Soil conservation update
… and other topics

Chuck Bulmer
Kalamalka Forestry Centre

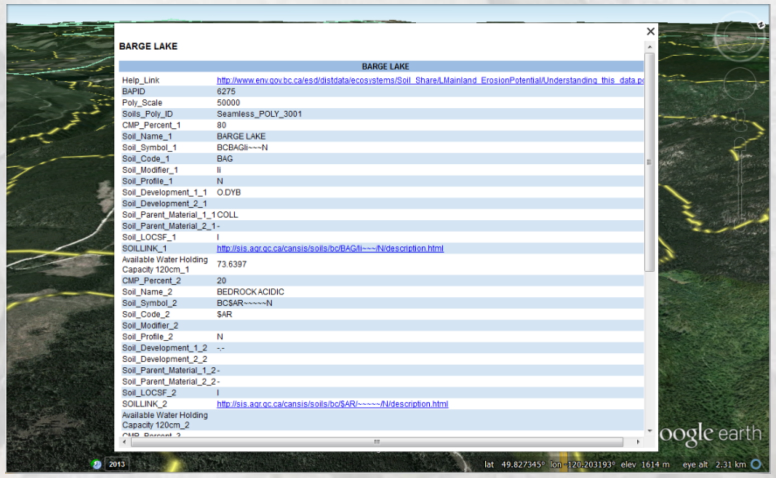
October 3 2015

Outline

- Know your soils
  - Where to go for information
- Soil conservation update
  - Long-term soil productivity / Rehab research
  - Soil physical properties
- What's coming next
  - Monitoring (FREP) .. Roads
  - The coming wave of new soils info

Know your soils

- Soil survey information for most areas of the province is now available on the web
- Google earth format…
  - http://www.env.gov.bc.ca/esd/distdata/ecosystems/Soil_Data/SIFT
- Raster image format…
  - http://www.hectaresbc.org raster data // soil parent materials




Wilbert
Field stop
Keogan / Tunkwa
Silver Lake Resort Rd
Silver Lake
Connaly / Hellroarer
97C
Image Landsat
© 2015 Google
Image © 2015 DigitalGlobe
Image RDCO
Google earth
2005
Imagery Date: 7/24/2013 lat 49.836529° lon -119.841807° elev 1122 m eye alt 2.00 km

BARGE LAKE

BARGE LAKE	
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Soil_Code_1	BAG
Soil_Modifier_1	li
Soil_Profile_1	N
Soil_Development_1_1	O.DYB
Soil_Development_2_1	
Soil_Parent_Material_1_1	COLL
Soil_Parent_Material_2_1	-
Soil_LOCSF_1	I
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CMP_Percent_2	20
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Soil_Symbol_2	BC$AR~~~~~N
Soil_Code_2	$AR
Soil_Modifier_2	
Soil_Profile_2	N
Soil_Development_1_2	-.-
Soil_Development_2_2	
Soil_Parent_Material_1_2	-
Soil_Parent_Material_2_2	-
Soil_LOCSF_2	I
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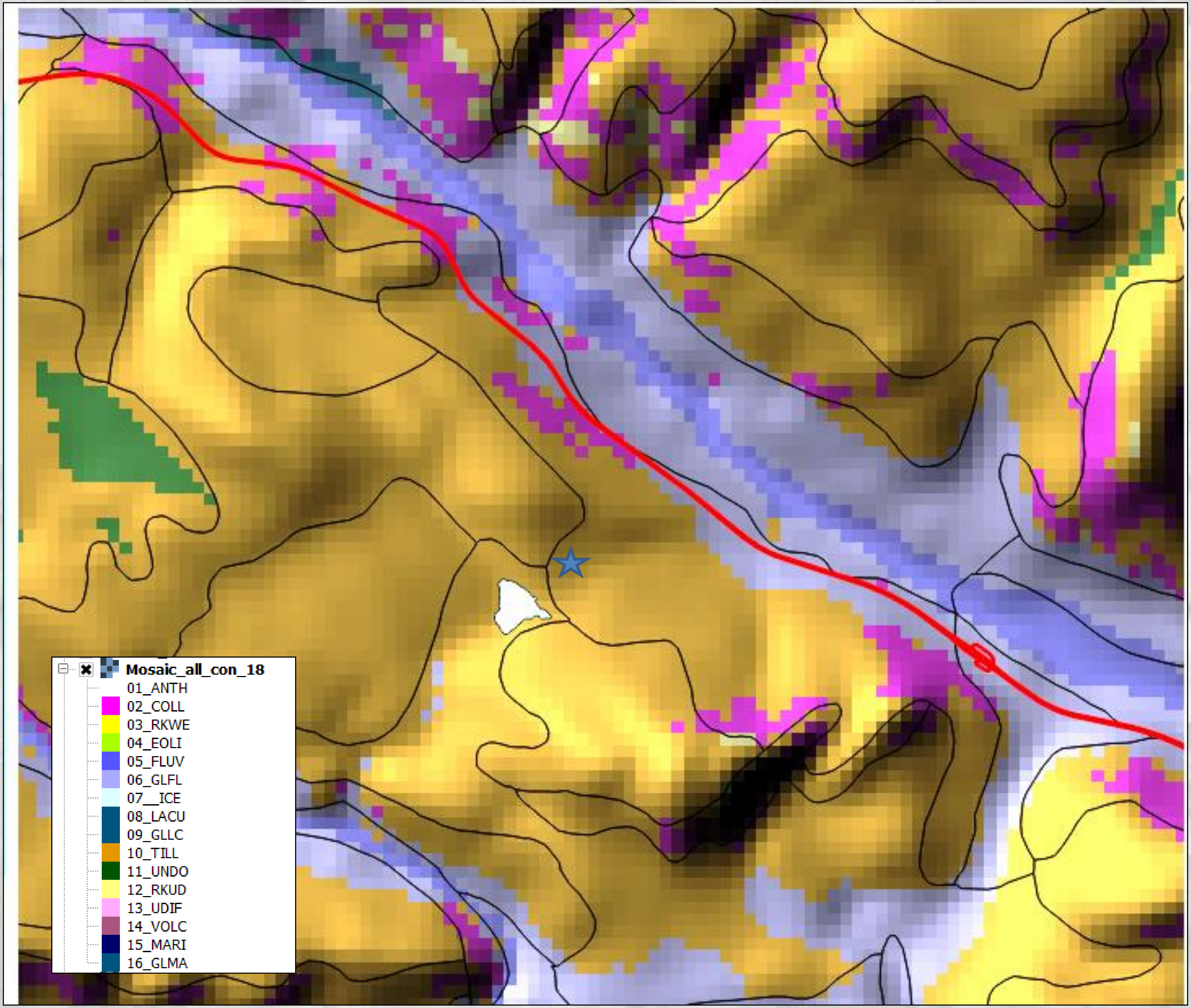
Soil_Code_3	
Soil_Modifier_3	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05_FLUV
06_GLFL
07__ICE
08_LACU
09_GLLC
10_TILL
11_UNDO
12_RKUD
13_UDIF
14_VOLC
15_MARI
16_GLMA

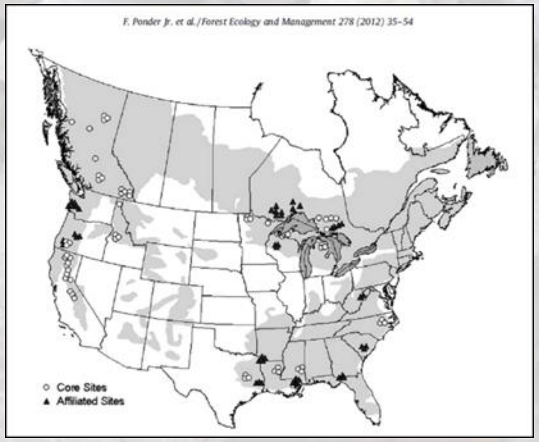
Soil Conservation Update

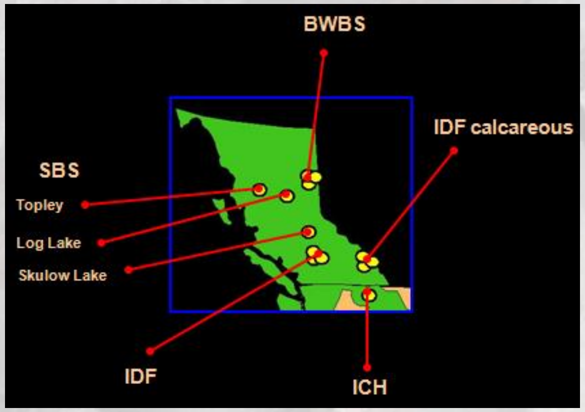
- **Long term soil productivity (LTSP)**
  - North America-wide study 45 study sites
  - 5 installations in BC: BWBS; SBS; IDFx2; ICH
- Soil Rehabilitation Research
  - Retrospective; field trials; controlled studies
- Properties of the pore system
  - Proctor compaction and the relative bulk density
  - Implications for soil resilience

Long term soil productivity study

Q: What are the effects of soil disturbance on site productivity ?

- Compaction and organic matter removal
  - 3 levels of compaction (‘none’ ‘light’ ‘heavy’)
  - 3 levels of om removal
    (‘stems only’ ‘stems+slash’ ‘stems+slash+forest floor’)
- Rotation length experiment
- Established 1990’s





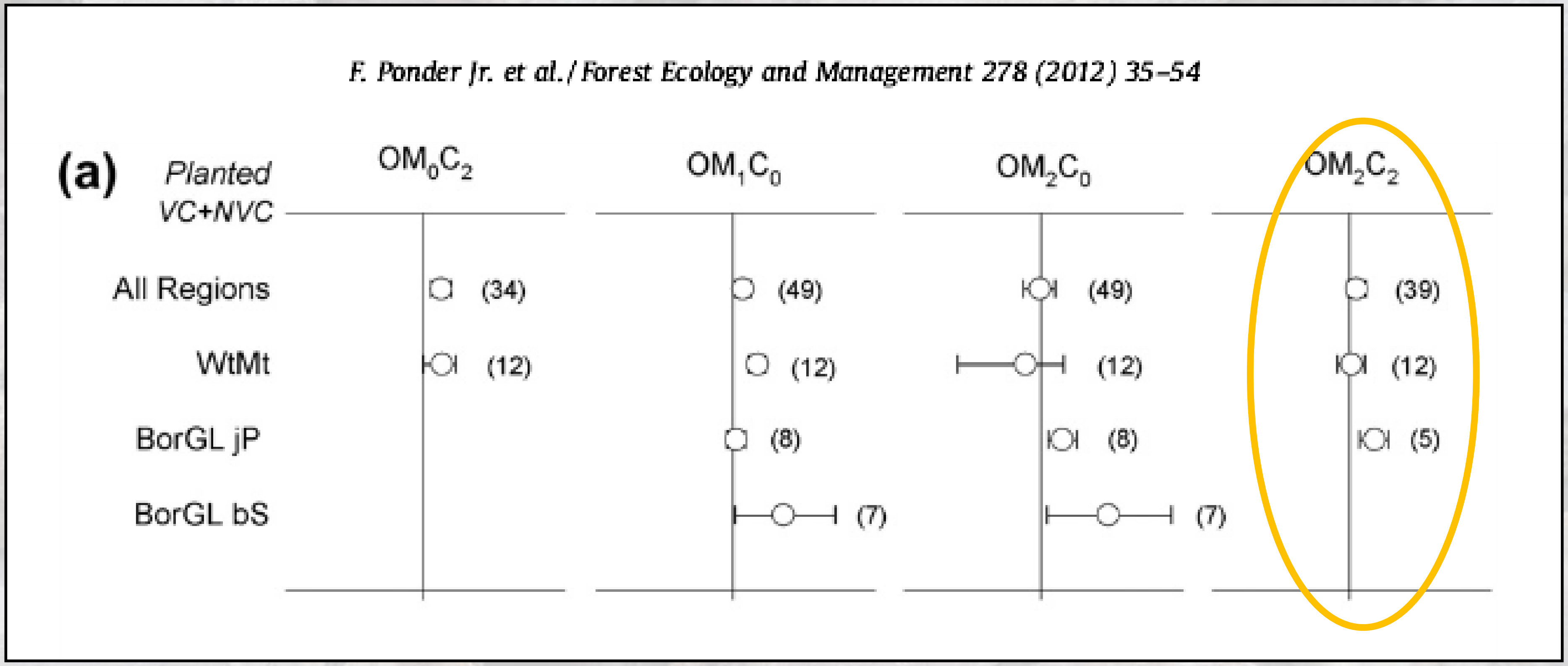
OM1C0 Boles removed No compaction	OM2C0 Boles and crowns removed No compaction	OM3C0 Boles, crowns, forest floor removed No compaction
OM1C1 Boles removed Moderate compaction	OM2C1 Boles and crowns removed Moderate compaction	OM3C1 Boles, crowns, forest floor removed Moderate compaction
OM1C2 Boles removed Heavy compaction	OM2C2 Boles and crowns removed Heavy compaction	OM3C2 Boles, crowns, forest floor removed Heavy compaction

Long term soil productivity study

Dairy Creek
- Effect of compaction
- Effect of slash removal
- Lodgepole pine vs Douglas-fir

Long term soil productivity study

Q: What are the effects of soil disturbance on site productivity ?

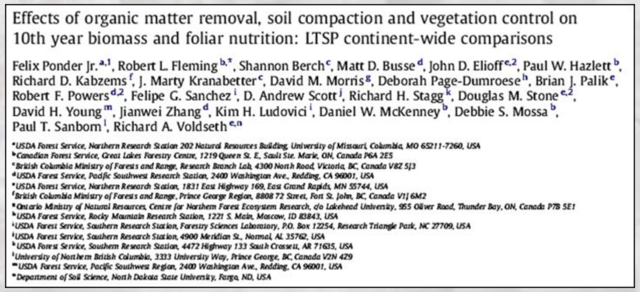


"Most sites had deep med-coarse soils: compaction treatments may not have exceeded theoretical growth limiting bulk densities"

10 yr Results – Long Term Site Productivity Study

- Overall (slight) **positive** response to compaction
- No consistent effect of organic matter removal

A: "Soil disturbance levels on slightly disturbed growing sites appear to produce levels of soil compaction and om that allow for the development of healthy young forests"



Effects of organic matter removal, soil compaction and vegetation control on 10th year biomass and foliar nutrition: LTSP continent-wide comparisons

Felix Ponder Jr.[a,1], Robert L. Fleming[b,*], Shannon Berch[c], Matt D. Busse[d], John D. Elioff[e,2], Paul W. Hazlett[b], Richard D. Kabzems[f], J. Marty Kranabetter[c], David M. Morris[g], Deborah Page-Dumroese[h], Brian J. Palik[e], Robert F. Powers[d,2], Felipe G. Sanchez[i], D. Andrew Scott[j], Richard H. Stagg[k], Douglas M. Stone[e,2], David H. Young[m], Jianwei Zhang[d], Kim H. Ludovici[i], Daniel W. McKenney[b], Debbie S. Mossa[b], Paul T. Sanborn[l], Richard A. Voldseth[e,n]

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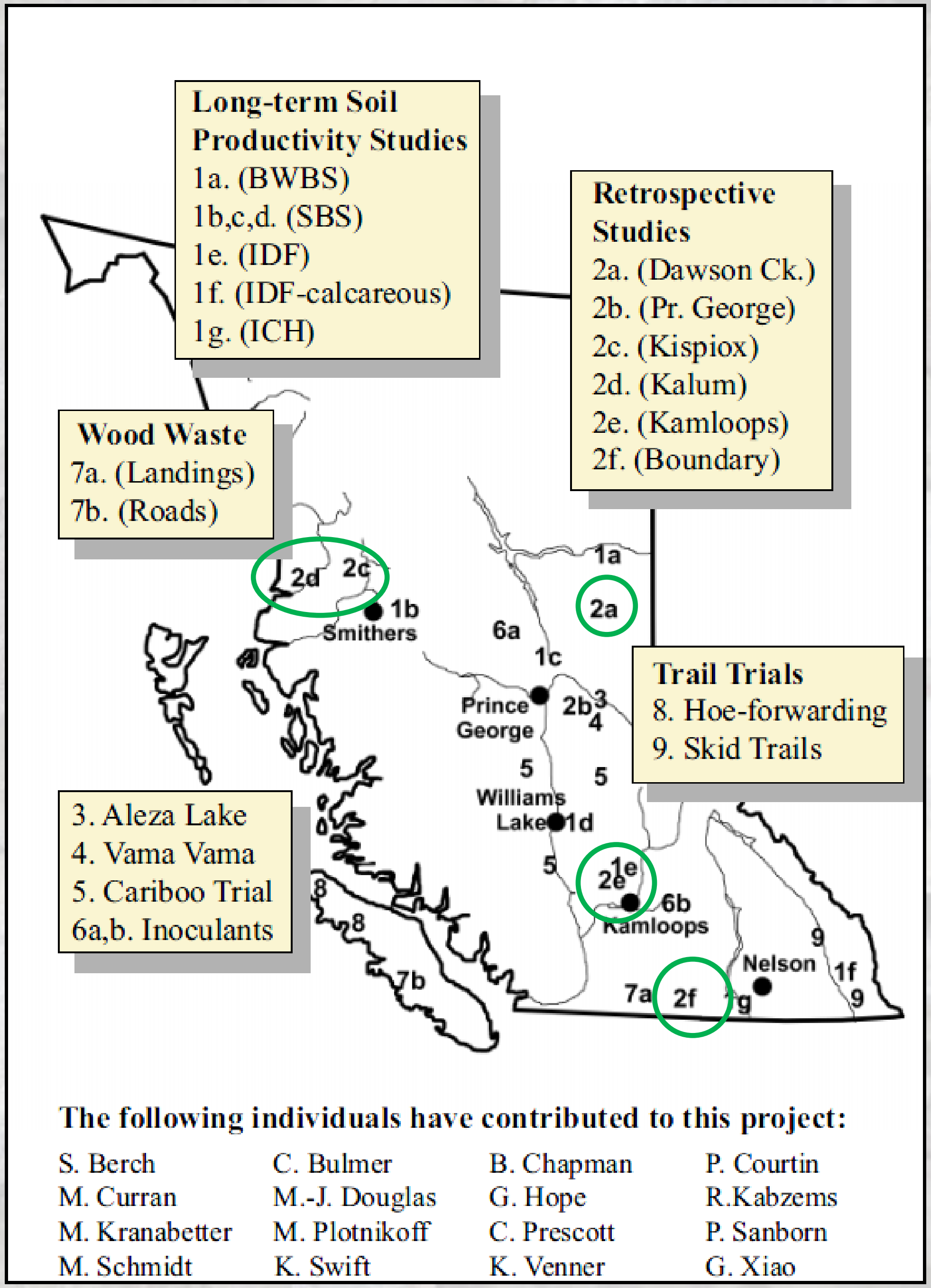
[n] Department of Soil Science, North Dakota State University, Fargo, ND, USA

Soil rehabilitation research

Q: Can soil rehabilitation treatments restore productivity?

- **Retrospective studies**
  - Winged subsoiler on landings
    - ICH: 88 landings
    - BWBS: 54 landings
    - Kamloops: ripper on landings and roads
  - Compared tree growth on landings and adjacent plantation
- **Field trials**
  - Aleza Lake
  - Wood waste for organic amendment
    - OK Falls
- **Controlled studies**
  - Raised beds at Kalamalka



Soil rehabilitation research

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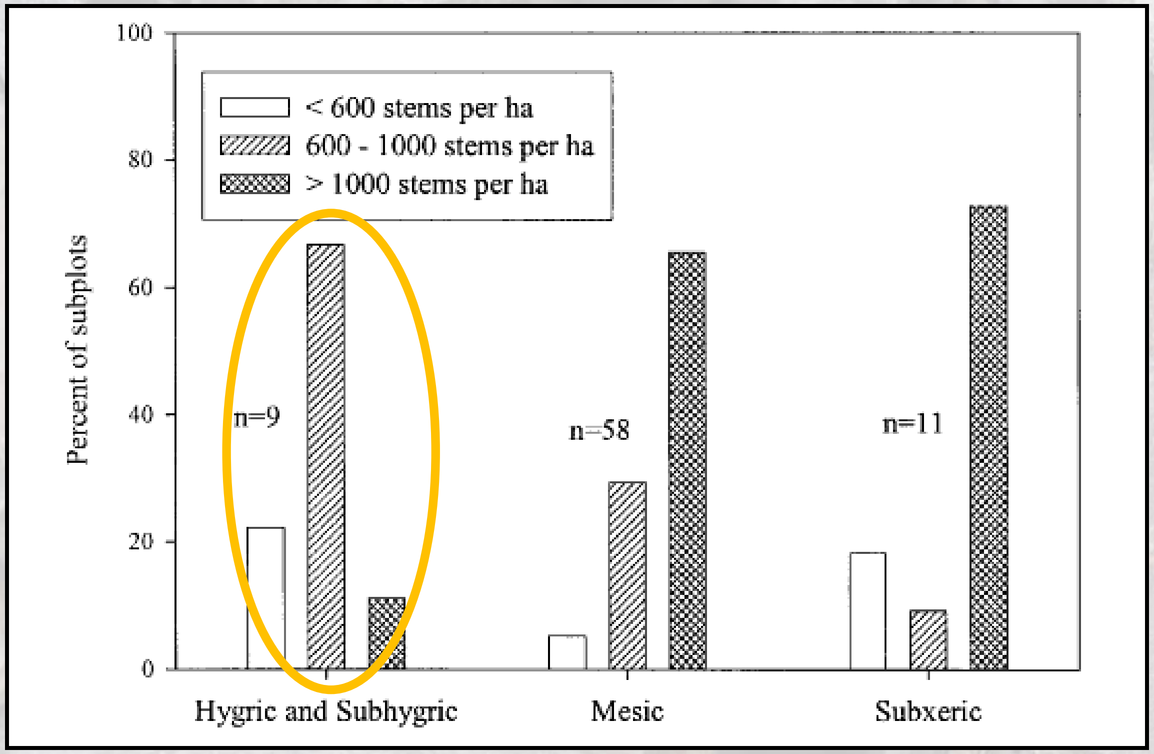
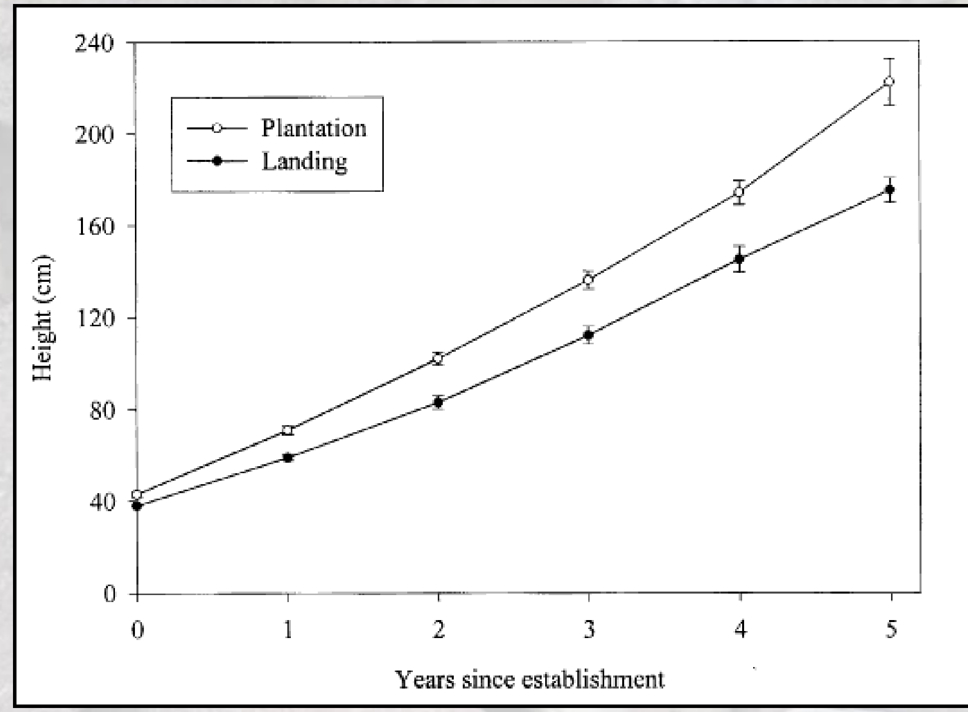




Results – Dawson Creek

- Adequate stocking except on wet sites
- Slightly better growth on plantations

Soil properties and lodgepole pine growth on rehabilitated landings in northeastern British Columbia

C. E. Bulmer[1] and M. Krzic[2]

[1]BC Ministry of Forests, Research Branch, 3401 Reservoir Road, Vernon, British Columbia, Canada V1B 2C7; [2]Faculty of Agricultural Sciences / Faculty of Forestry, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4.

Received 21 February 2003, accepted 29 May 2003.

Bulmer, C. E. and Krzic, M. 2003. **Soil properties and lodgepole pine growth on rehabilitated landings in northeastern British Columbia.** Can. J. Soil Sci. **83**: 465–474. We determined post-establishment tree growth and soil properties on rehabilitated log landings and forest plantation sites with medium texture in northeastern British Columbia. Six years after rehabilitation treatments were applied, 60% of rehabilitated landing plots had more than 1000 stems ha^{-1}, while 17% had fewer than 600 stems ha^{-1}. The average height of undamaged lodgepole pine trees on rehabilitated landings was consistently lower than for trees of the same age on plantations. Surface (0–7 cm) and subsurface (10–17 cm) soil bulk densities were higher for rehabilitated landings than for adjacent plantations. Rehabilitated landing and plantation soils had similar values of total and aeration porosity. Plantation soils had higher **available water storage capacity** (AWSC) than rehabilitated soils. Soil mechanical resistance after landing rehabilitation was often higher than for plantation soils at the same depth. Soils on both rehabilitated landings and plantations showed an increase in mechanical resistance from June to September 2001. With the exception of June 2001, soil mechanical resistance after landing rehabilitation was often higher than 2500 kPa. For surface mineral soils, there were no differences in total C, N, or **cation exchange capacity** (CEC) between rehabilitated landings and plantations. Rehabilitated landing soils had significantly higher total C and N at 10–17 cm depth than plantation soils, which coincided with higher clay content for the landing subsoils.

Key words: Forest soil rehabilitation, soil degradation, soil productivity, soil conservation

Soil rehabilitation research

Q: Can soil rehabilitation treatments restore productivity?

Retrospective studies: Longer term measurements

Table 3. Average values (std dev) for tree growth and expected site index.[1]

	Stocking stems per ha [2]	Total height cm	Age (breast height)	dbh (cm)	Ht / dbh (m/cm)	Site index m	P (t-test) site index
BDY landings	1321 (458)	311 (74)	3.7 (0.8)	4.5 (2.0)	69.6 (21.1)	28.1 (3.5)	<0.01
BDY plantations	nd	418 (75)	6.0 (0.9)	6.2 (1.4)	70.2 (6.3)	24.8 (2.4)	
KAM landings	1248 (351)	414 (87)	6.1 (1.8)	6.2 (1.9)	68.7 (9.0)	22.2 (3.0)	0.20
KAM plantations	nd	438 (88)	6.7 (1.6)	6.5 (1.8)	69.7 (9.3)	21.5 (2.0)	
WNSA landings	1156 (196)	669 (76)	9.3 (0.7)	9.3 (1.5)	72.4 (5.5)	25.6 (1.3)	0.34
WNSA plantations	nd	952 (158)	12.9 (1.7)	11.6 (2.0)	82.7 (9.7)	26.2 (1.6)	
KPX landings	1835 (287)	308 (65)	4.5 (0.9)	4.2 (1.3)	75.1 (4.8)	23.4 (1.1)	<0.01
KPX plantations	nd	636 (56)	8.3 (0.6)	9.2 (1.2)	70.4 (3.0)	27.1 (0.6)	
NSGA landings	1911 (866)	340 (47)	4.4 (0.7)	5.3 (1.1)	63.8 (10.4)	26.8 (1.9)	0.22
NSGA plantations	nd	646 (108)	8.6 (1.8)	8.9 (1.5)	72.7 (9.8)	27.5 (1.8)	

A: “Ten to fifteen years after planting lodgepole pine on rehabilitated landings, a young forest has established in most cases and growth rates are similar to or slightly lower than trees growing in adjacent plantations”

Soil rehabilitation research

Q: Are some rehabilitation treatments more effective than others?

Use of Wood Waste in Rehabilitation of Landings Constructed on Fine-Textured Soils, Central Interior British Columbia, Canada

Paul Sanborn, *Ecosystem Science and Management Program, University of Northern British Columbia, 3333 University Way, Prince George, BC, Canada V2N 4Z9;* **Chuck Bulmer,** *Kalamalka Research Station, BC Ministry of Forests, 3401 Reservoir Road, Vernon, BC, Canada V1B 2C7; and* **Dave Coopersmith,** *6325 Chatham Street, West Vancouver, BC, Canada V7W 2E1.*

ABSTRACT: *Rehabilitation of temporary landings and roads constructed on fine-textured Alfisols must ameliorate poor soil structure, high bulk densities, and greatly reduced organic matter. A long-term field experiment in the central interior of British Columbia (BC) was begun in 1995 to compare soil properties and seedling growth on landings rehabilitated with three operationally feasible treatments: (1) incorporation of waste wood chips (140 t/ha, oven-dry basis), supplemented with 600 kg N/ha; (2) subsoiling; and (3) shallow tillage combined with recovery and spreading of topsoil. After 4 years, soil bulk density at 7–14 cm depth was lowest in the chip incorporation treatment. Although total C, N, and S, and mineralizable N concentrations were highest in the topsoil recovery treatment, the chip incorporation treatment had the highest 3-year growth rates of hybrid white spruce (*Picea glauca × engelmannii*). Foliar analyses indicated that macro- and micronutrient concentrations were generally adequate, with only S and Mg being of concern. Establishment of paper birch (*Betula papyrifera*) did not succeed due to severe rodent damage to seedlings, perhaps encouraged by rapid and dense revegetation by seeded agronomic legumes. Silviculturists should consider treatments involving incorporation of chipped wood wastes, with appropriate supplementary N fertilization, in rehabilitation of access structures on fine-textured soils in the BC central interior. West. J. Appl. For. 19(3):175–183.*

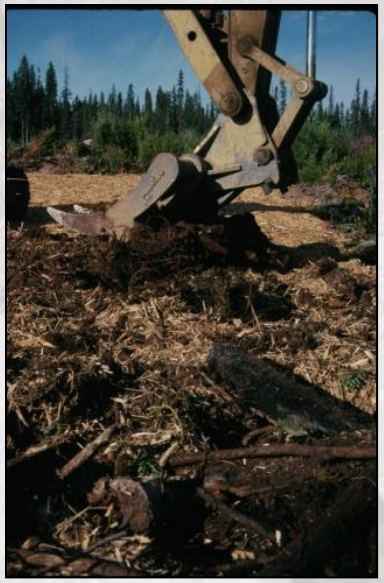
Key Words: Hybrid white spruce, paper birch, soil nutrients, bulk density.

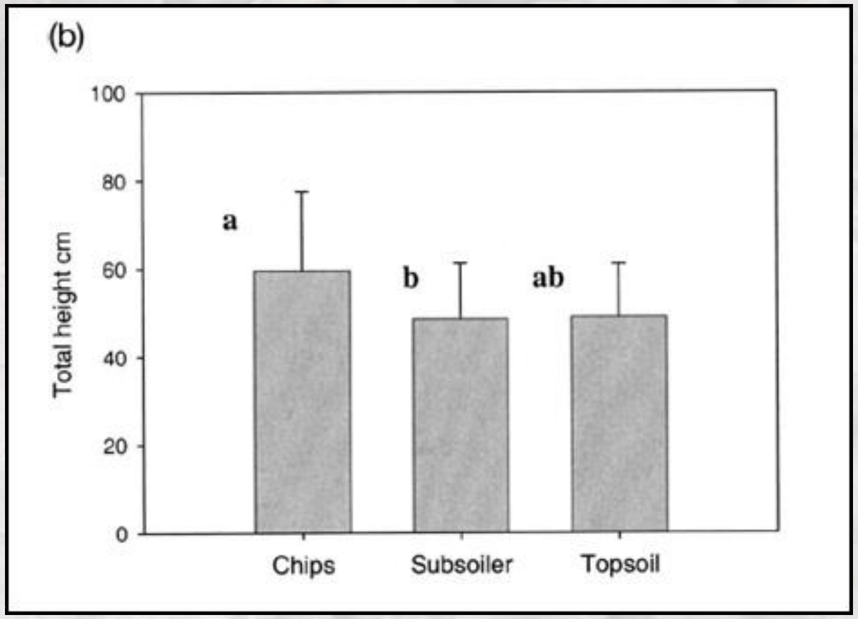
Aleza Lake, OK Falls

Forest soil rehabilitation with tillage and wood waste enhances seedling establishment but not height after 8 years

C. Bulmer, K. Venner, and C. Prescott

Abstract: We evaluated soil conditions of rehabilitated log landings in the Interior Douglas-fir biogeoclimatic zone of British Columbia during the first 3 years after treatment and the growth of lodgepole pine (*Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm.) on these log landings over 8 years. Rehabilitation treatments included combinations of tillage and the addition of either stockpiled topsoil or one of three organic amendments: hog fuel, sort-yard waste, and a wood waste – biosolids compost. The woody amendments were either applied as a surface mulch or incorporated into the soil after tillage. Tillage and addition of wood waste reduced soil bulk density and increased carbon content. Daytime soil temperatures in summer were lower under a hog fuel mulch than for the other treatments. The plots receiving hog fuel also had higher soil moisture content. One year after treatment, soil mechanical resistance for untreated soils, and those that were simply tilled, exceeded 2500 kPa for much of the growing season. Plots receiving wood waste had lower mechanical resistance. Use of wood waste in rehabilitation improved soil conditions and contributed to improved survival rates for planted lodgepole pine seedlings. Height growth after 8 years was not significantly affected by the treatments.

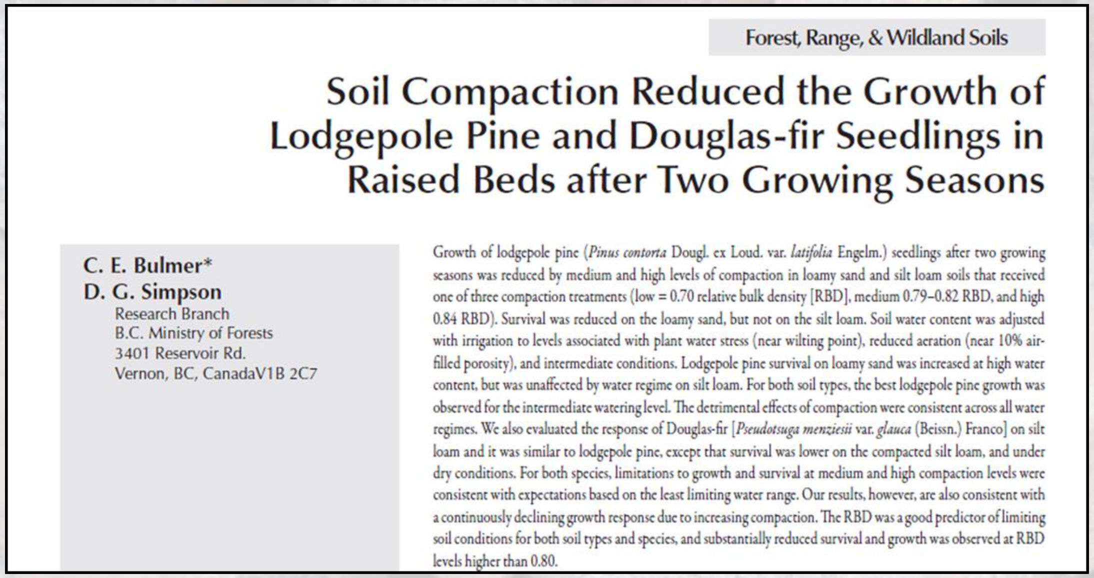




A: "Relatively simple treatments are capable of creating growing conditions that are similar to those of more expensive treatments"

Soil physical properties research

Controlled studies on raised beds at Kalamalka



Forest, Range, & Wildland Soils

Soil Compaction Reduced the Growth of Lodgepole Pine and Douglas-fir Seedlings in Raised Beds after Two Growing Seasons

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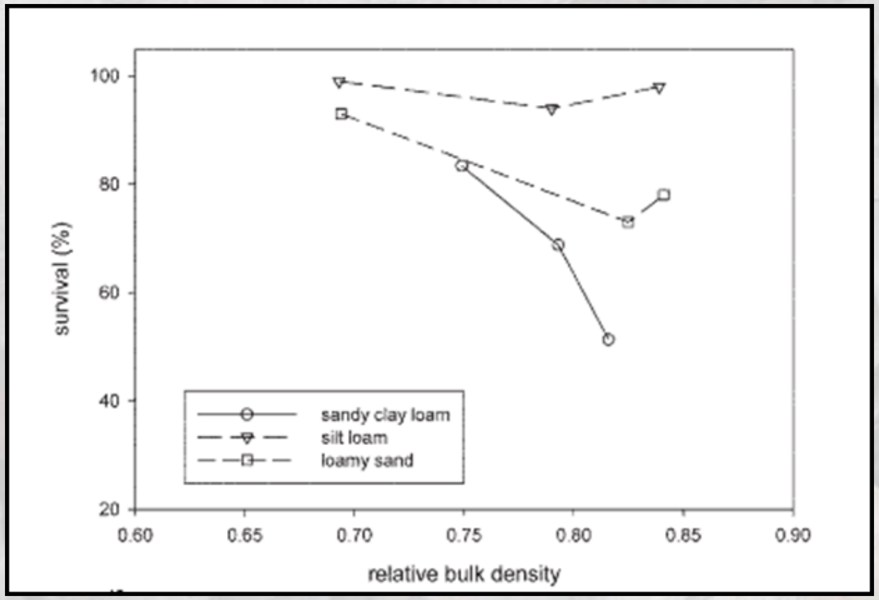
B.C. Ministry of Forests
3401 Reservoir Rd.
Vernon, BC, CanadaV1B 2C7

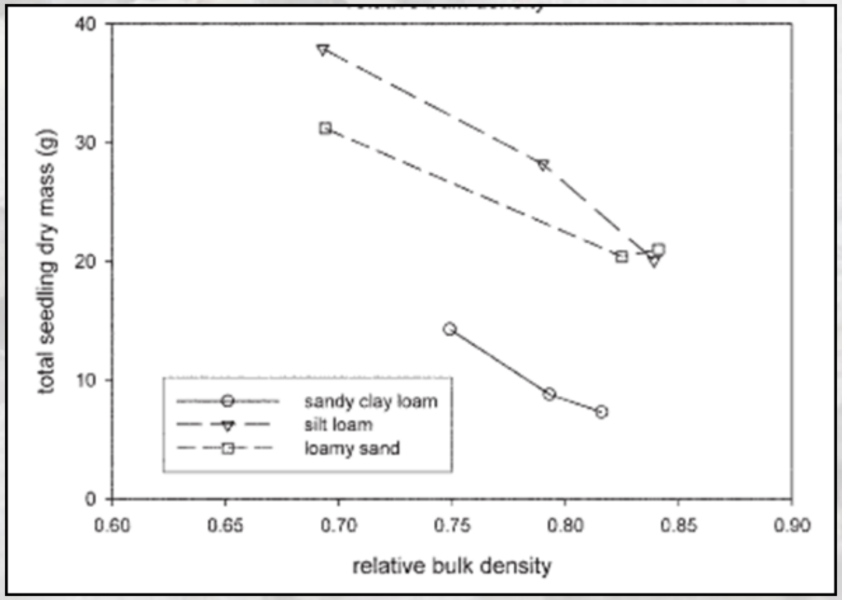
Growth of lodgepole pine (*Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm.) seedlings after two growing seasons was reduced by medium and high levels of compaction in loamy sand and silt loam soils that received one of three compaction treatments (low = 0.70 relative bulk density [RBD], medium 0.79–0.82 RBD, and high 0.84 RBD). Survival was reduced on the loamy sand, but not on the silt loam. Soil water content was adjusted with irrigation to levels associated with plant water stress (near wilting point), reduced aeration (near 10% air-filled porosity), and intermediate conditions. Lodgepole pine survival on loamy sand was increased at high water content, but was unaffected by water regime on silt loam. For both soil types, the best lodgepole pine growth was observed for the intermediate watering level. The detrimental effects of compaction were consistent across all water regimes. We also evaluated the response of Douglas-fir [*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco] on silt loam and it was similar to lodgepole pine, except that survival was lower on the compacted silt loam, and under dry conditions. For both species, limitations to growth and survival at medium and high compaction levels were consistent with expectations based on the least limiting water range. Our results, however, are also consistent with a continuously declining growth response due to increasing compaction. The RBD was a good predictor of limiting soil conditions for both soil types and species, and substantially reduced survival and growth was observed at RBD levels higher than 0.80.

Q: What is the growth limiting threshold for bulk density?

Results – Raised beds

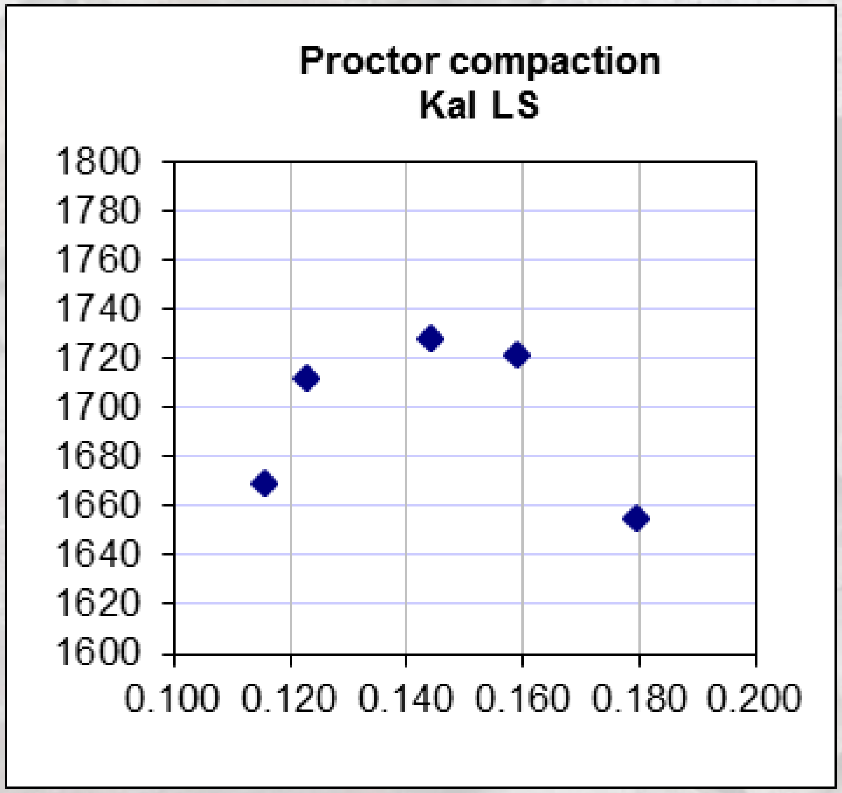
- Finally ! Consistent and significant growth results across 3 soil types
- Under controlled conditions, compaction effect is significant
- **A: Limiting bulk density is somewhere around RBD = 0.80 – 0.85**





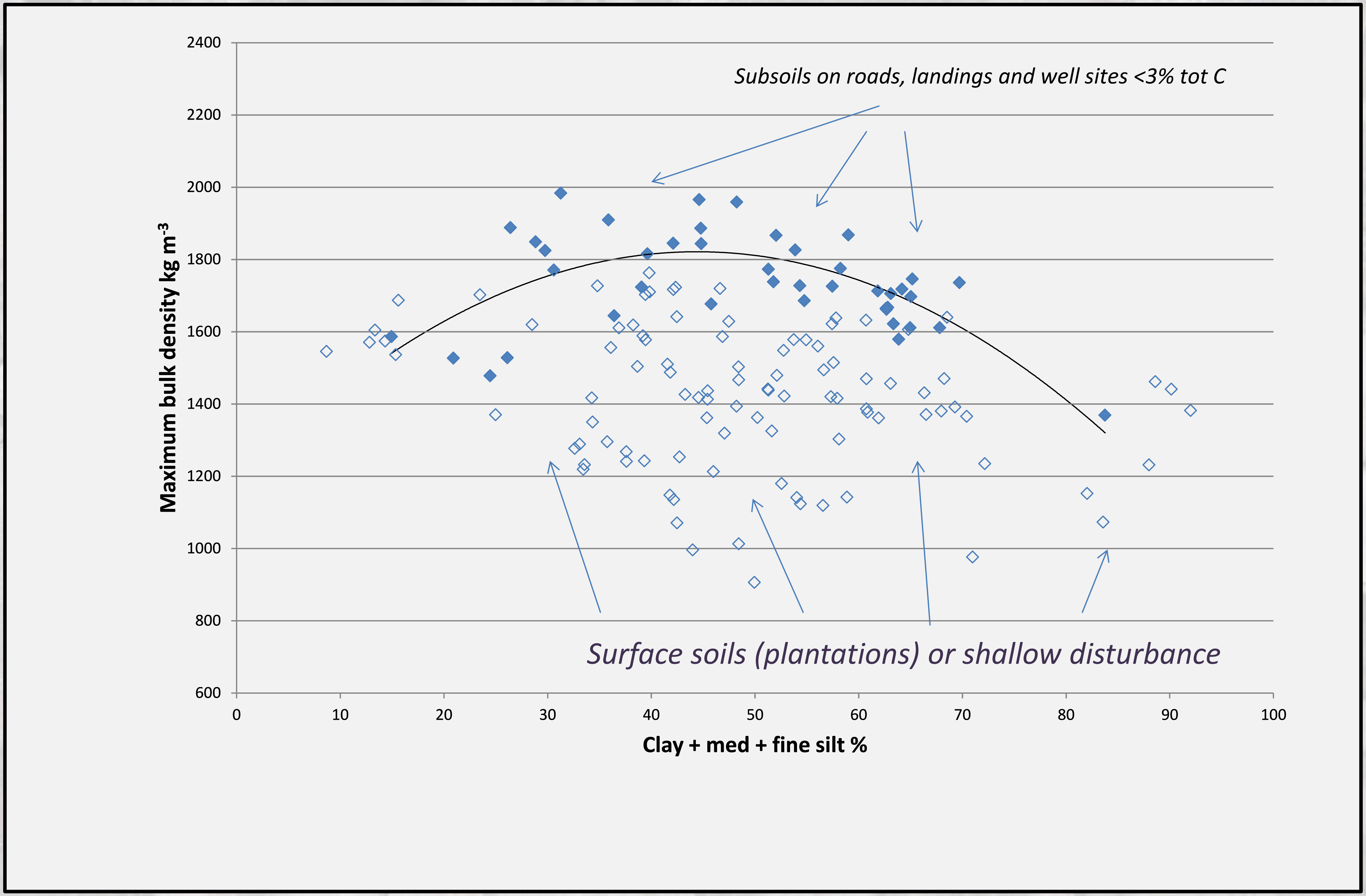
Soil physical properties research

Relative bulk density (RBD)
RBD = BD / MBD
Proctor test MBD provides standard 'index' value

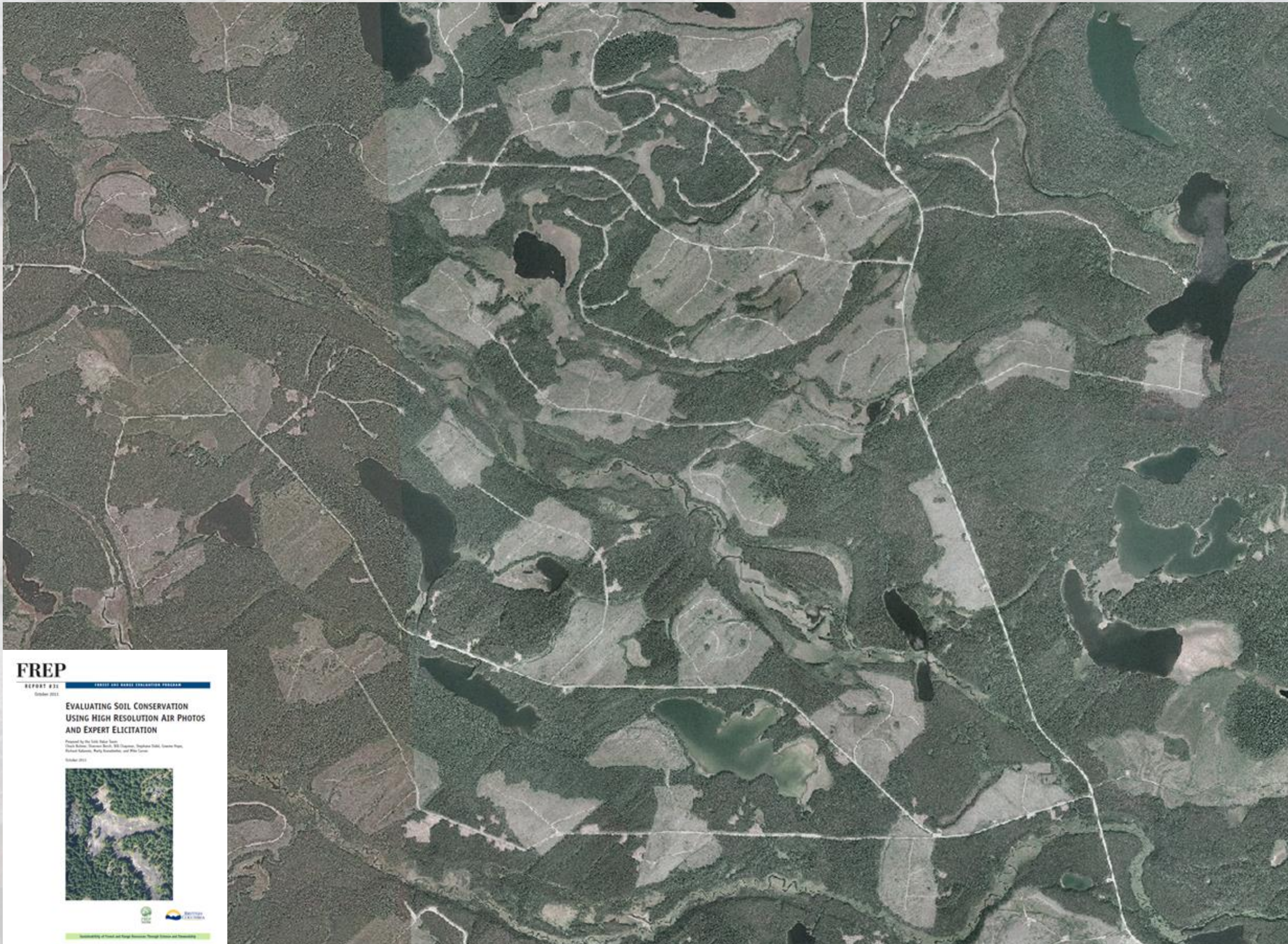


Soil physical properties research

- MBD relationship (clay+silt) *1 possible view of the data*



Monitoring: FREP roads study



Opportunities

- Research on soil disturbance and rehab has answered some of the early questions, Need to keep monitoring to be sure we’ve got it right

- Better understanding of soil pore system improves management for disturbance and rehab, and physical properties are also fundamental in plant water uptake processes.

- Improved spatial information is coming, not just a 1ha scale, or 25m but much finer resolution. This will help us to better understand the variability of soils on small plots like woodlots.