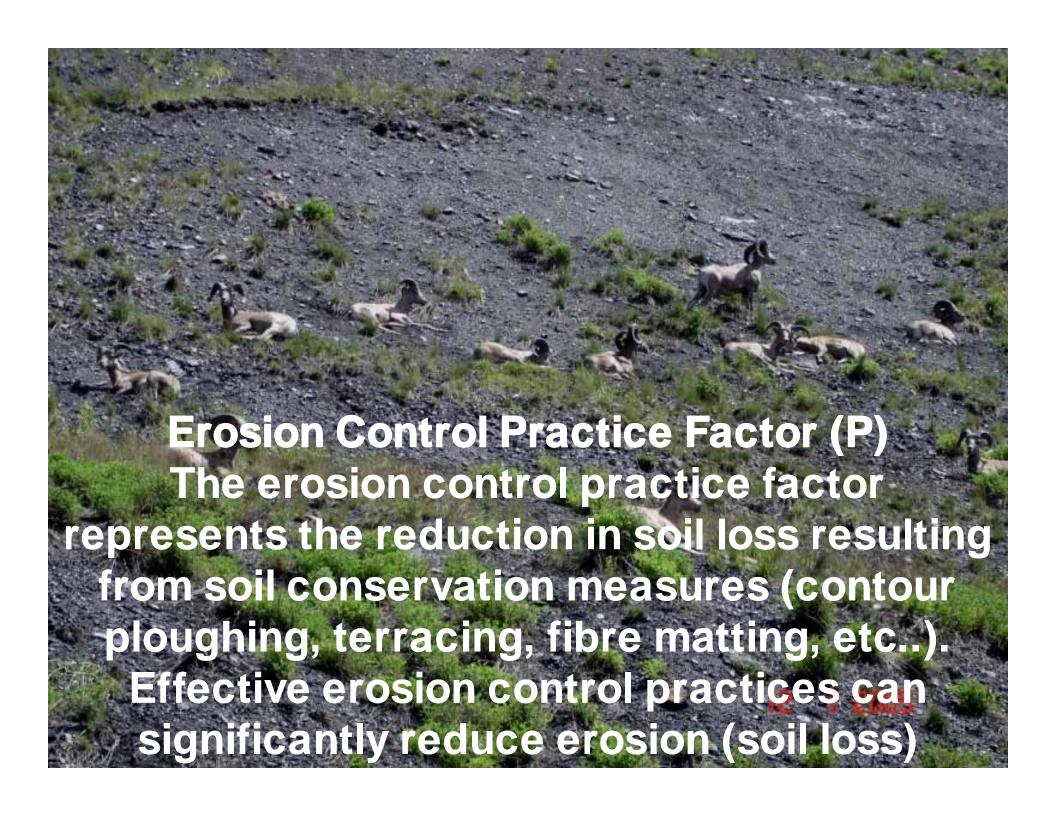
P = erosion control practice factor

Rainfall Factor (R)
The rainfall factor for Vancouver Island is about 200 while in Calgary it is about 50. Vancouver Island winter storms (Nov. - Feb.) give heavy rainfall over long periods.

Soil Erodibility Factor (K)
The soil erodibility factor ranges from 0.02 - 0.69 depending on the texture, structure and permeability of the soils. Fine textured cohesionless soils will have a soil erodibility factor which approaches unity.

Slope Length and Steepness Factor (LS)

Soil loss increases dramatically on steep, long slopes:

100 ft. long slope @ 10%, LS = 1.4
100 ft. long slope @ 20%, LS = 4.2

Cropping (Vegetation) Factor (C)
The vegetation factor ranges from 0.45 for no vegetation cover to 0.003 for a 95% cover of grasses and legumes. Vegetation is one of the easiest factors to manipulate and provides one of the biggest benefits.

Erosion Control Practice Factor (P)
The erosion control practice factor represents the reduction in soil loss resulting from soil conservation measures (contour ploughing, terracing, fibre matting, etc..). Effective erosion control practices can significantly reduce erosion (soil loss)

How Can We Change Soil Loss? (X)

We can't change:

    R, rainfall erosion index

    K, soil erodibility factor

We can change:

    LS, slope lengths and steepness

    C, cropping factor

    P, erosion control practices factor

Changing C, Cropping Factor:

C = 1.0 for bare ground

Treatment	C value
Fall rye	0.1
Sod	0.01
Permanent seeding (90%)	0.01
Wood fibre mulch	0.1
Fibre matting	0.02

Surface Conditions Factor (Cs)

Loose as a disked plough layer, Cs = 1.0

Treatment	Cs Value
Compact and smooth, (scraped with a bulldozer)	1.3
Loose with rough surface	0.8
Loose with smooth surface	0.9

Changing Erosion Control Practices Factor (P)

Normal erosion control practices at construction sites (check dams, interceptor berms, chutes & flumes, etc.) yield a P value of 0.50.

Treatments such as contour wattling can reduce P to 0.05.

Typical Erosion Rates
(tons/mile^2 /year)

Undisturbed Forest Land	13 - 83
Agriculture	1,000 - 70,000
Urban Construction	1,000 - 100,000
Mine Construction	50,000 - 150,000

16 6 2006

Types of Erosion

Solution erosion, CaCO$_3$

Raindrop erosion

Action: *Protect the soil surface*

How:

- *by establishing vegetation*
- *with netting or mats*
- *with mulches*
- *with hydroseeding mulch*
- *with gravel or rock*

Raindrop erosion

During a heavy rain, as much as 100 tons/acre of soil can be lifted in the air ready for erosion…

Once the soil is in the air, it can easily be moved down the slope.

Sheet erosion

Rill erosion

Gully erosion

'97 1 30

Sheet Erosion

Action: *Prevent overland flow:*

How:

- *Create rough loose surface*
- *Top-dress with woody debris*
- *Straw baffles (expensive)*
- *Sod strips (expensive)*
- *Armour surface (expensive)*

Rill erosion

Action: *Prevent / control flows*

How:
- Armour gully channels
- Slow velocities (non-living)
- Bioengineering

NOTE: Matting not effective for sheet, rill or gully erosion as the erosion may occur under the matting.

Streambank Erosion

Action: *Protect channel banks, slow flows*

How:
- Armour channel (riprap)
- Drop structures (slows flow)
- Bioengineering (various)

Mass Movement Erosion

Action: *Depends on source of movement*

How:

- Need to develop specific solutions to specific problems

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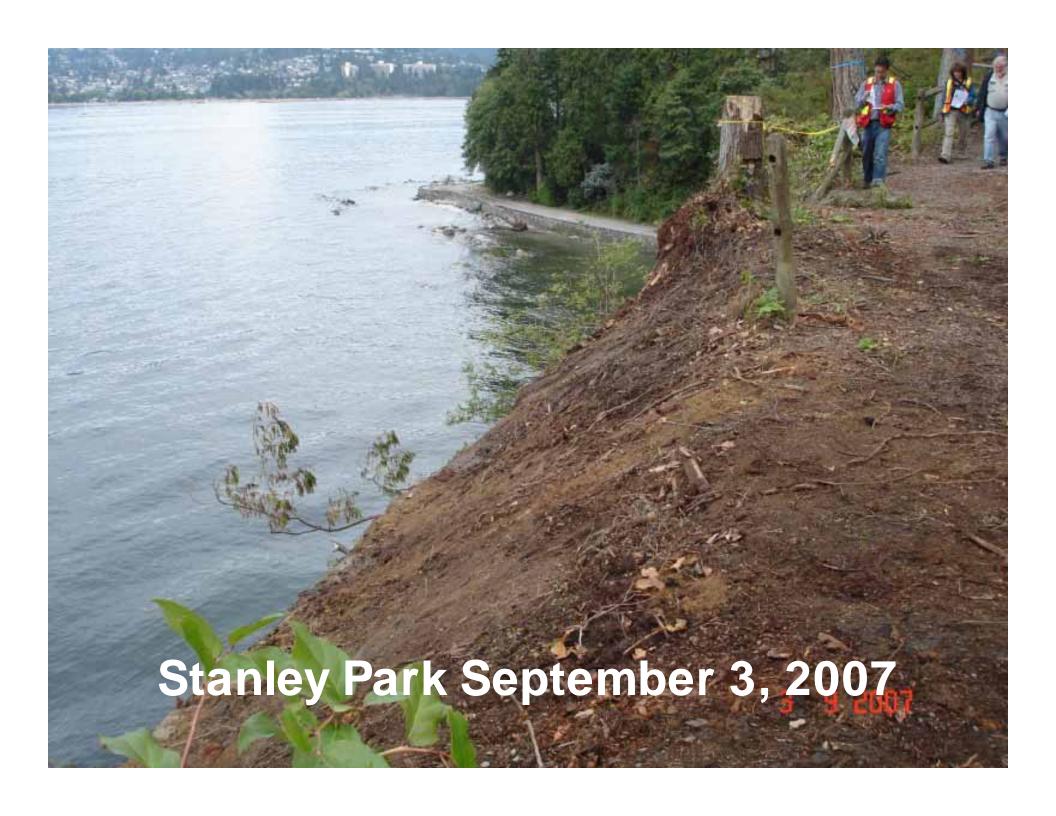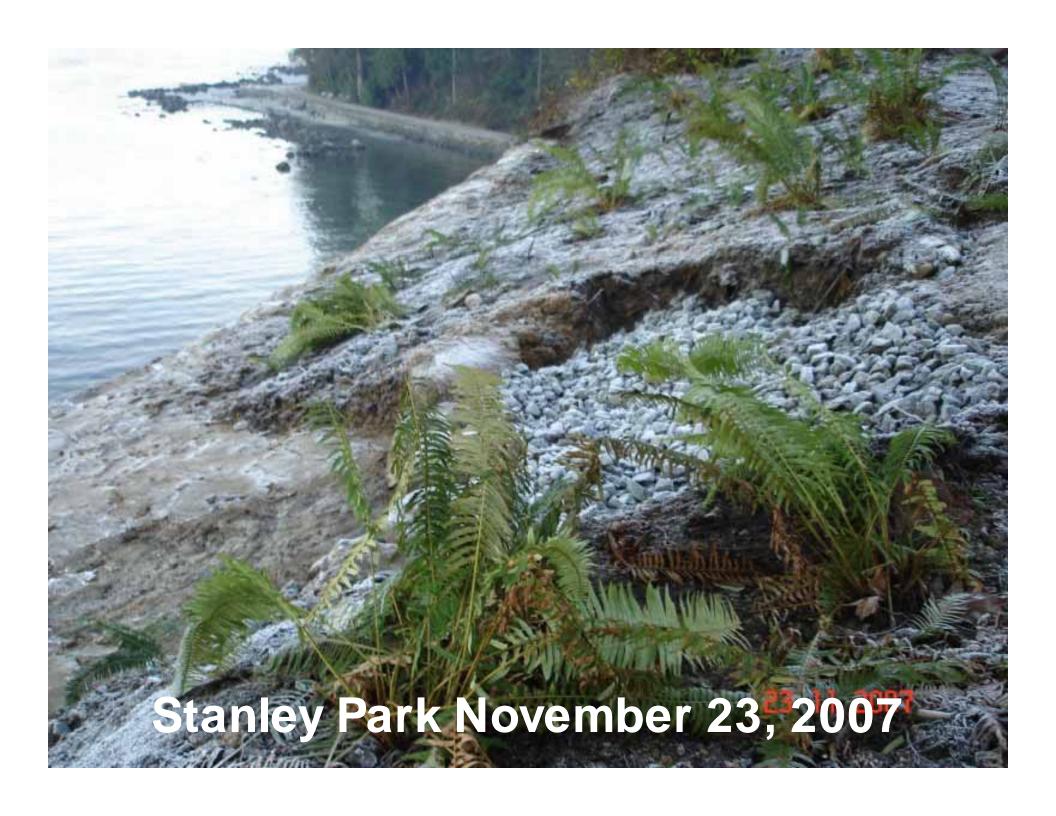Erosion can move massive amounts of material in short times

Erosion control practices that made things worse…

...but they meant well.

How does nature deal with flowing water?

Mass movements

Soil slump

10 8 2005

Small slumps under straw blanket

Soil slumps under spray on blanket

Natural mass movements

Natural mass movements associated with melting permafrost

Large ice lenses form the scarp on these slides

The start of something big ???

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Cryoturbation (stone stripes)

Solifluction

Aeolian deposits – Wind erosion

Wave erosion

How can we solve erosion problems?

Erosion solution - Kemess Mine tailings dam

Spreading topsoil

Erosion starting on smooth surface before spreading is even completed.

Making it rough and loose

Stopping overland flows

Roughened the whole surface…

...even some of the flatter areas.

Added woody debris and planted trees and lupines – not seeded

Tsawout sewer line restoration November 26, 1999

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November 26, 1999

Tsawout sewer line restoration February 3, 2008

Tsawout sewer line restoration February 3, 2008

Tsawout sewer line restoration
Immediate erosion control, long term successional re-integration
February 3, 2008

Stanley Park September 3, 2007

Stanley Park September 3, 2007

Stanley Park forest floor under blown down trees

Stanley Park November 23, 2007

Stanley Park May 27, 2008

Cutting the nose off this slope.

Leaving the slope rough and loose

Rough and loose and covered with woody debris

Fixing landslides

Soil Bioengineering

Very steep slopes can be treated using pioneering species

Bamberton Beach Erosion

Bamberton Beach Erosion

Reference ecosystem – the natural solution

March 25, 2008

March 26, 2008

May 22, 2008

May 22, 2008

November 5, 2008

January 7, 2009

How do natural systems solve low nutrient problems?

Red Alder (*Alnus rubra*)

Natural nitrogen fixers

Mountain Avens (*Dryas drummondii*)

Natural nitrogen fixers

Soopolallie (*Shepherdia canadensis*)

Collecting Dryas seed

Hydroseeding Dryas seed, 1984

Established Dryas, July 3, 2005

Seeding alder, October 30, 1986

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Alder seedlings from seeding

Alder seeded slope, May 23, 1994

Alder seeded slope, July 16, 1999

Alder seeded slope, July 16, 1999

Alder seeded slope, July 9, 2005

Over 500,000 Red Alder trees planted at the Island Copper Mine

Alder kick-starts the successional processes that lead to productive forests…

2 9 2005

…later successional conifers establish naturally under the canopy of pioneering vegetation…

… but the dense cover of seeded grasses and legumes out-competes the alder unless the alder can form a closed canopy.

So we have seen a drop in the number of alder trees over the years…

…but the cover has gone up over the years.

Natural successional processes at the Faro Mine, Yukon

20 7 2007

A lot of bare ground…

Pioneering herbaceous species

20 7 2007

Grass established in wheel ruts

Willow seedlings establishing in puddle areas

Willows and other pioneering species

Conditions that encourage establishment of pioneers

Other pioneering species including Balsam poplar

Spruce establishing under willows

Later successional conifers poking through willows and other pioneering woody species

Late successional forest

What about invasive species?

Invasive species can prevent natural recovery of ecosystems

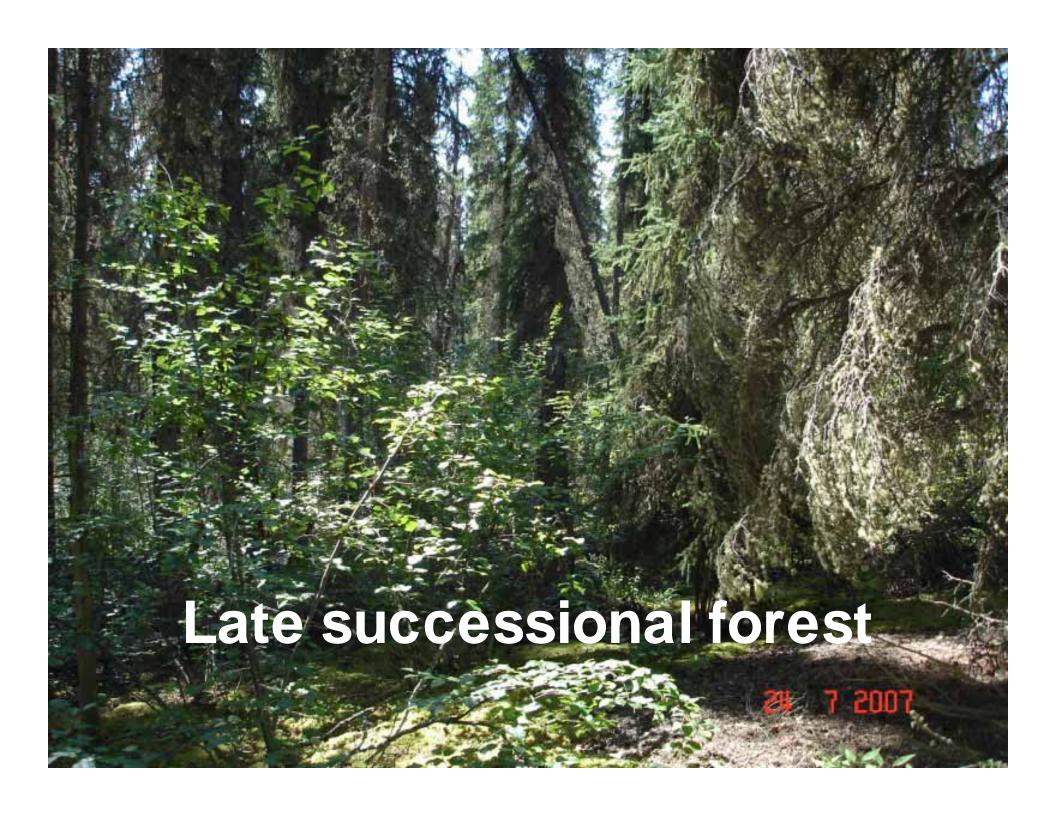**Invasive species management can be one part of an reclamation program**

I hope this has given you some ideas about the ways that natural processes can be used to cost-effectively solve some challenging restoration problems