

Natural Processes for the Restoration of Large Mines


An aerial photograph of a large open-pit mine. The mine is characterized by numerous terraced levels, creating a stepped appearance. A winding road or path is visible, snaking through the mine's levels. The surrounding landscape consists of rolling hills and a clear blue sky with some light, wispy clouds. The overall scene depicts a significant industrial site in a natural setting.

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.



14 7 2005

An aerial photograph of a vast, snow-covered mountain range. The terrain is rugged and mountainous, with numerous peaks and valleys covered in a thick layer of white snow. The perspective is from a high altitude, looking down on the landscape. The sky is a pale, hazy blue, suggesting a clear but slightly overcast day. The overall scene conveys a sense of a cold, high-altitude environment.

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

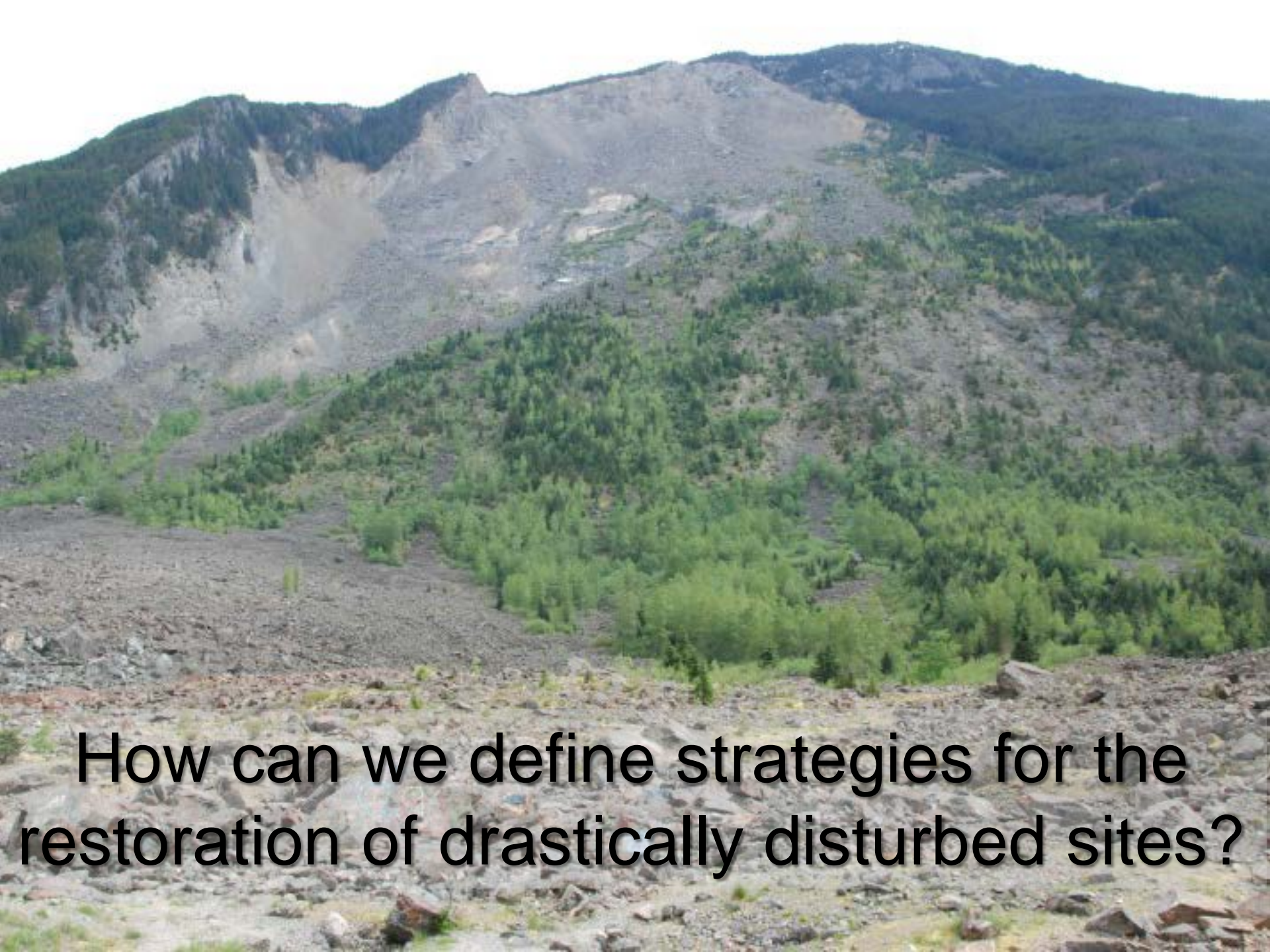
...and now we have a diversity of ecosystems...



...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?

9 10 2007



What characteristics do these species have?



What are the mechanisms of establishment?

14 10 2007



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

18 10 2007



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?



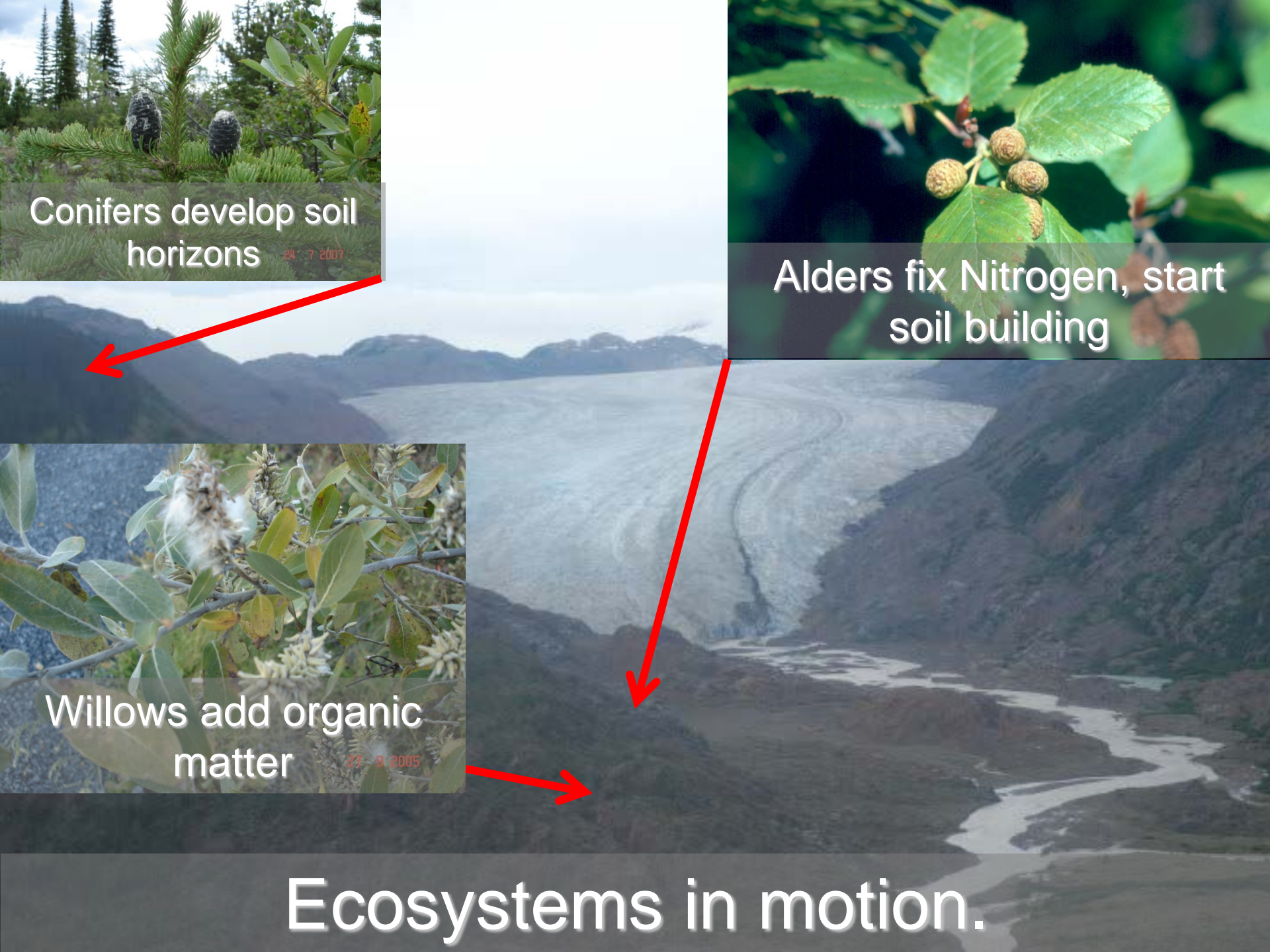
Conifers develop soil horizons 24 7 2007



Alders fix Nitrogen, start soil building



Willows add organic matter 27 8 2005



Ecosystems in motion.



On talus slopes?

18 5 2006



Conifers develop soil horizons

Lichens fix Nitrogen, start soil building

Deciduous species add organic matter

Ecosystems in motion.



On landslides?



Showy plants add diversity



Pioneering plants start rebuilding the ecosystem



Conifers move in

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

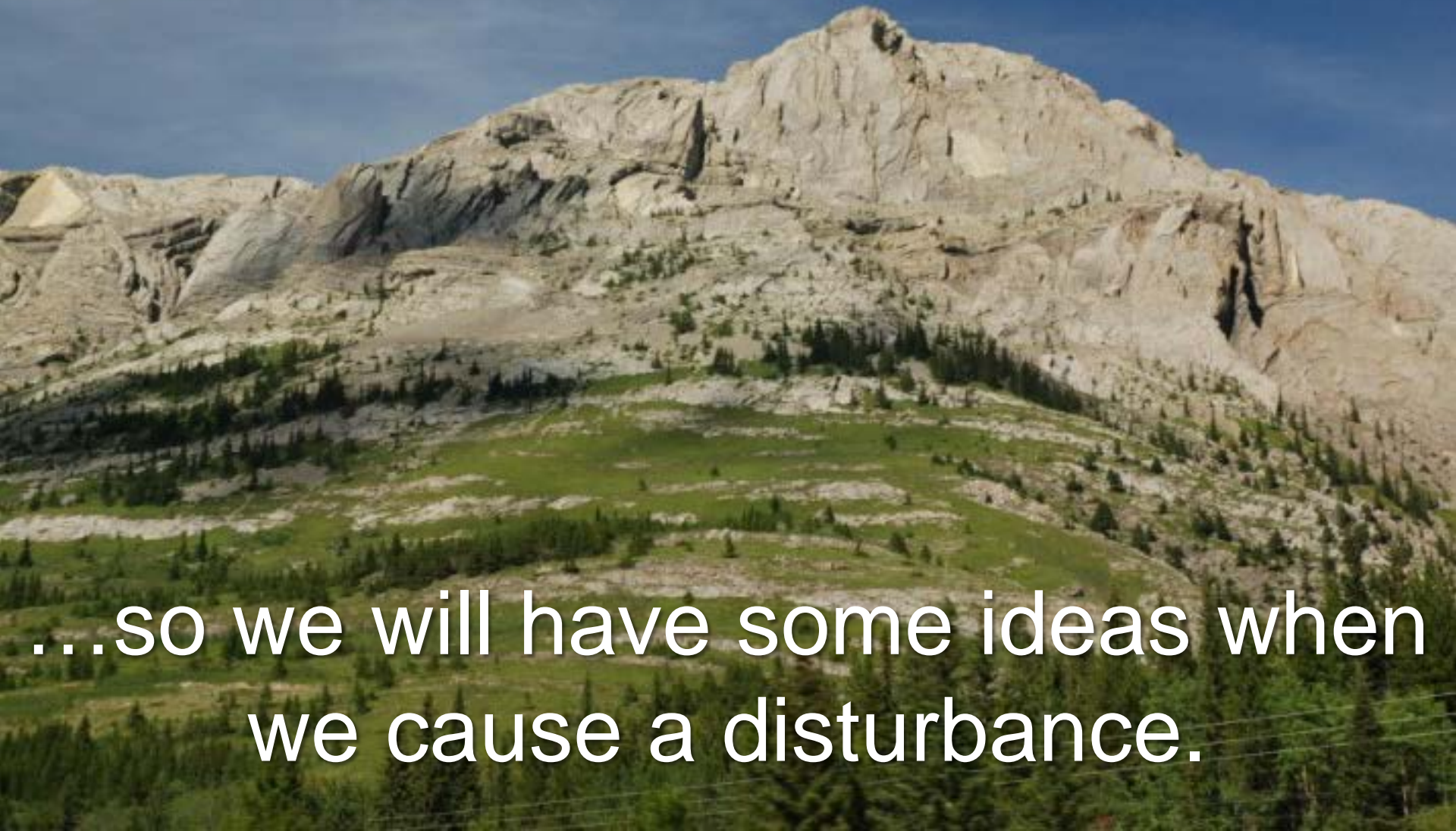
Species interactions

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.

14 10 2007



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


14 10 2007

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

A landscape photograph showing a rocky, eroded slope in the foreground, a dense forest in the middle ground, and mountains in the background. The text is overlaid on the top half of the image.

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

A landscape photograph of the Upper Elk Valley. The foreground is dominated by tall, green grasses and some yellowish-brown shrubs. In the middle ground, there is a valley floor covered in similar vegetation, with a few scattered trees. The background consists of steep, forested hillsides covered in dense evergreen trees under a clear sky.

Upper Elk Valley

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

Upper Elk Valley

A landscape photograph of the Upper Elk Valley. The foreground is a lush green meadow with several tree stumps, indicating a site of reclamation. The middle ground shows a dense forest of evergreen trees covering the hillsides. The background features more forested hills under a clear sky.

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

11 7 2005

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



"D 10" Bulldozer

Spreading soil material...



“D 10” Bulldozer

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

14 4 2010



Planting pioneering vegetation,
April 14, 2010



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

10/4/2010

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

A photograph of a forest with many bare trees, likely in late autumn or winter. The trees are thin and have no leaves. The ground is covered with dry grass and some snow. A red arrow points to a specific tree trunk in the middle ground.

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

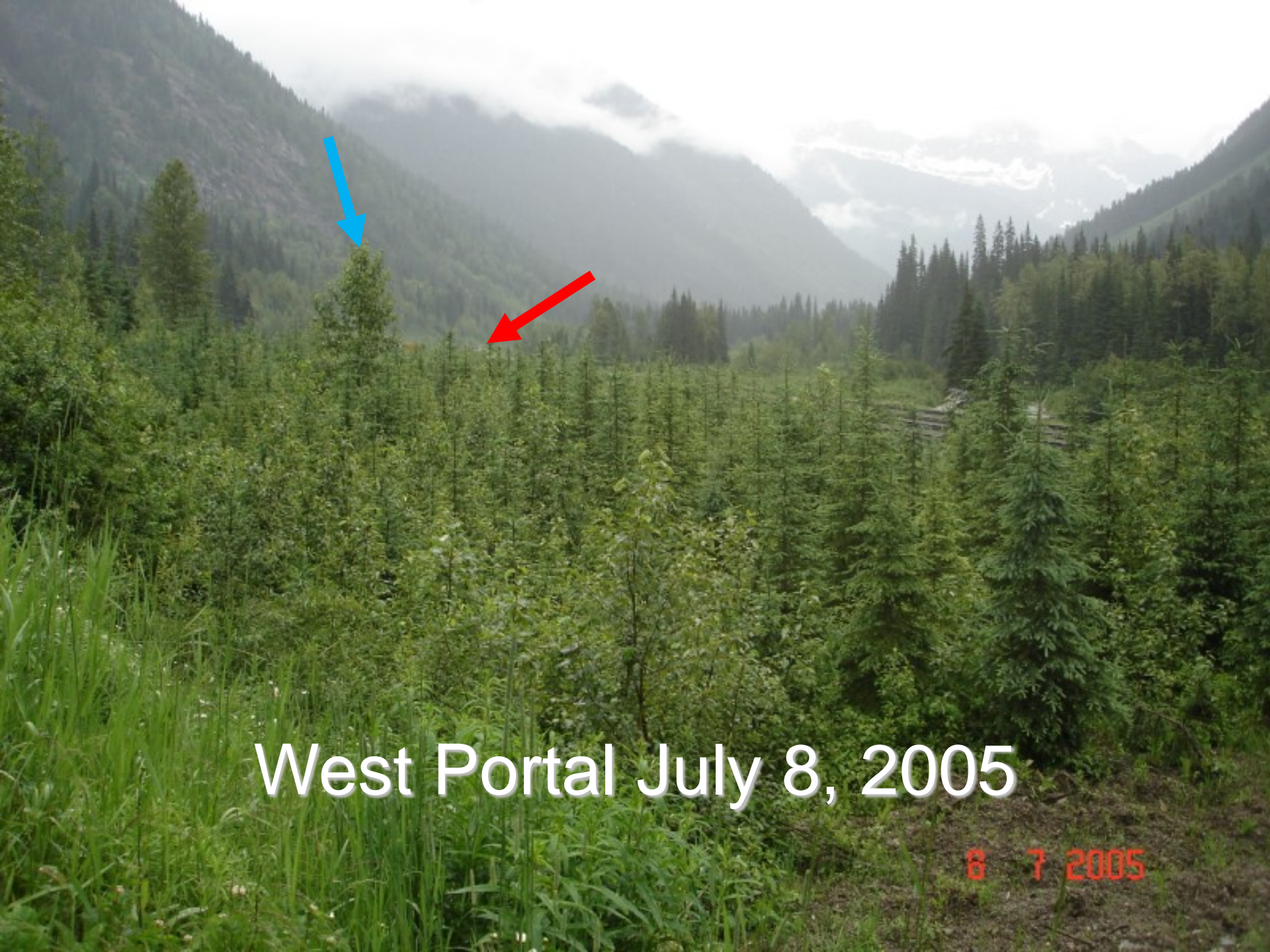


'99 7 15

West Portal August 3, 2003



'03 8 3

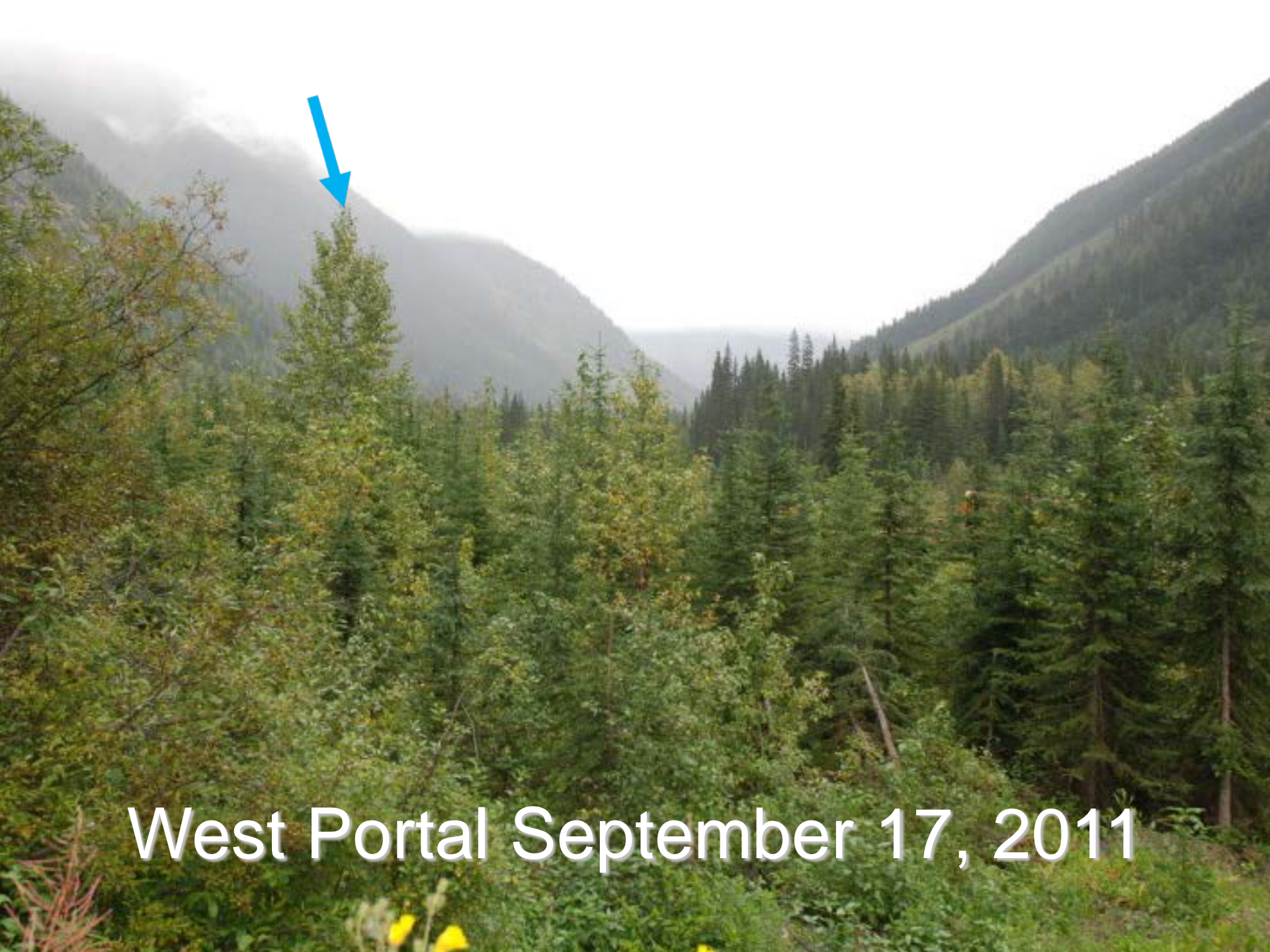


West Portal July 8, 2005

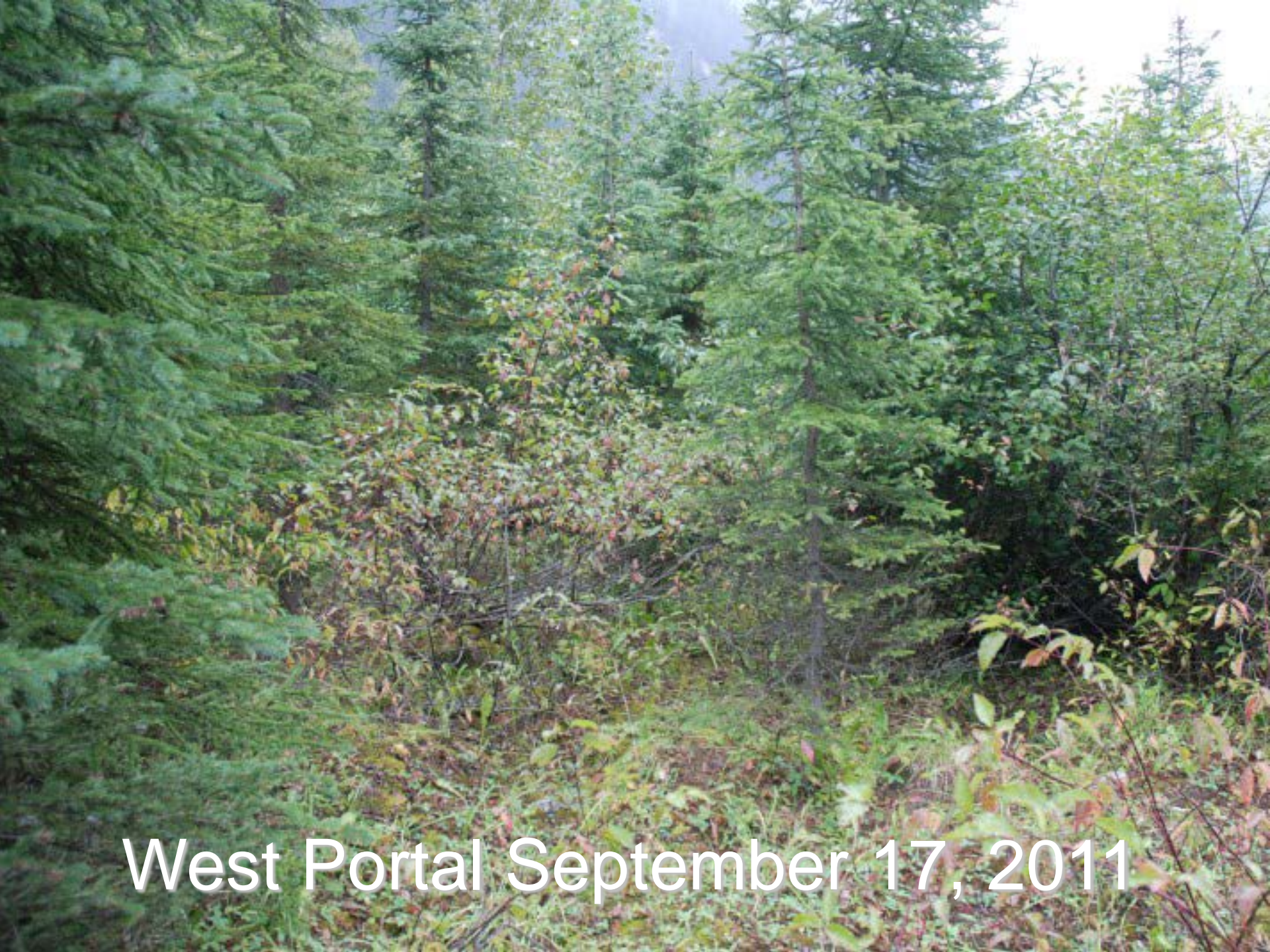
8 7 2005



West Portal July 27, 2008



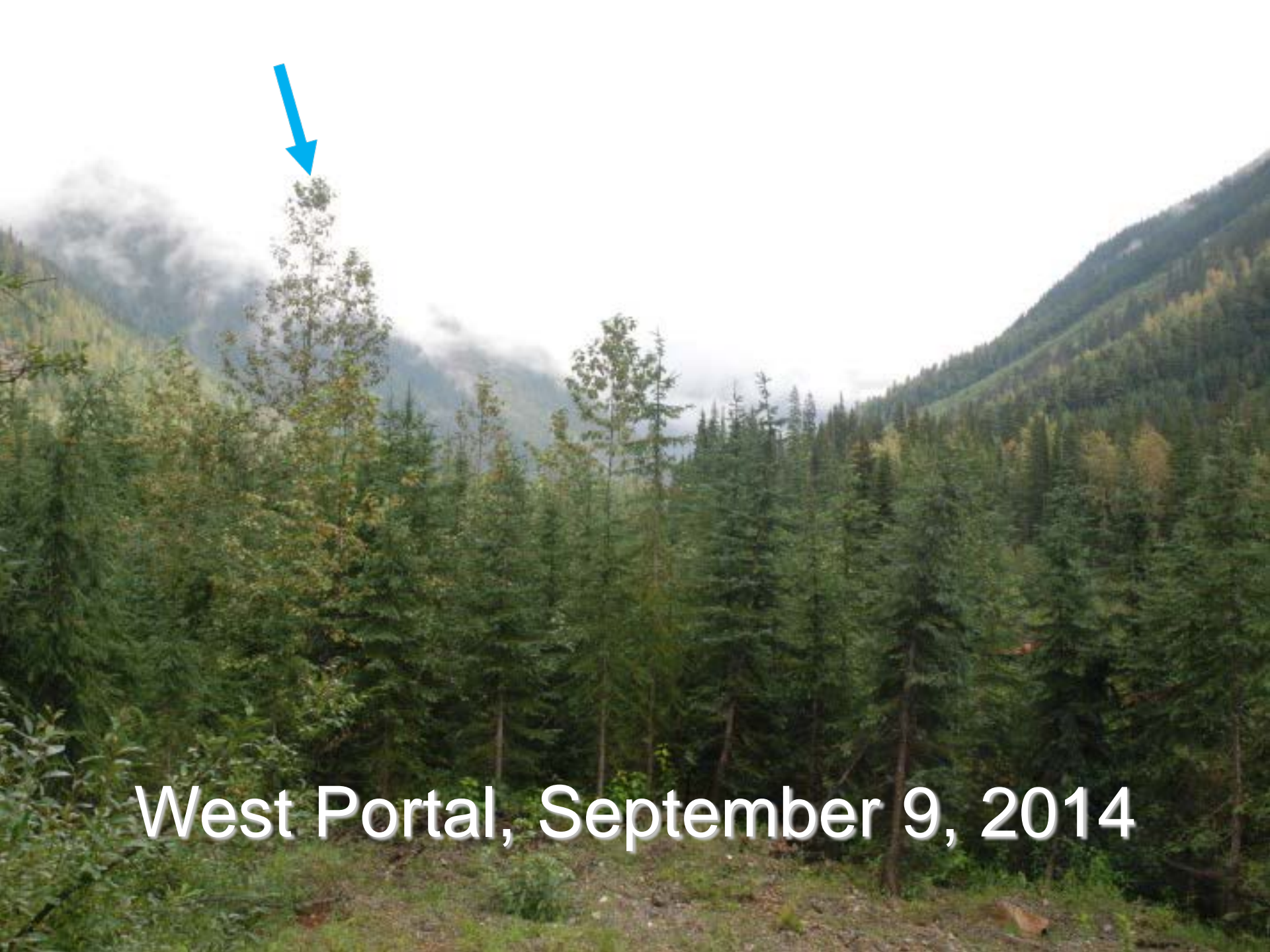
West Portal September 17, 2011



West Portal September 17, 2011

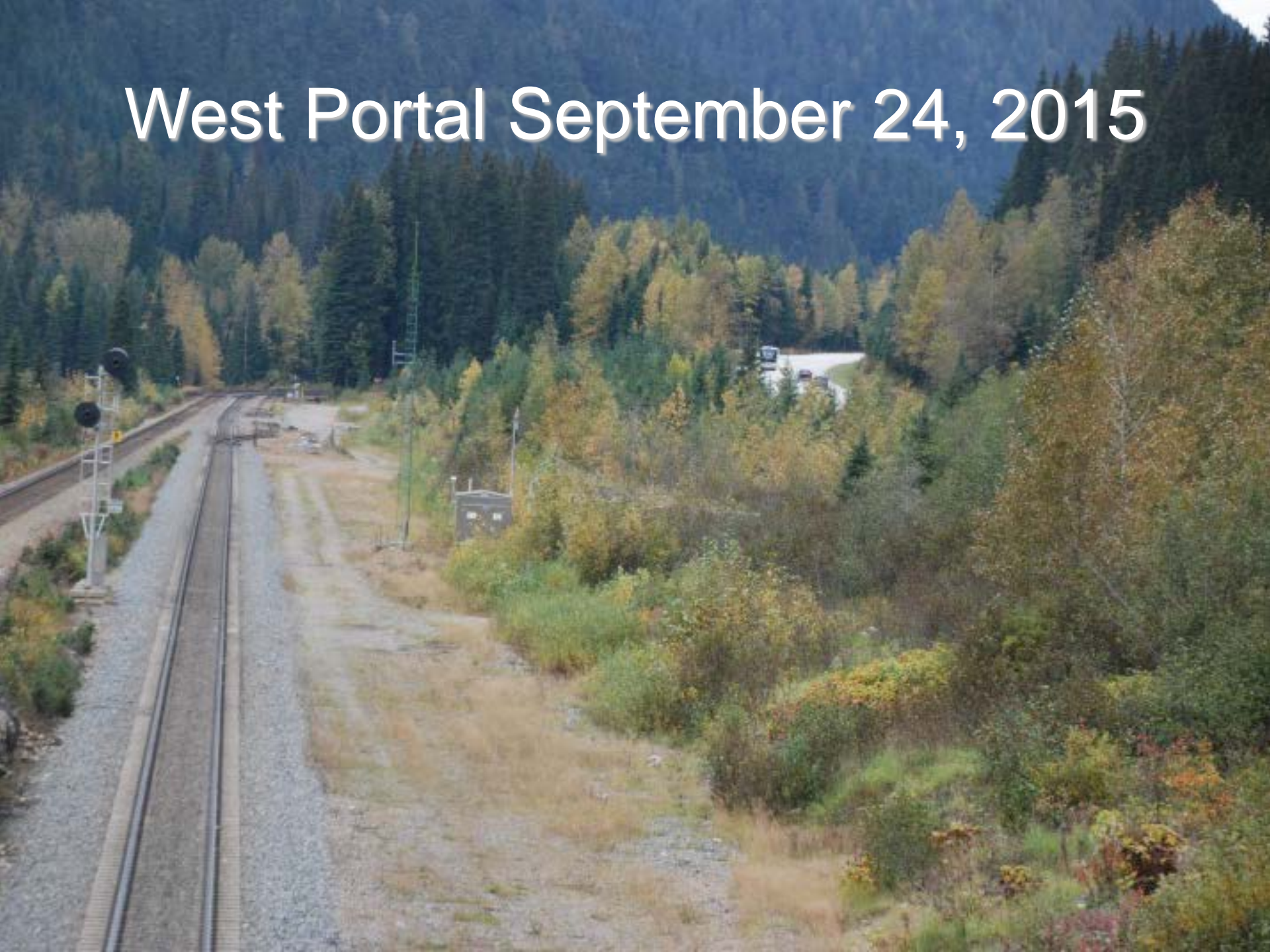


West Portal September 17, 2011



West Portal, September 9, 2014

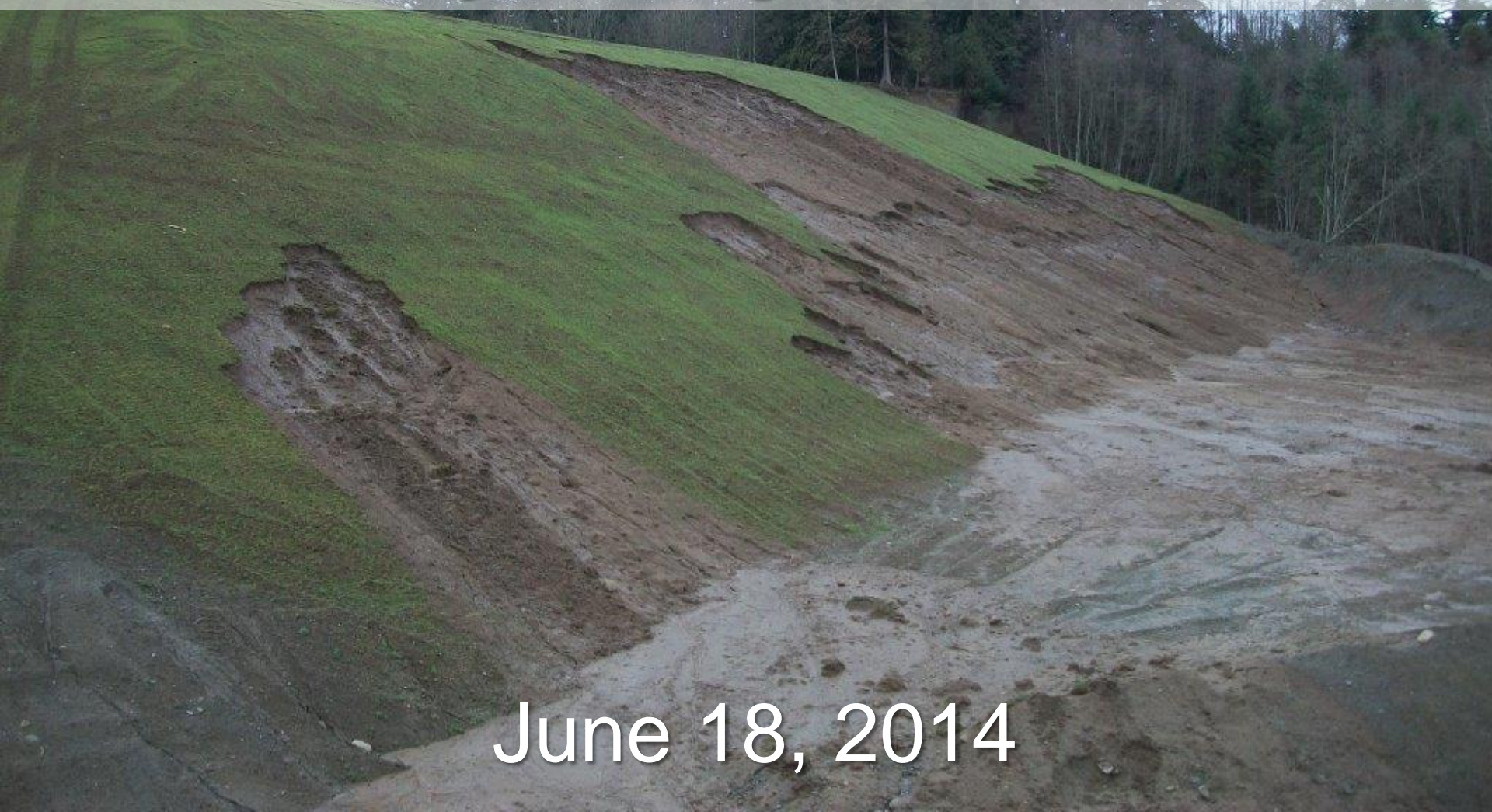
West Portal September 24, 2015





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

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



June 18, 2014



Shallowly rooted grasses provide no support for slope

...the hill was re-sloped.

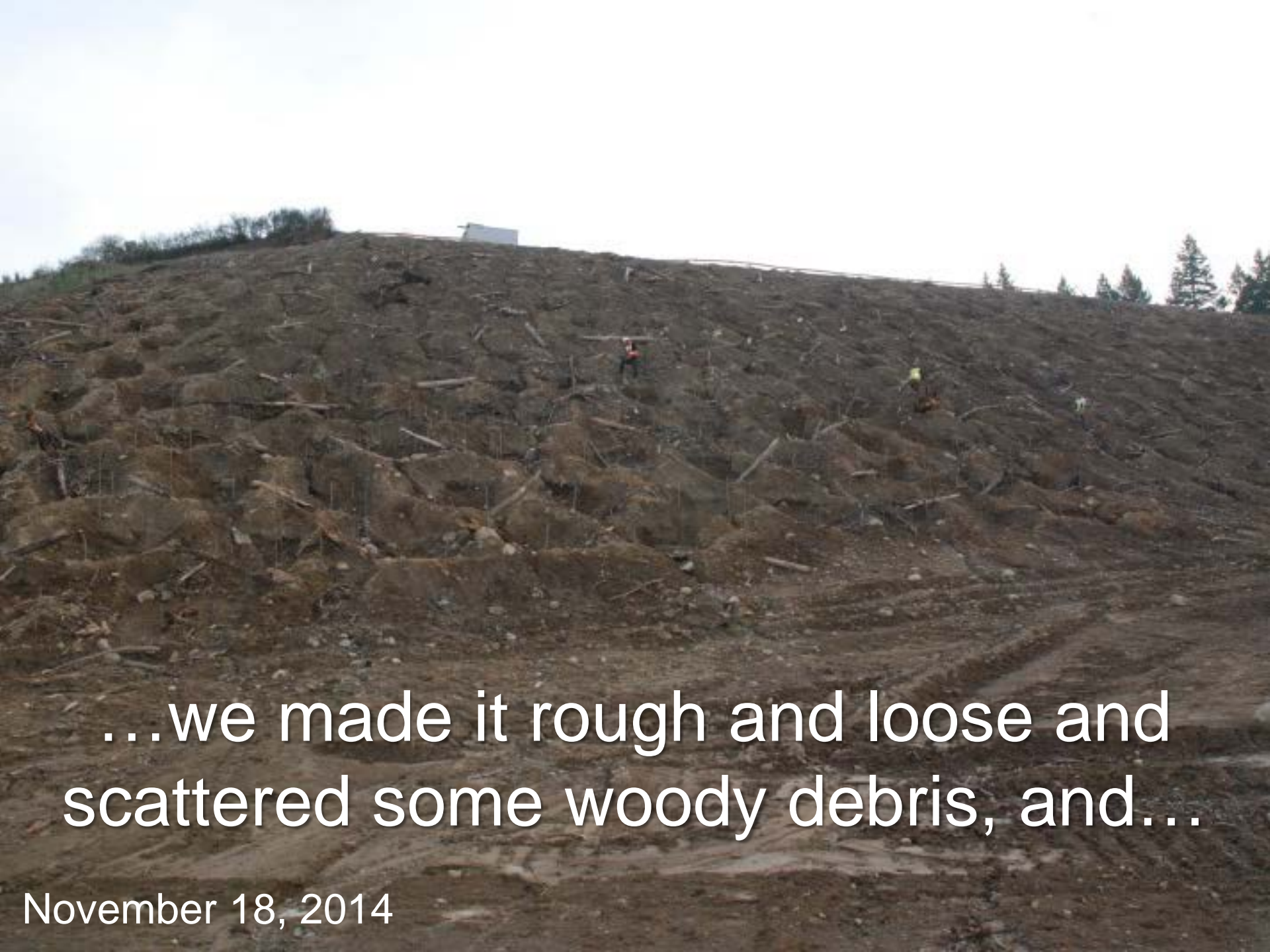


September 6, 2014



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



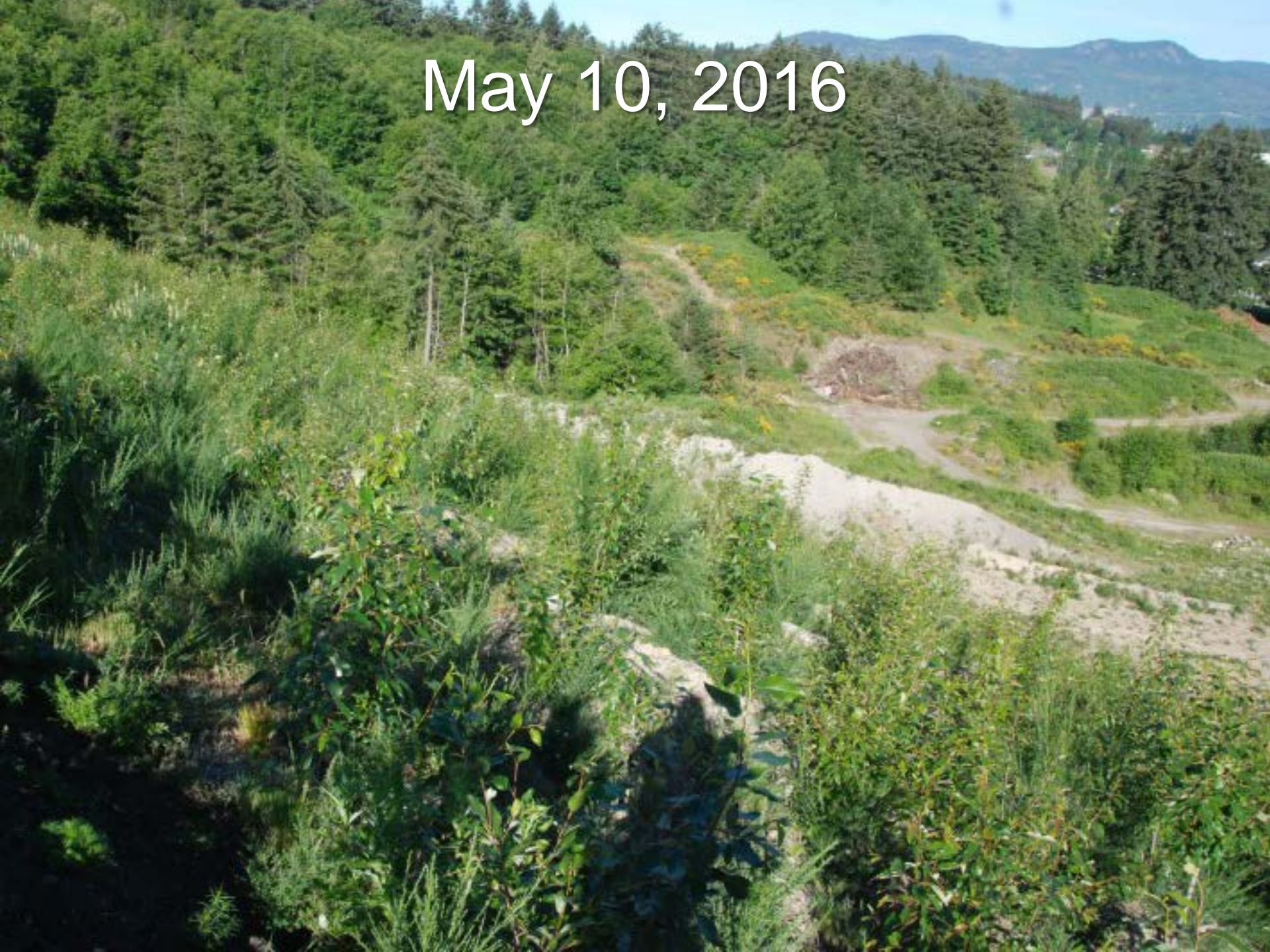
August 13, 2015



September 23, 2015



May 10, 2016



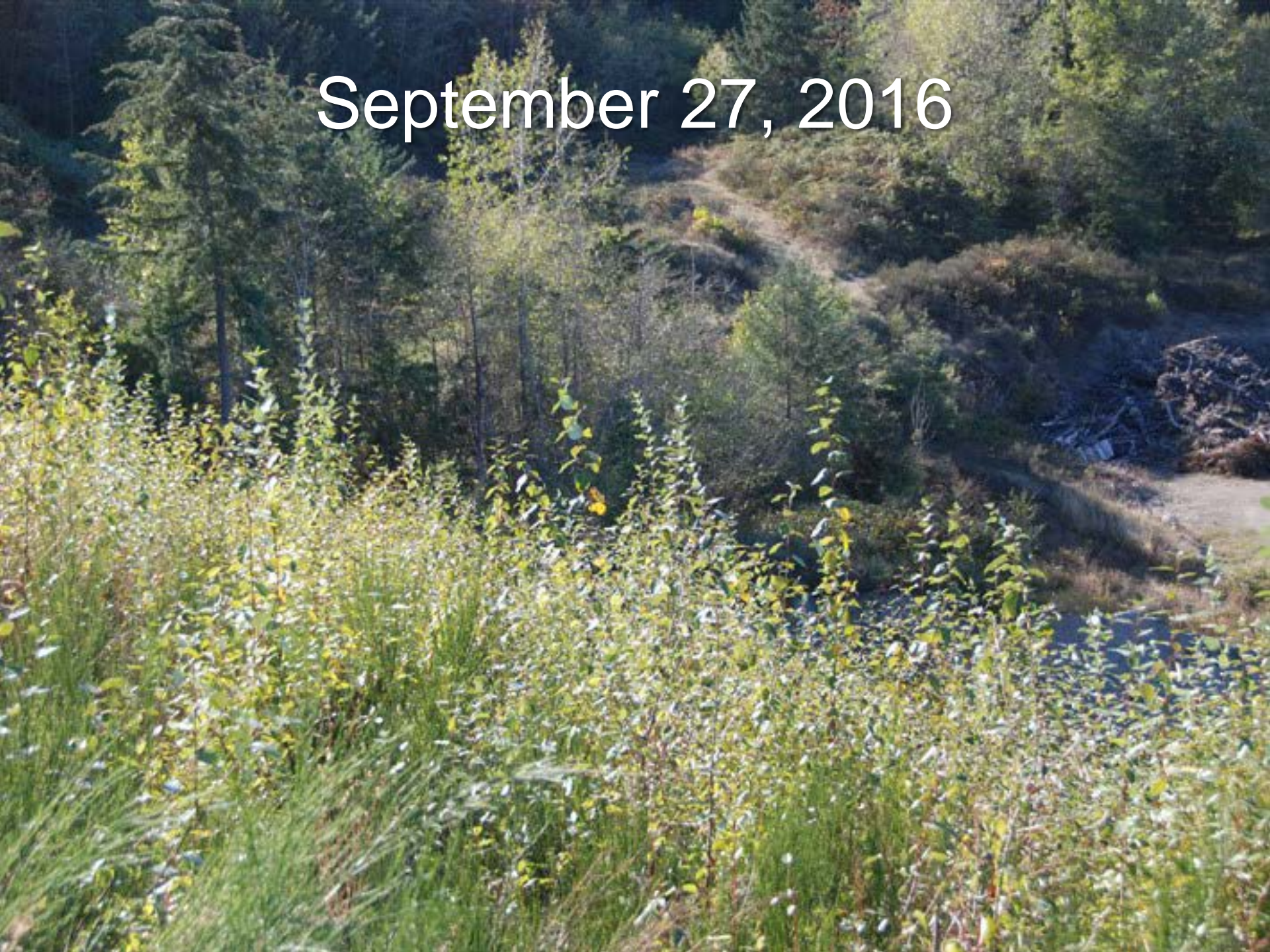
July 6, 2016



July 17, 2016



September 27, 2016



September 27, 2016



A photograph of a forest landscape. In the foreground, several young, slender trees with green leaves are growing. The background shows a dense forest of taller trees, a winding path or stream, and distant mountains under a clear sky.

September 27, 2016

This site is sequestering 20 to 25 tonnes/ha of CO₂ annually two years after planting.



Role of nitrogen fixing pioneering species in forest recovery

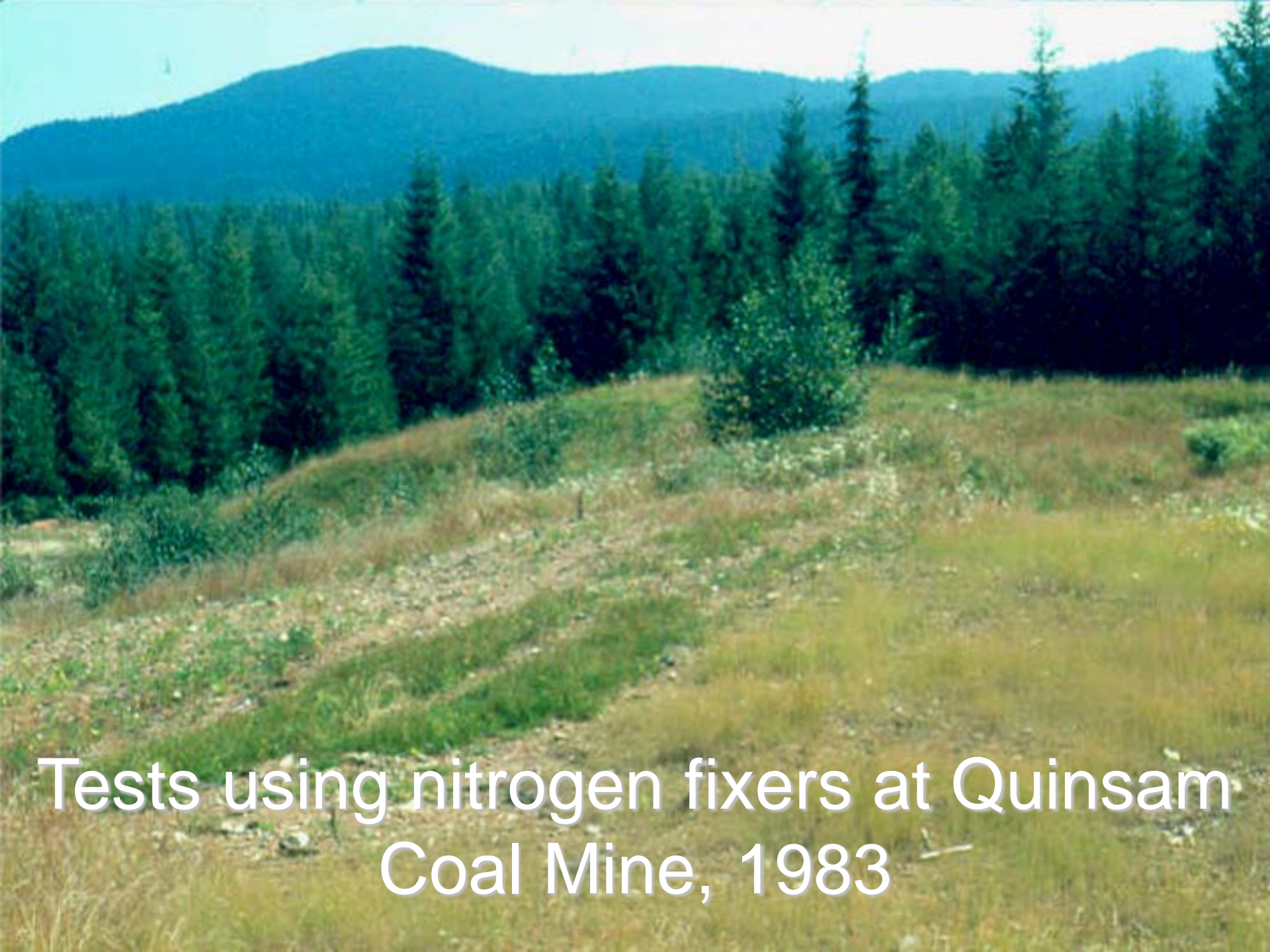


Use of nitrogen fixing pioneering species to enhance forest productivity at Quinsam Coal Mine

27 2 2007



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

27 2 2007

A photograph of a forest. In the foreground, there are several trees with light-colored bark, possibly birch. The ground is covered in moss and fallen branches. A small orange marker is visible near the base of one of the trees. The background shows a dense forest of evergreen trees.

Assessment of
forest productivity
Quinsam Coal
Mine, 2007

Natural forests

27 2 2007

Height vs. Age 2007

27 2 2007



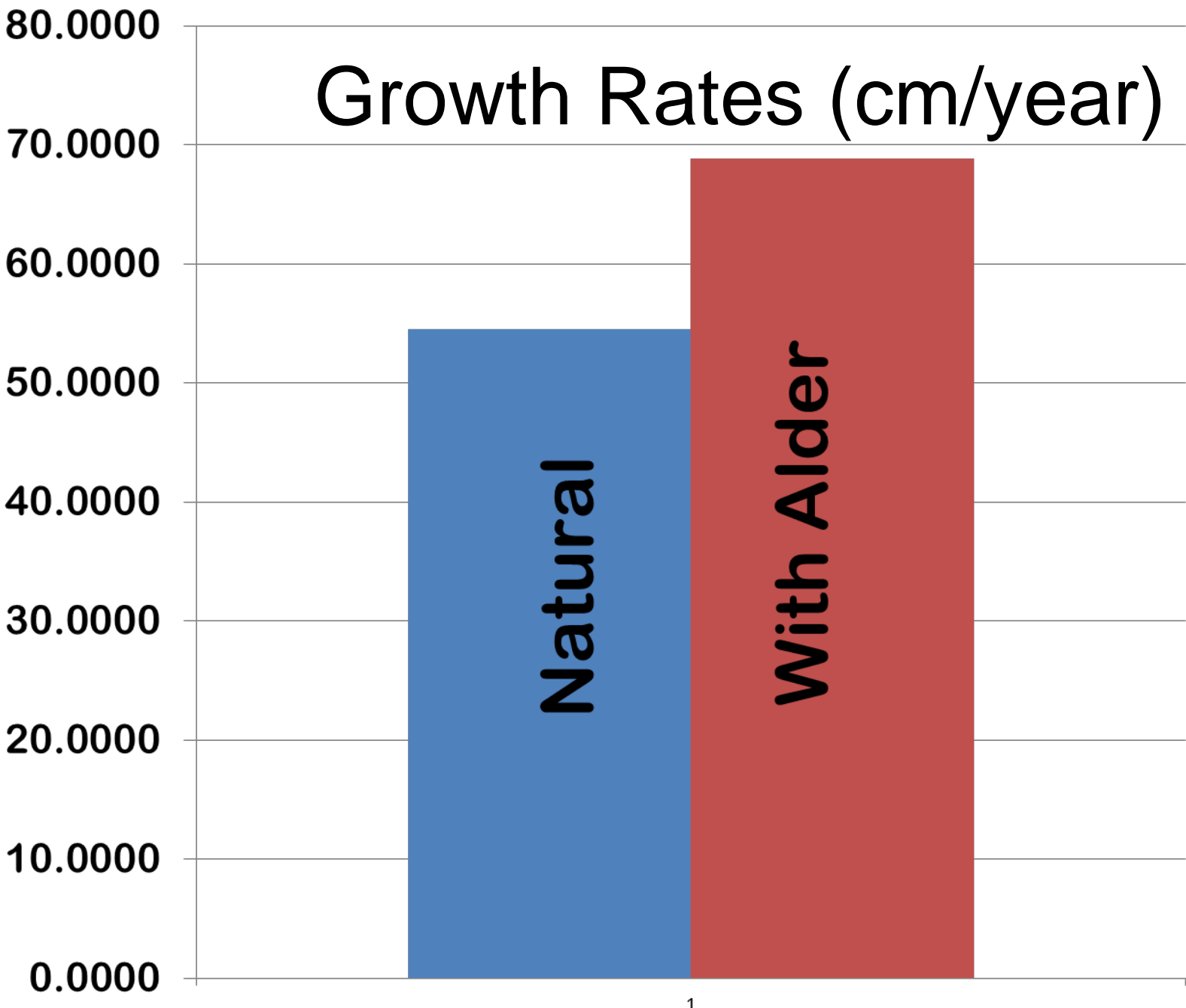
Natural sites have an average
growth rate of 0.54 m/yr

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)



Planting strategy based on trial results, July 31, 2007



31 7 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