Natural Processes for the Restoration of Large Mines

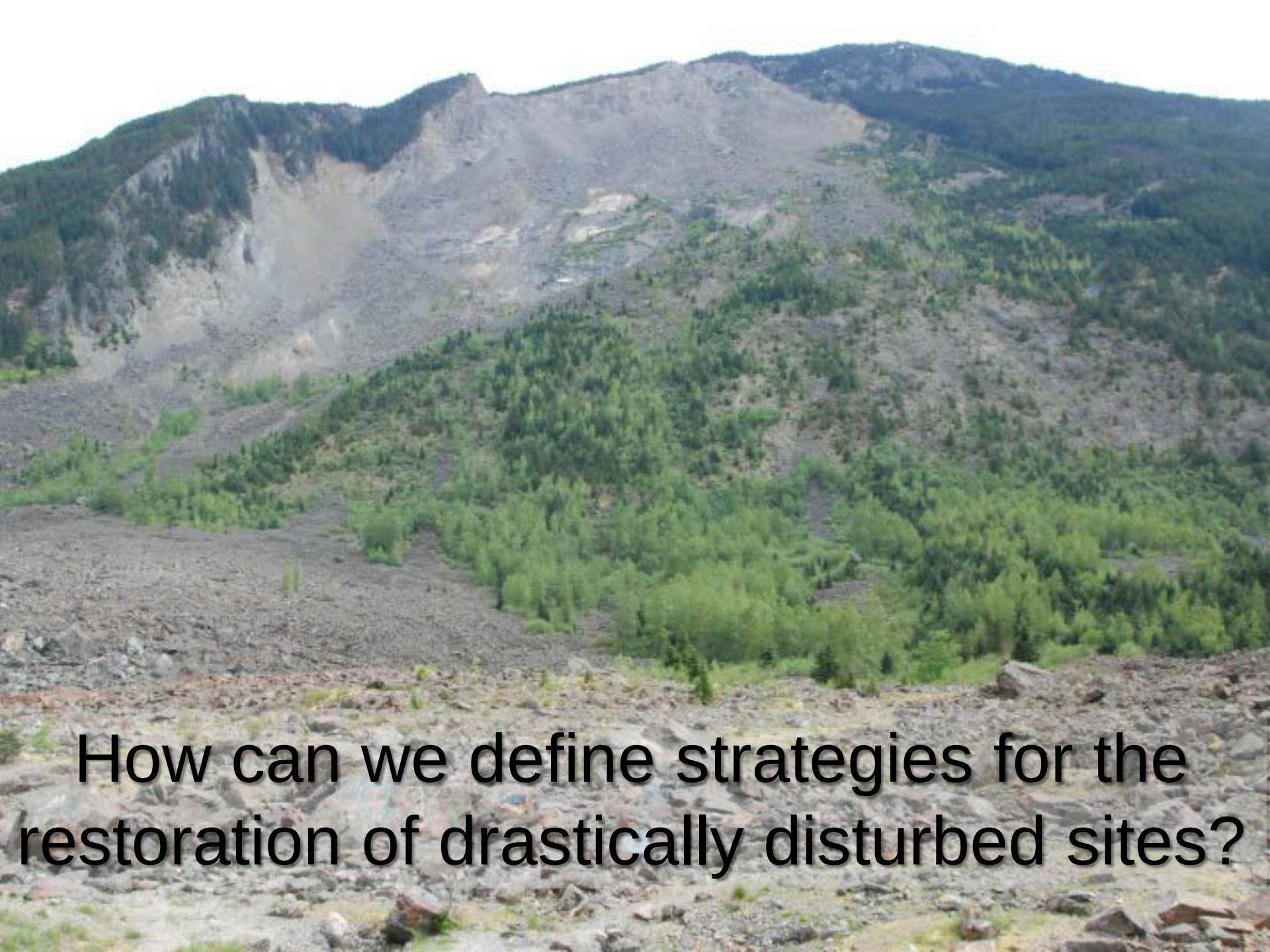
David F. Polster, M.Sc., R.P.Bio., CERP
Polster Environmental Services Ltd.

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


At one point not long ago most of the northern hemisphere was covered by ice…


…and now we have a diversity of ecosystems…


…with all sorts of fancy interactions and connections.
Natural processes made this happen.


How can we define strategies for the restoration of drastically disturbed sites?


What are the species that establish naturally on disturbed sites?

What characteristics do these species have?


What are the mechanisms of establishment?


How do pioneering species build soils on sites with no soil?


On gravel bars?

Develops soil horizons

Starts soil building, N fixing

Adds organic matter

Ecosystems in motion.


On lava flows?


Develops soil horizons
Lichens fix Nitrogen, start soil building
Adds organic matter
Ecosystems in motion.


Behind retreating glaciers?

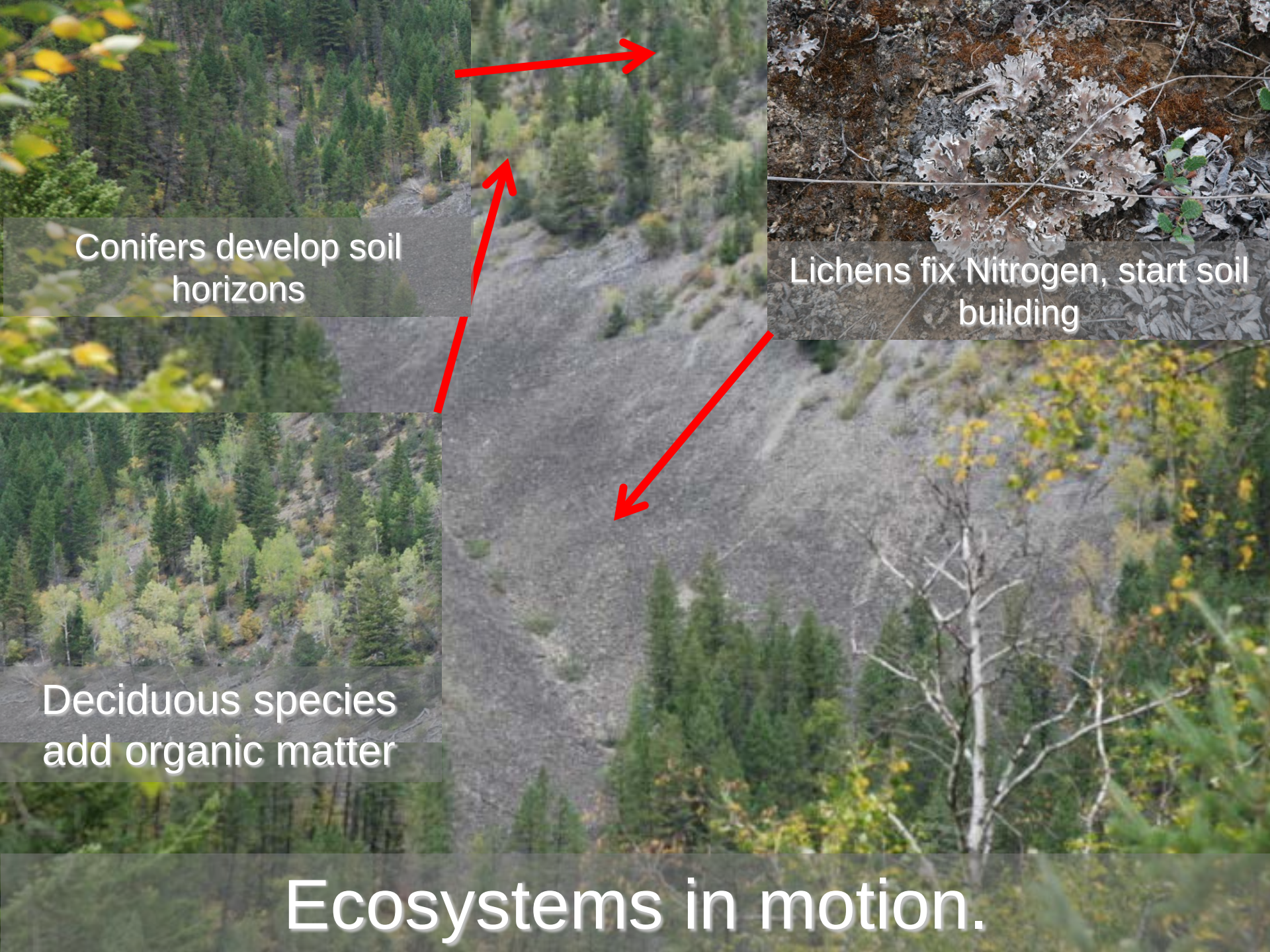
Conifers develop soil horizons

Alders fix Nitrogen, start soil building

Willows add organic matter

Ecosystems in motion.

On talus slopes?



Ecosystems in motion.


On landslides?

Ecosystems in motion.


Natural processes build ecosystems
from scratch.

So how can we use these natural processes to restore ecosystems?

What are the “filters” that are preventing recovery, and how can we “assist” that recovery?

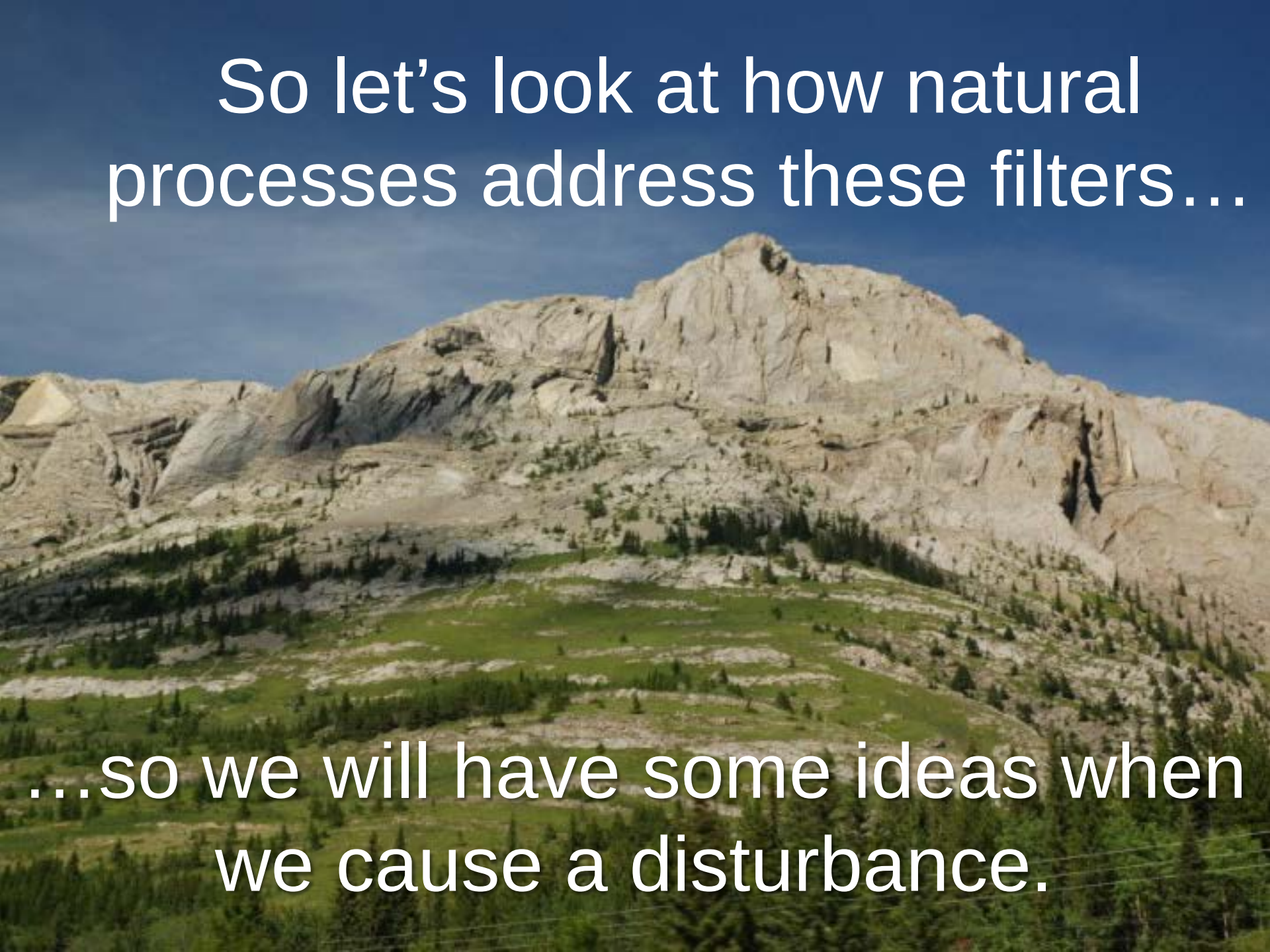
Common abiotic filters:

Steep slopes
Adverse texture
Nutrient status (+/-)
Adverse chemical properties
Soil temperature extremes
Compaction
Adverse micro-climatic conditions
Excessive erosion

Common biotic filters:

Herbivory
Competition
Propagule availability
Phytotoxic exudates
Facilitation
Species interactions

Spotted Knapweed *Centaurea maculosa*


So let’s look at how natural processes address these filters…
…so we will have some ideas when we cause a disturbance.


What about steep slopes and adverse textures?
11 7 2005

Frank Slide

Over time natural processes “restore” these sites.

Studying how this happens provides a foundation for the design of restoration programs for our largest disturbances

Phytocoenologia	8 (1)	1 – 12	Stuttgart-Braunschweig, September 10, 1980

Vegetation of talus slopes on the Liard Plateau, British Columbia*

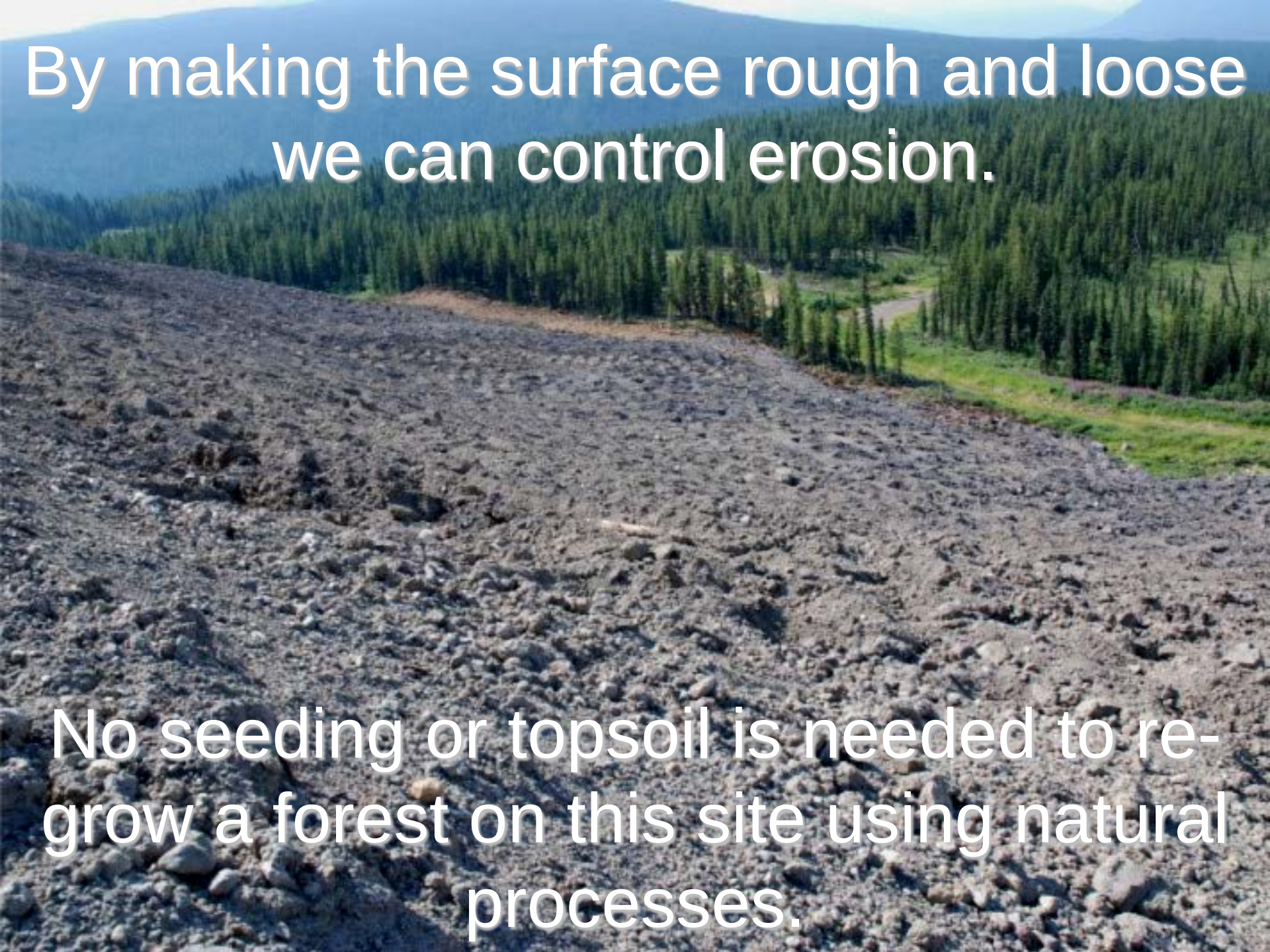
by D.F. POLSTER, Calgary, and M.A.M. BELL, Victoria

See any similarities???

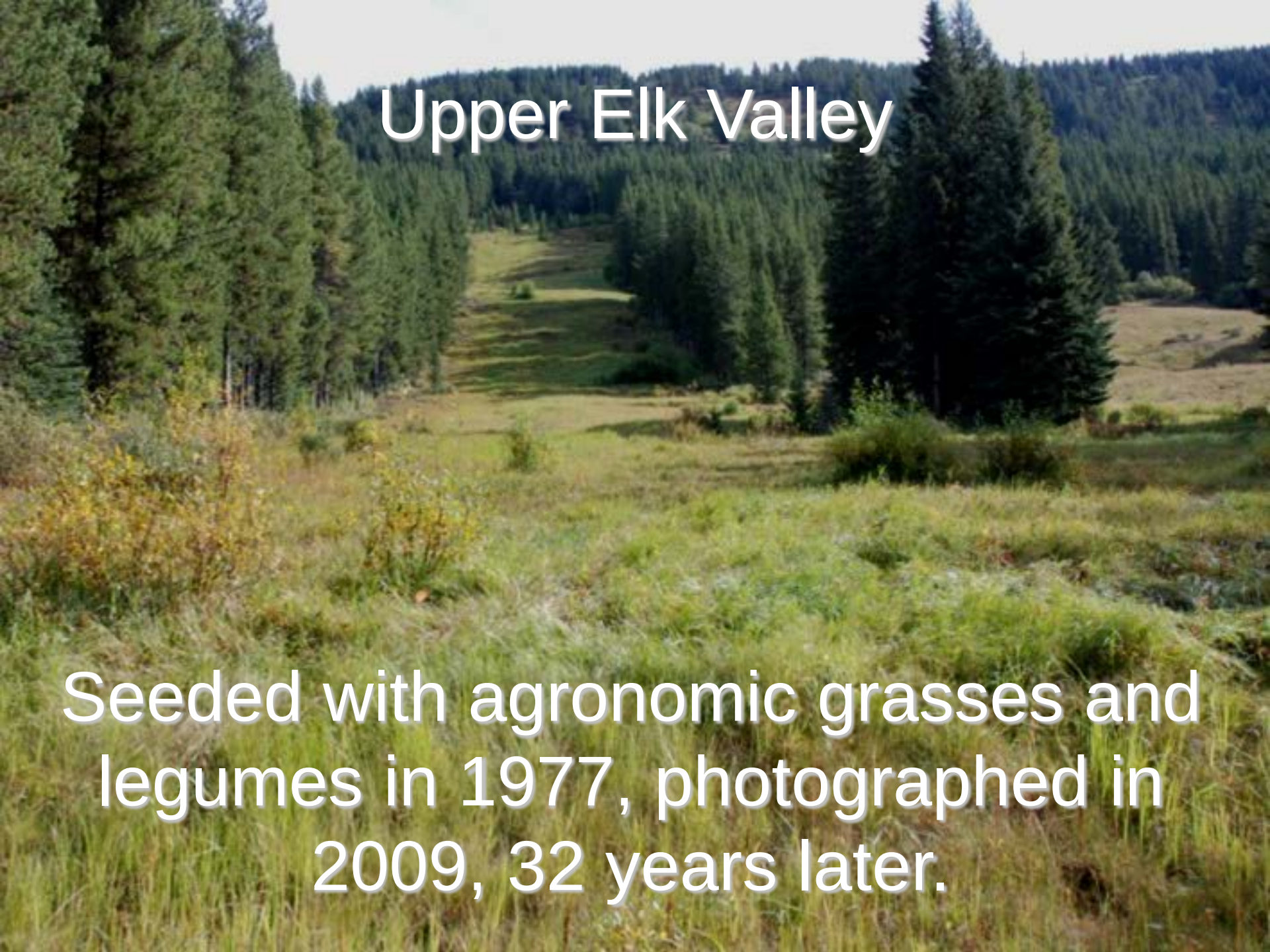

By looking at natural solutions to revegetation we can develop effective restoration systems


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

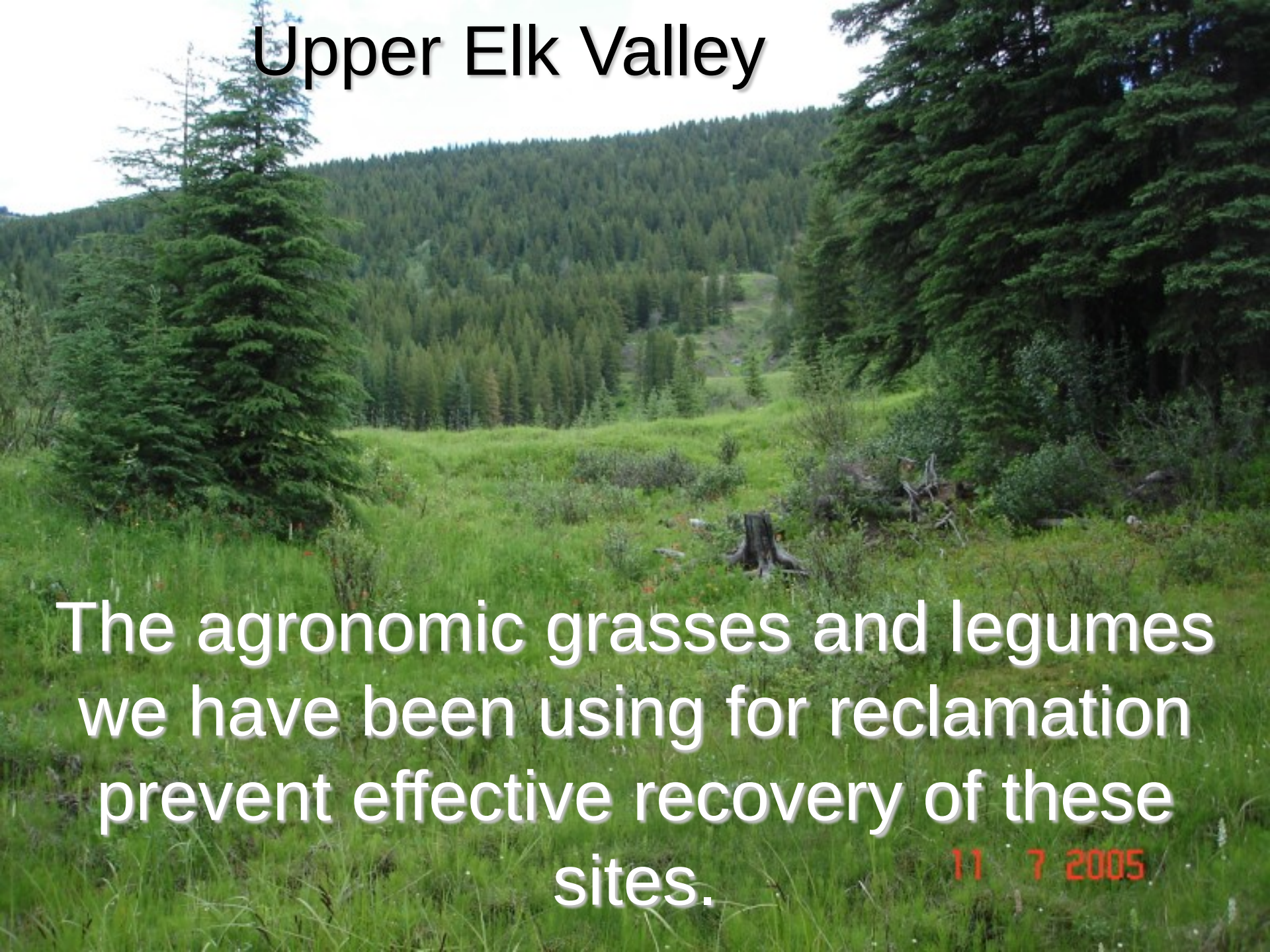

By pushing the fine textured materials over the face we can eliminate the limitations of the coarse substrate.
6 9 2007


By making the surface rough and loose we can control erosion.
No seeding or topsoil is needed to re-grow a forest on this site using natural processes.

Helicopter seeding exploration trench in the Upper Elk Valley in the fall of 1977


Upper Elk Valley
Seeded with agronomic grasses and legumes in 1977, photographed in 2009, 32 years later.

Upper Elk Valley



The agronomic grasses and legumes we have been using for reclamation prevent effective recovery of these sites.

How can we deal with erosion without grass and legume seeding?

Spreading soil material…


Erosion starting on smooth surface
before spreading is even completed.


Making the surface rough and loose


Roughened the whole surface


Cost of rough and loose treatment at Kemess Mine was $715/ha while hydroseeding costs over $3,500/ha
Making surfaces rough and loose controls erosion and enhances native species establishment.


Northern BC, September 22, 2014
Rough and Loose Restoration Treatments


Creating ideal conditions for vegetation growth.

NE Alberta

August 27, 2012


Happy willows…
NE Alberta,
September 10, 2014

Gas plant site near Edmonton to be restored, March 11, 2010

Rough and loose, April 14, 2010

Planting pioneering vegetation, April 14, 2010


Planting pioneering vegetation,
April 14, 2010, note fence.
2010

August 19, 2011

Two growing seasons


Happy Balsam Poplar…
August 17, 2013

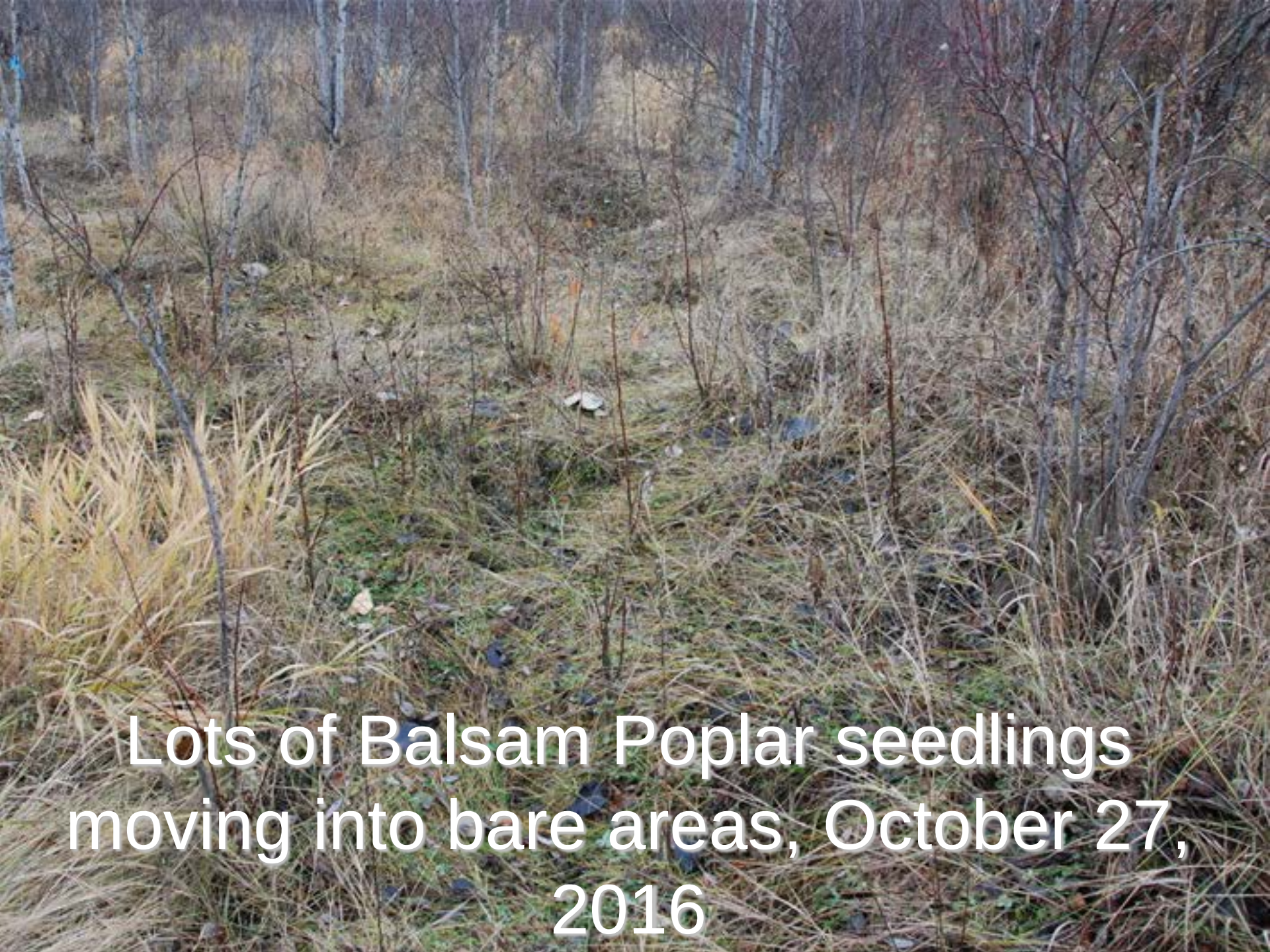

February 24, 2015


September 25, 2015


September 25, 2015
Six growing seasons after planting and we have 25 ft. high trees!

Pioneering forest established, October 27, 2016.


Conifers coming in around the edges
for free, October 27, 2016



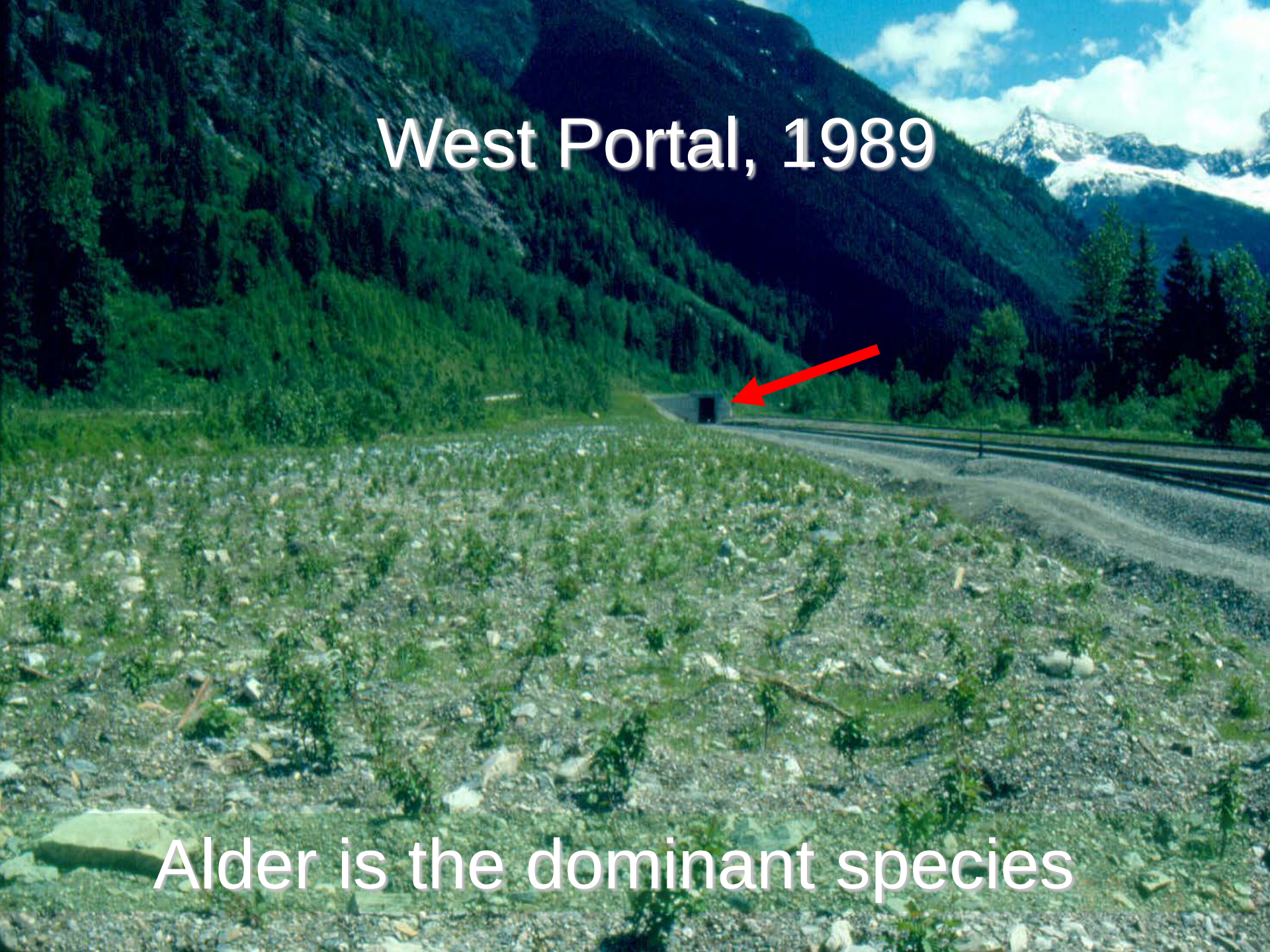
Lots of Balsam Poplar seedlings moving into bare areas, October 27, 2016

Lots of Prickly Rose found in many areas, October 27, 2016


A diverse forest has a diversity of organisms, October 27, 2016


As the forest matures, additional species will establish, October 27, 2016
The use of natural processes can provide cost-effective solutions for the restoration of drastically disturbed sites.


West Portal, Natural successional planting in 1989
Rough and loose

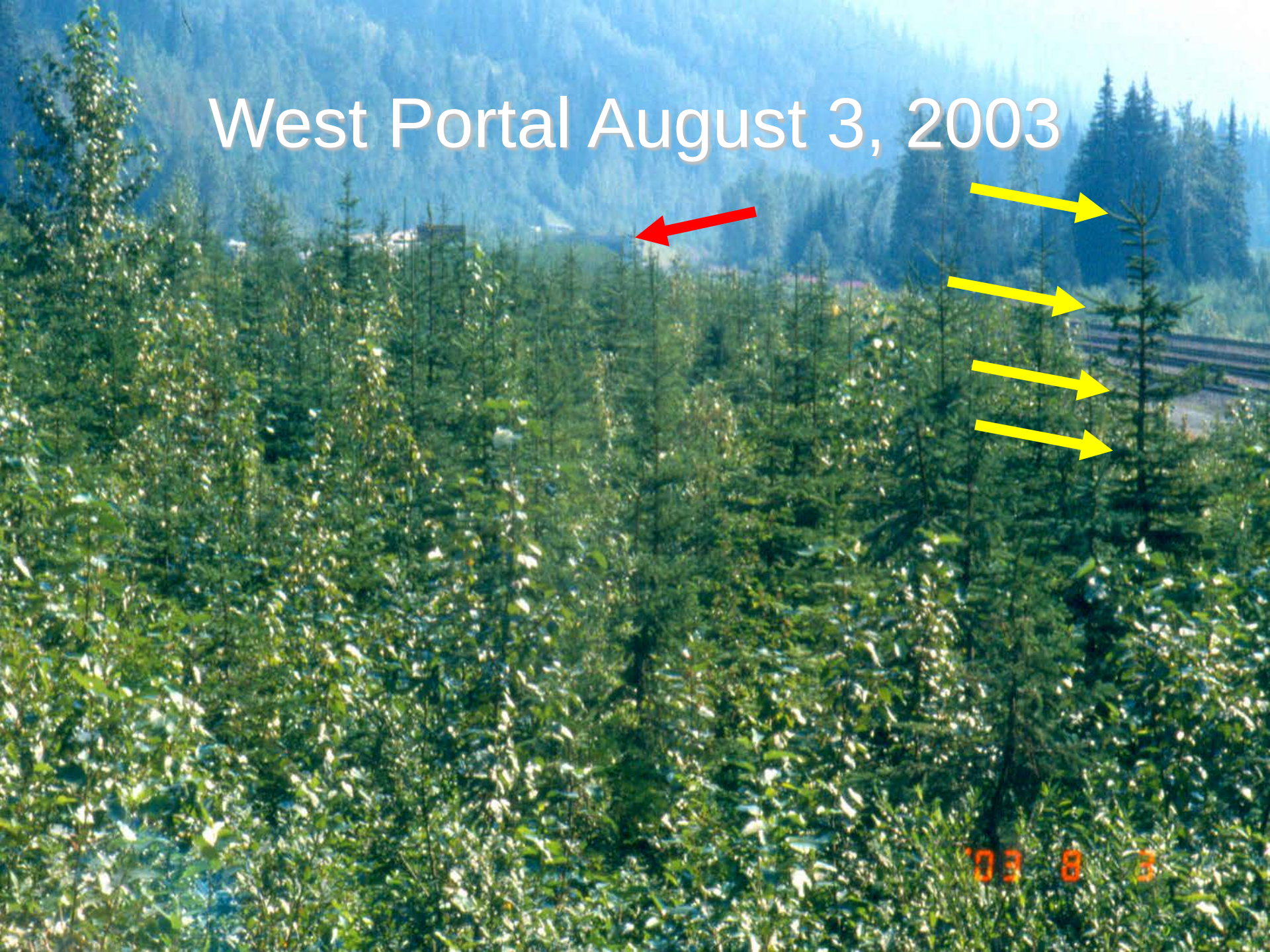

West Portal, 1989
Alder is the dominant species

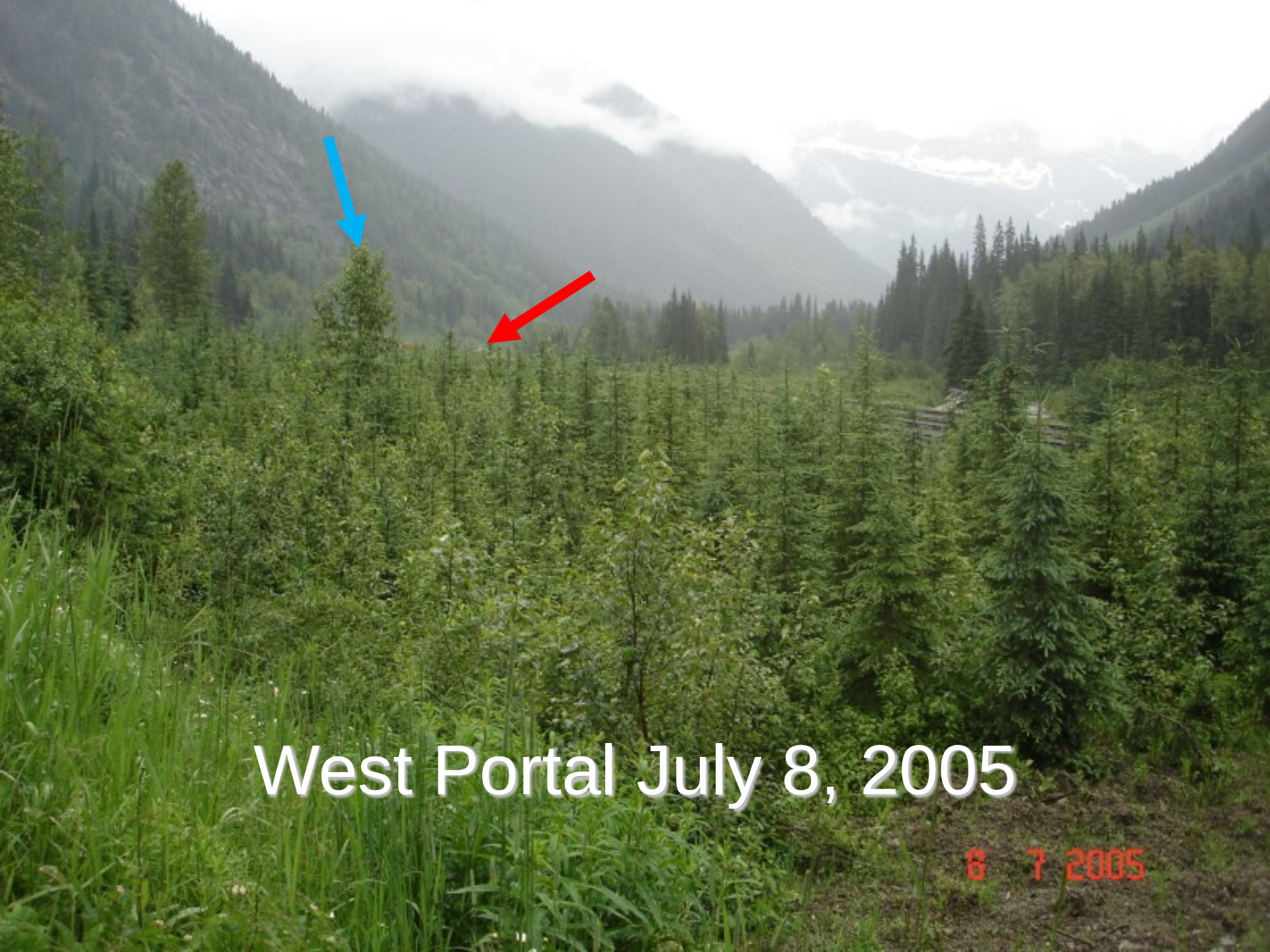
West Portal tree & shrub planting, 1989


West Portal August 25, 1992

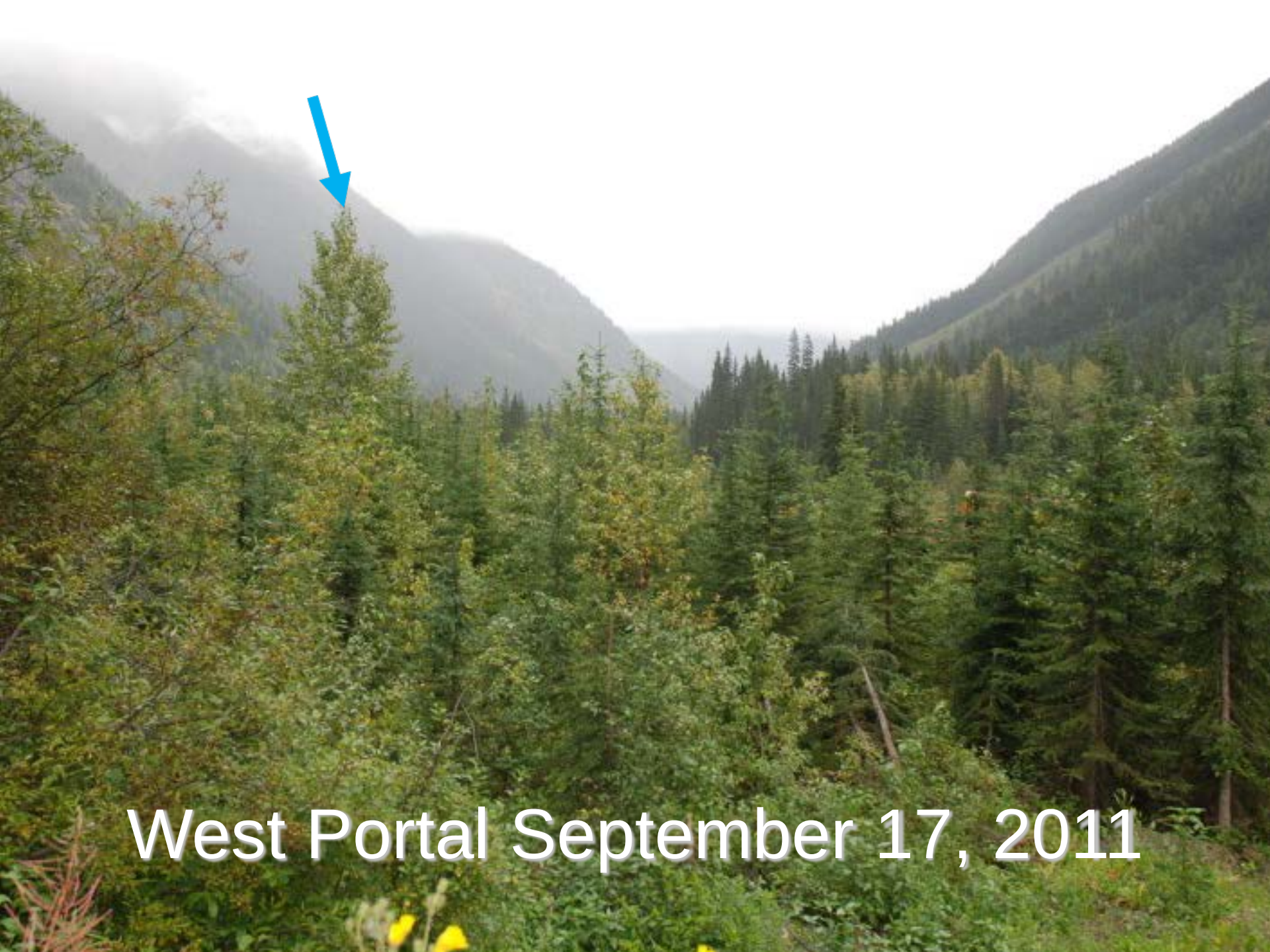

West Portal August 5, 1997
'97 8 5


West Portal July 15, 1999
'99 7 15


West Portal August 3, 2003
'03 8 3

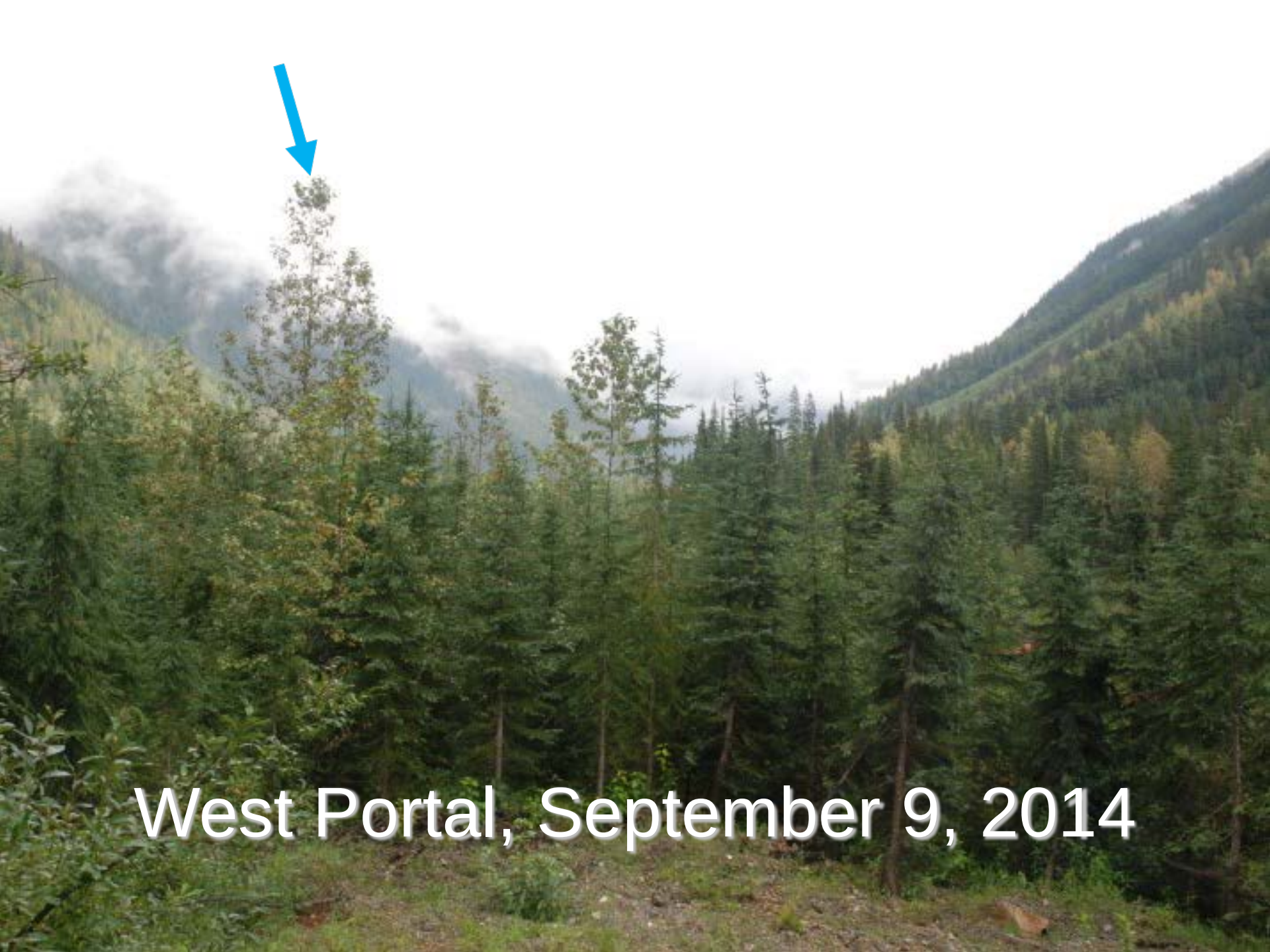

West Portal July 8, 2005
8 7 2005

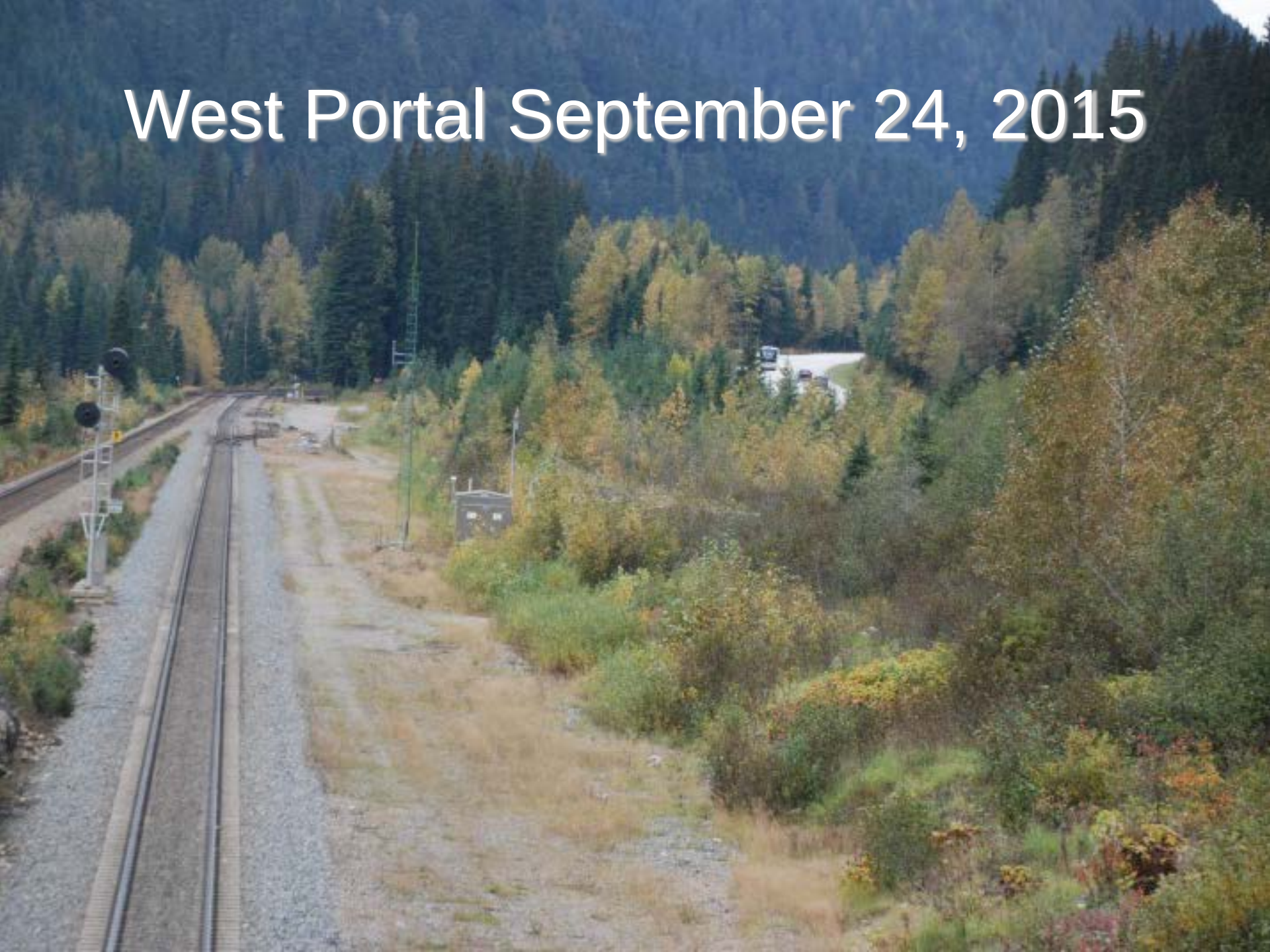

West Portal July 27, 2008


West Portal September 17, 2011


West Portal September 17, 2011


West Portal September 17, 2011


West Portal, September 9, 2014


West Portal September 24, 2015

West Portal, September 24, 2015 26 years after planting.

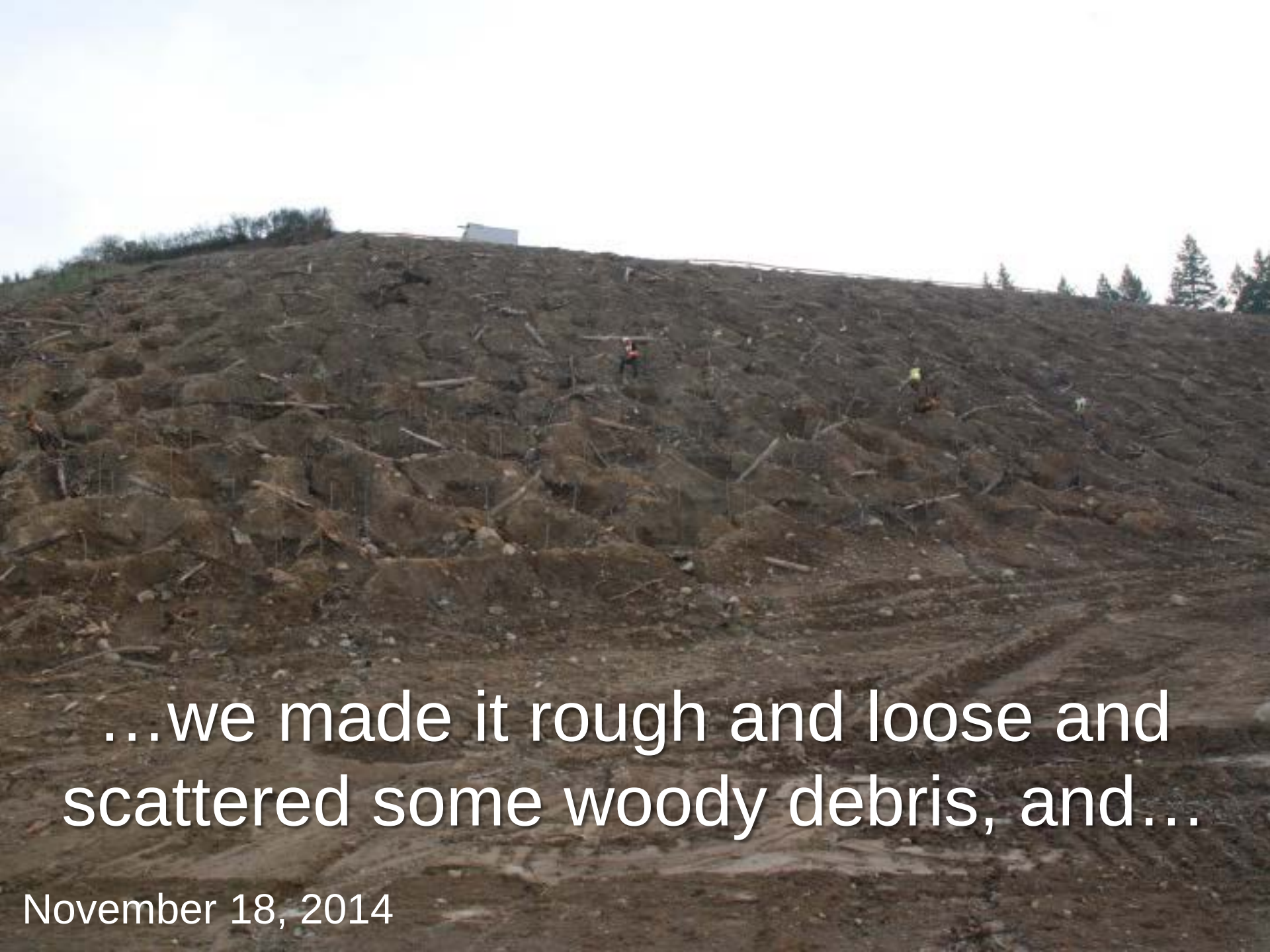
Failing Slope – Using plants to perform stability functions rather than expensive engineering solutions.


Shallowly rooted grasses provide no support for slope

…the hill was re-sloped.

September 6, 2014


The steep, smooth slope was prone to erosion, so…
September 6, 2014


…we made it rough and loose and scattered some woody debris, and…
November 18, 2014


…installed 2,500 2 m long live stakes
with 1 m in the ground.
November 18, 2014


A fence was installed to keep out the deer.


By March 16th, 2015, the cuttings were starting to sprout.

The slope was starting to turn green by May 12, 2015

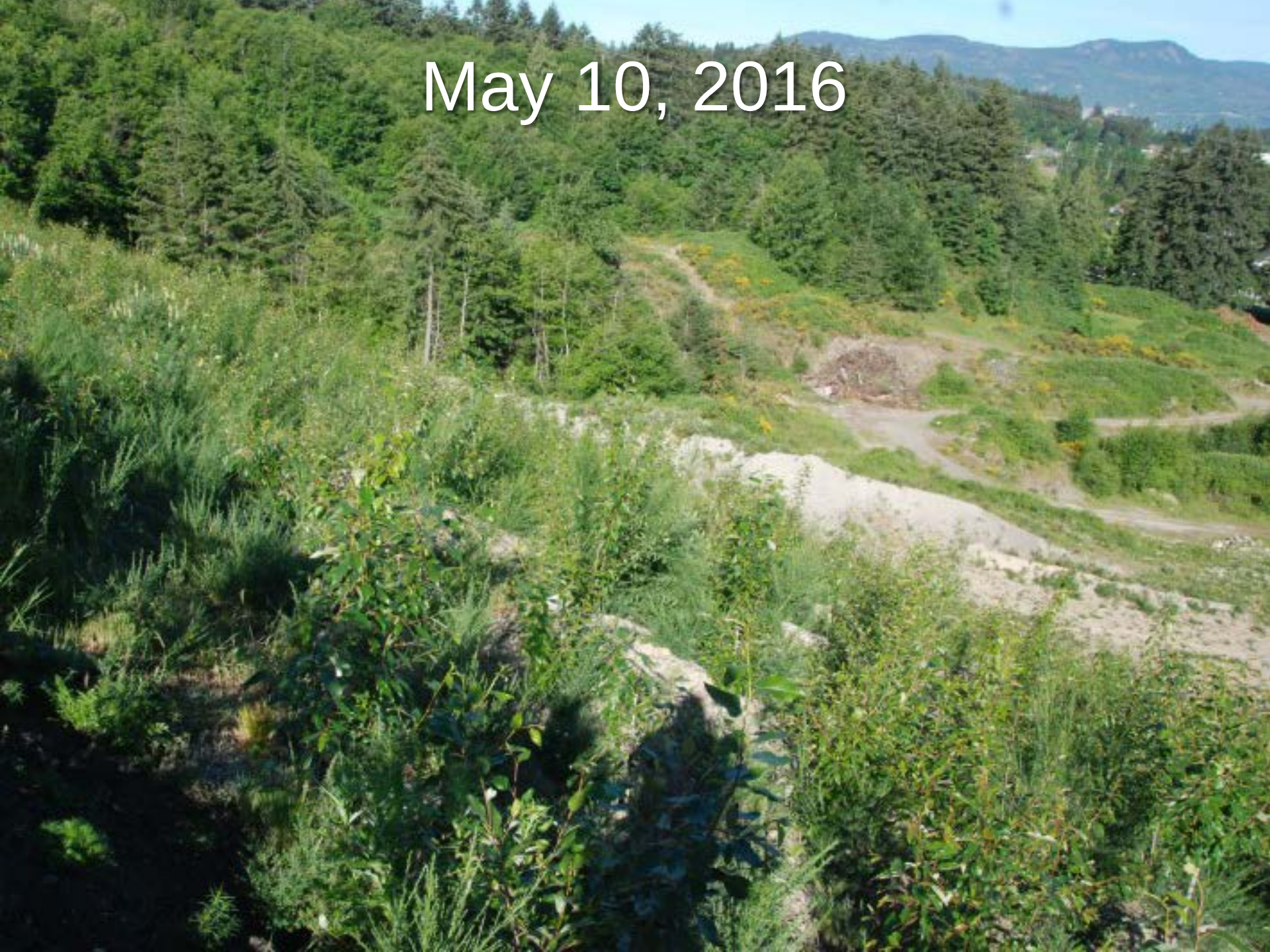

Cutting’s growth, May 12, 2015


Almost all of the cuttings were showing signs of growth, May 26, 2015


Some cuttings have almost a meter of new growth, July 21, 2015

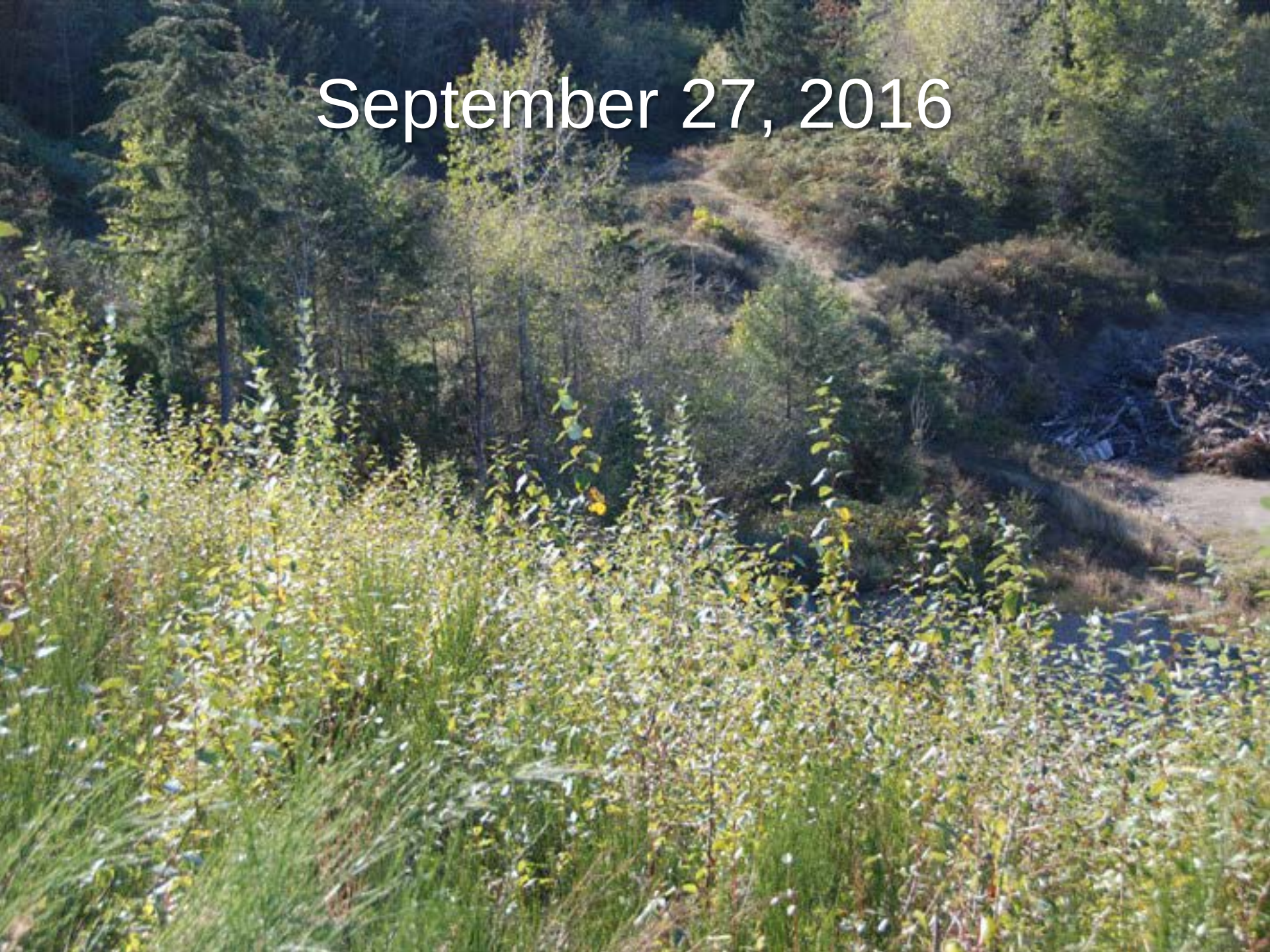

August 13, 2015


September 23, 2015


May 10, 2016


July 6, 2016


July 17, 2016


September 27, 2016


September 27, 2016

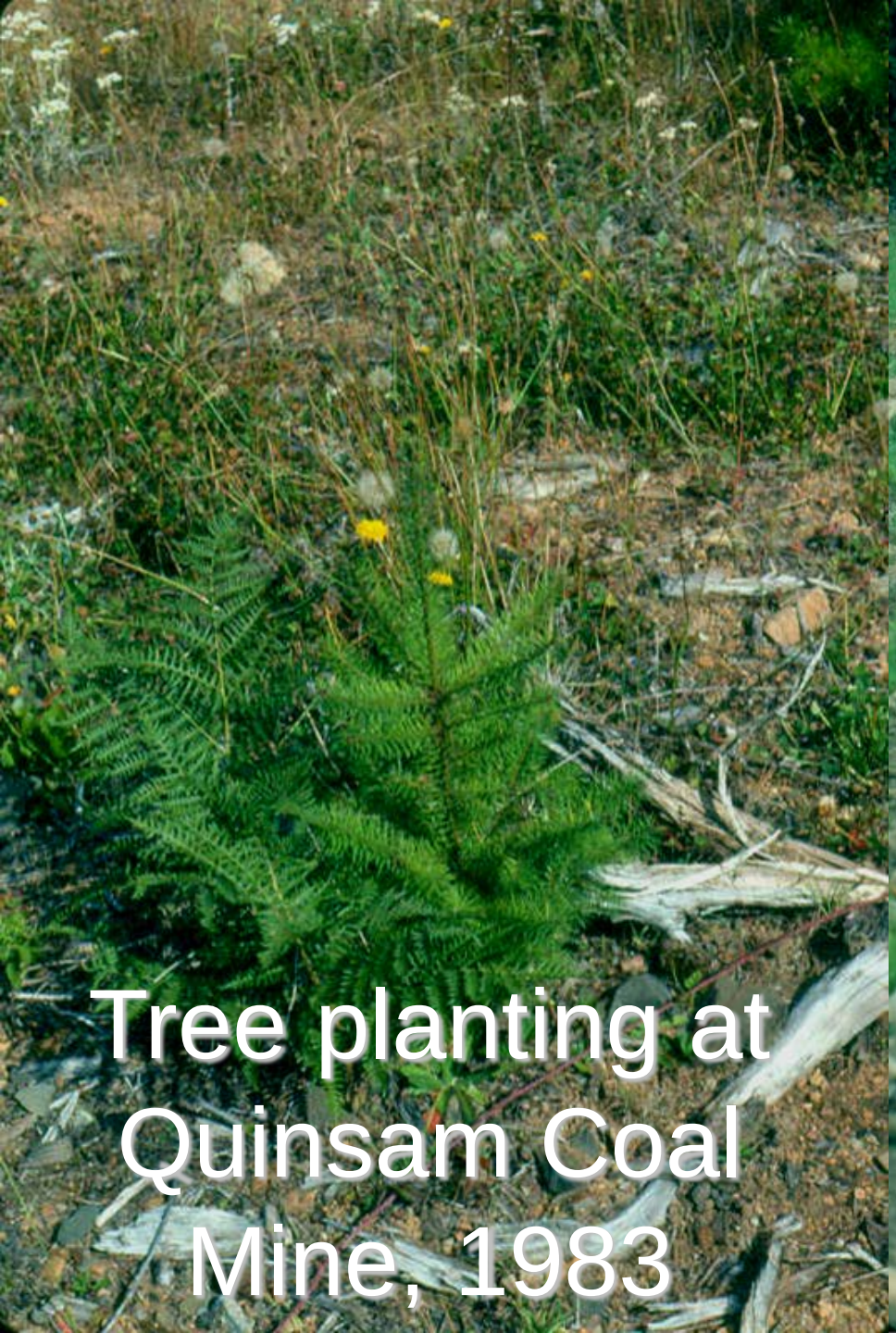

September 27, 2016
This site is sequestering 20 to 25 tonnes/ha of CO_2 annually two years after planting.


Role of nitrogen fixing pioneering species in forest recovery

Use of nitrogen fixing pioneering species to enhance forest productivity at Quinsam Coal Mine

Tests at Quinsam Coal Mine, 1982


Tests using nitrogen fixers at Quinsam Coal Mine, 1983



Tree planting at Quinsam Coal Mine, 1983

Soil bioengineering at Quinsam Coal Mine, 1982

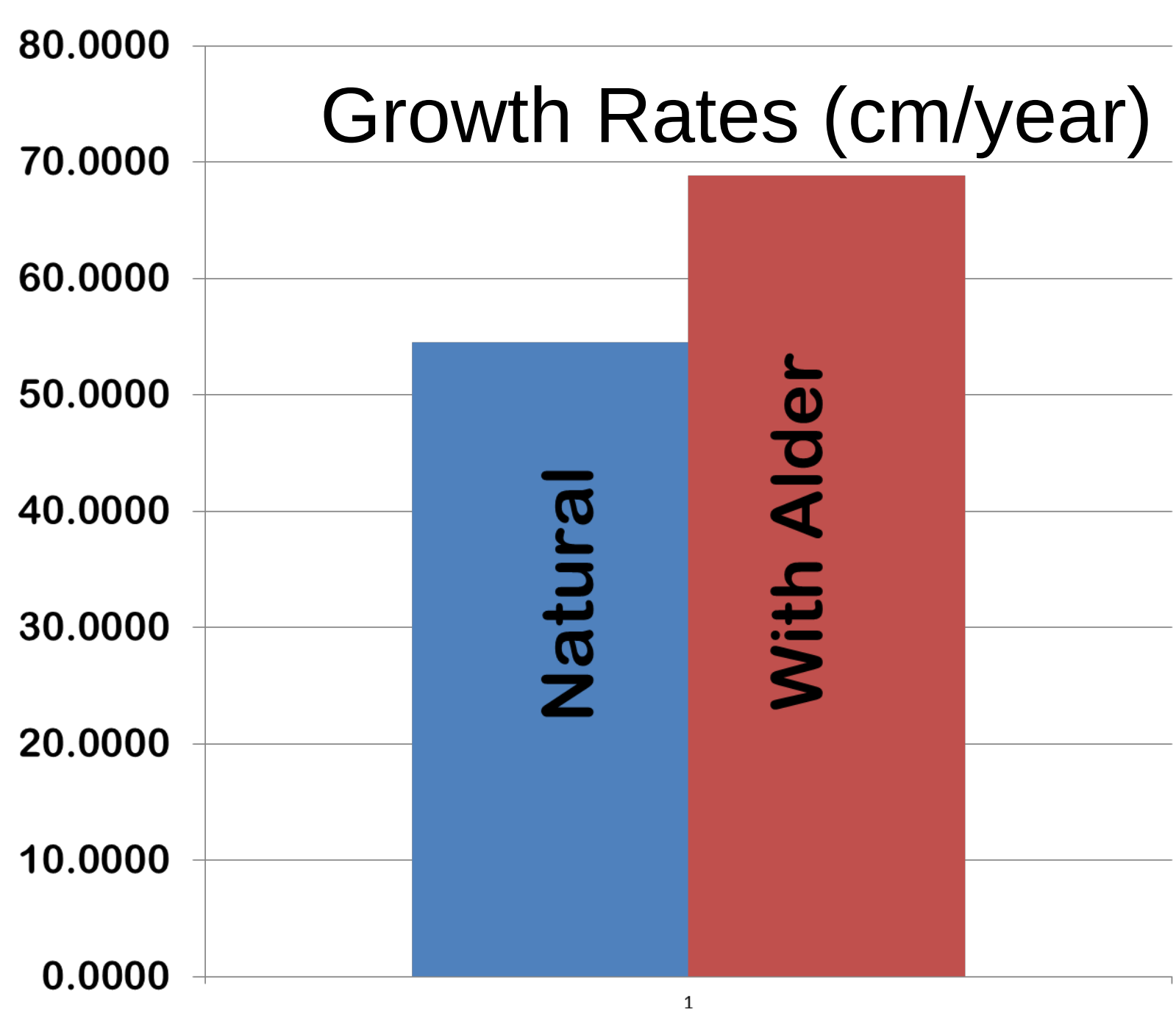
Soil bioengineering at Quinsam Coal Mine, 2007


Assessment of forest productivity Quinsam Coal Mine, 2007
27 2 2007
Natural forests

Height vs. Age 2007

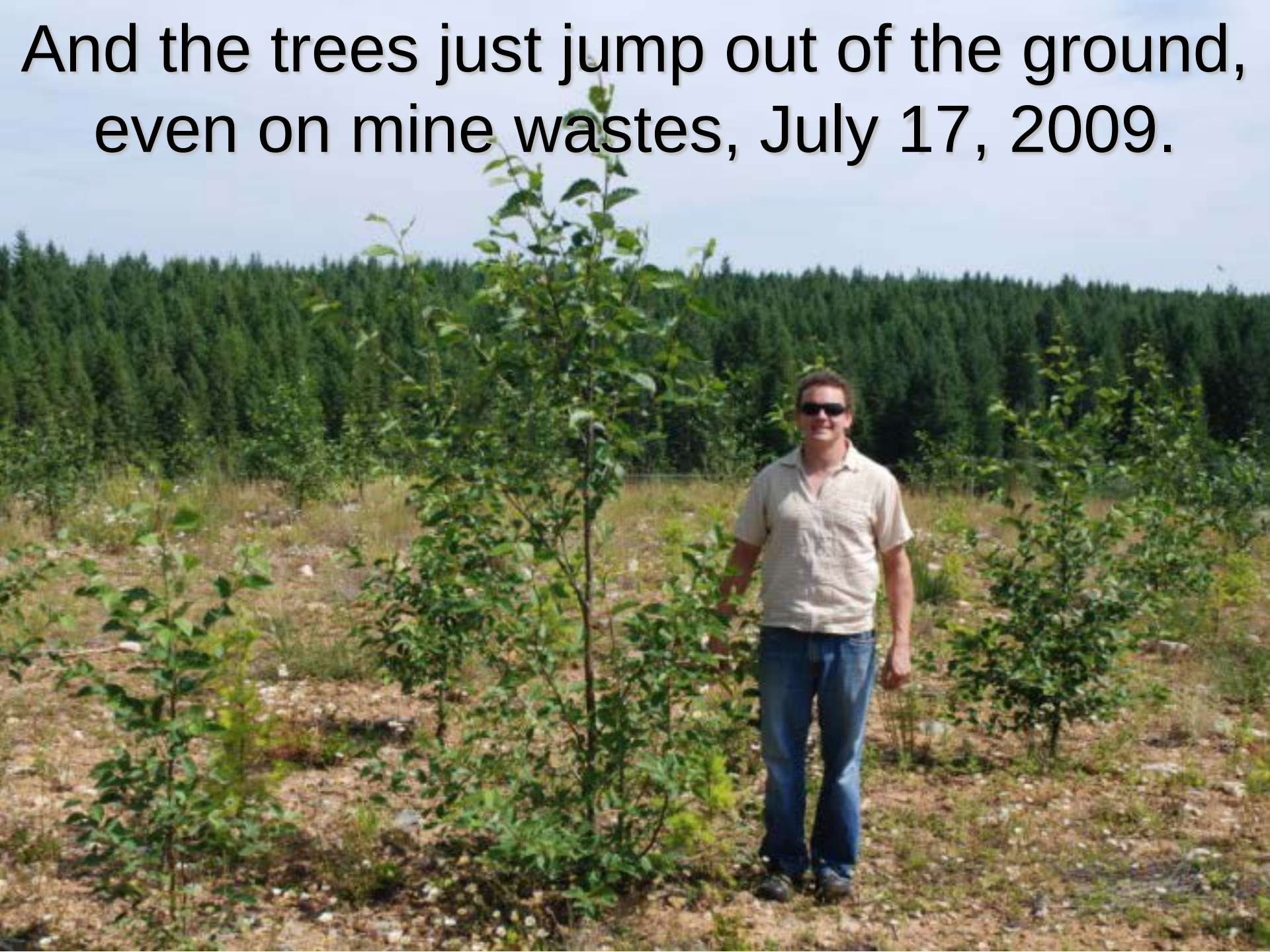

Natural sites have an average growth rate of 0.54 m/yr
26 2 2007


Trees on the trial site have an average growth rate of 0.69 m/yr
27 2 2007


Growth Rates (cm/year)
80.0000
70.0000
60.0000
50.0000
40.0000
30.0000
20.0000
10.0000
0.0000
Natural
With Alder
1

Planting strategy based on trial results, July 31, 2007


By following the successional model of the forests around the site we can make reclamation a profit centre.


And the trees just jump out of the ground, even on mine wastes, July 17, 2009.


June 25, 2012


July 22, 2016, 9 growing seasons after planting
At year 25 the alder and half of the Douglas-fir will be harvested.


Natural processes can provide significant advantages.

At this coal mine site, the rough and loose surface creates North and South exposures.


We can use natural processes as a model for the restoration of large mines.
Questions?
18 7 2005