Burning Questions

Meta-analysis of the effects of fire and post-fire reforestation on ecosystems and wildlife habitat: A step on the path to sustainable fire management of our future forests in British Columbia, Canada

Dr. Julia R. Chandler

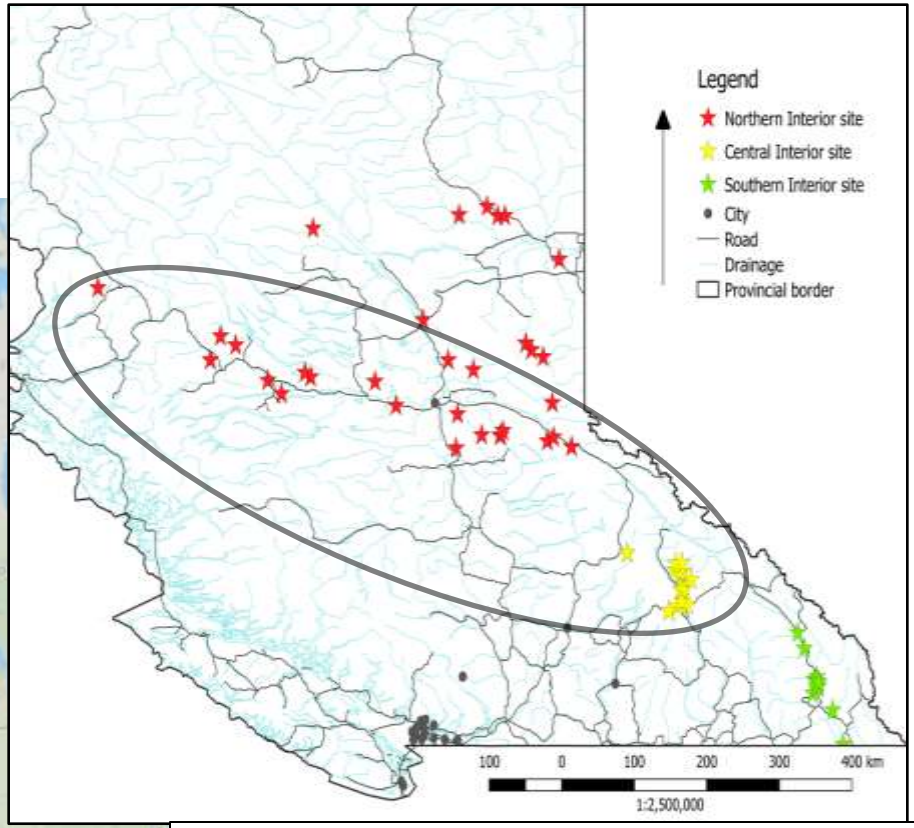
August 15th, 2019

Project Rationale

- Understanding response of forest ecosystems to fire and the risks for BC's forests and rangelands is a priority
- Effects of fire on fuels, soils, vegetation, tree growth studied since 1970s yet limited synthesis and meta-analysis relevant to current priorities
- Our project builds on considerable fire ecology knowledge and was funded by FESBC and MFLRNORD for 2017/18 ($77K)
- Databases at risk of being lost but new questions

Photo: © JR Chandler

Study Area



73 datasets catalogued describing vegetation response to fire slashburns, restoration burns, wildfire

49 datasets were updated & analyzed in north and central regions

https://www.for.gov.bc.ca/hre/becweb/

Burning Questions

- Key Fire Related Information Needs -

Landscape-scale

– What are the expected rates of recovery of watersheds after wildfires? i.e., what are rates of vegetation development?

Wildlife

– What are implications of fire management for wildlife like grizzly bear, moose and caribou especially with respect to forage quantity and quality ?

Vegetation

– Can fire be used to restore/enhance First Nations food, medicine & cultural plants (e.g., berries, devil's club)?

Restoration and Reforestation

– Does wildfire reduce lodgepole pine stem rusts or their alternate host species?

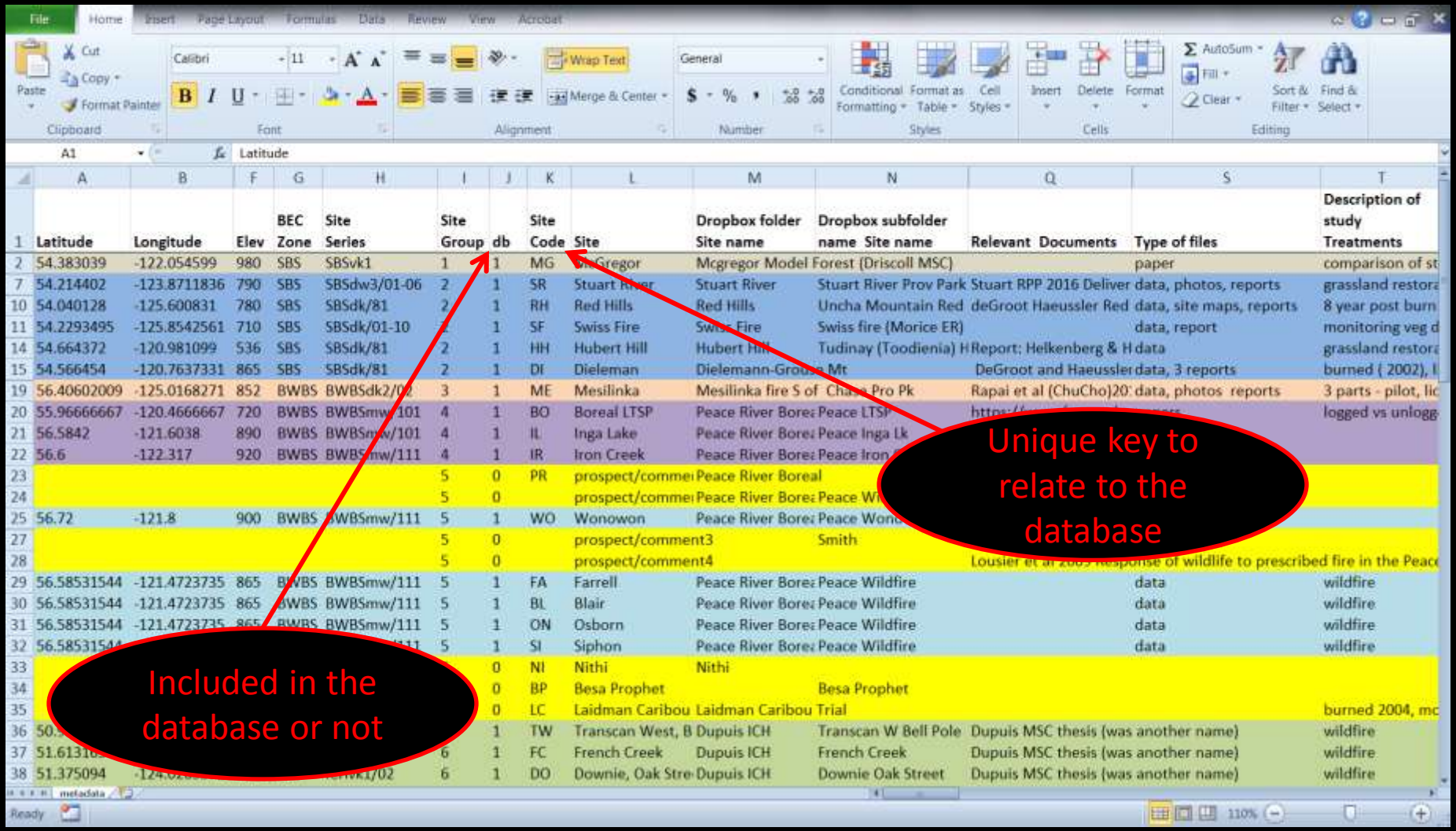
Photo: © JR Chandler

Types of Data & Products

- Vegetation (% cover), soils, treatment data
- Plot photos
- Maps and spatial analysis

➢ *Able to perform tailored deep analysis that is targeted, produce answers to questions that span scales from species to ecosystems, and present future operational directions for land managers*

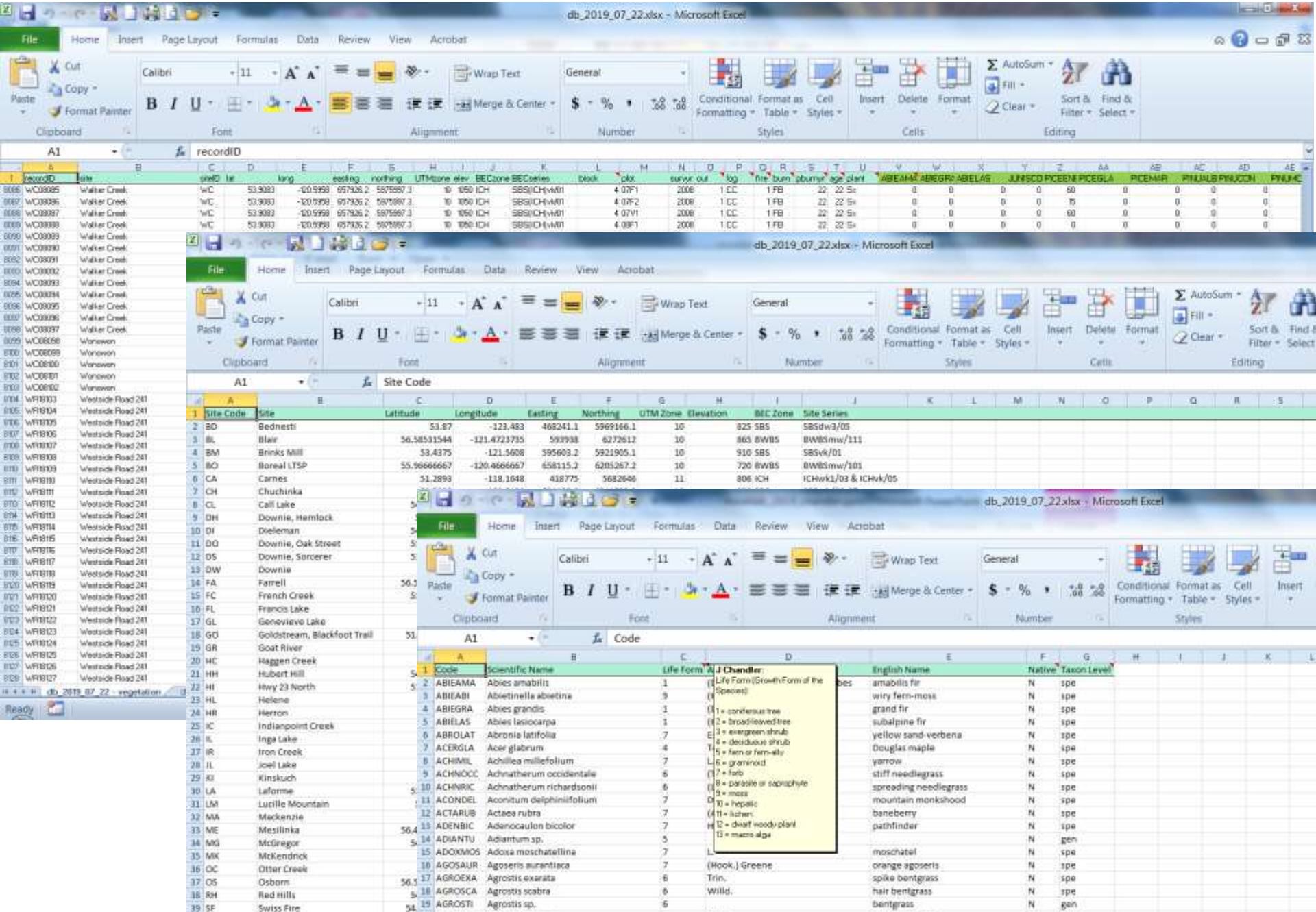
- Metadata -

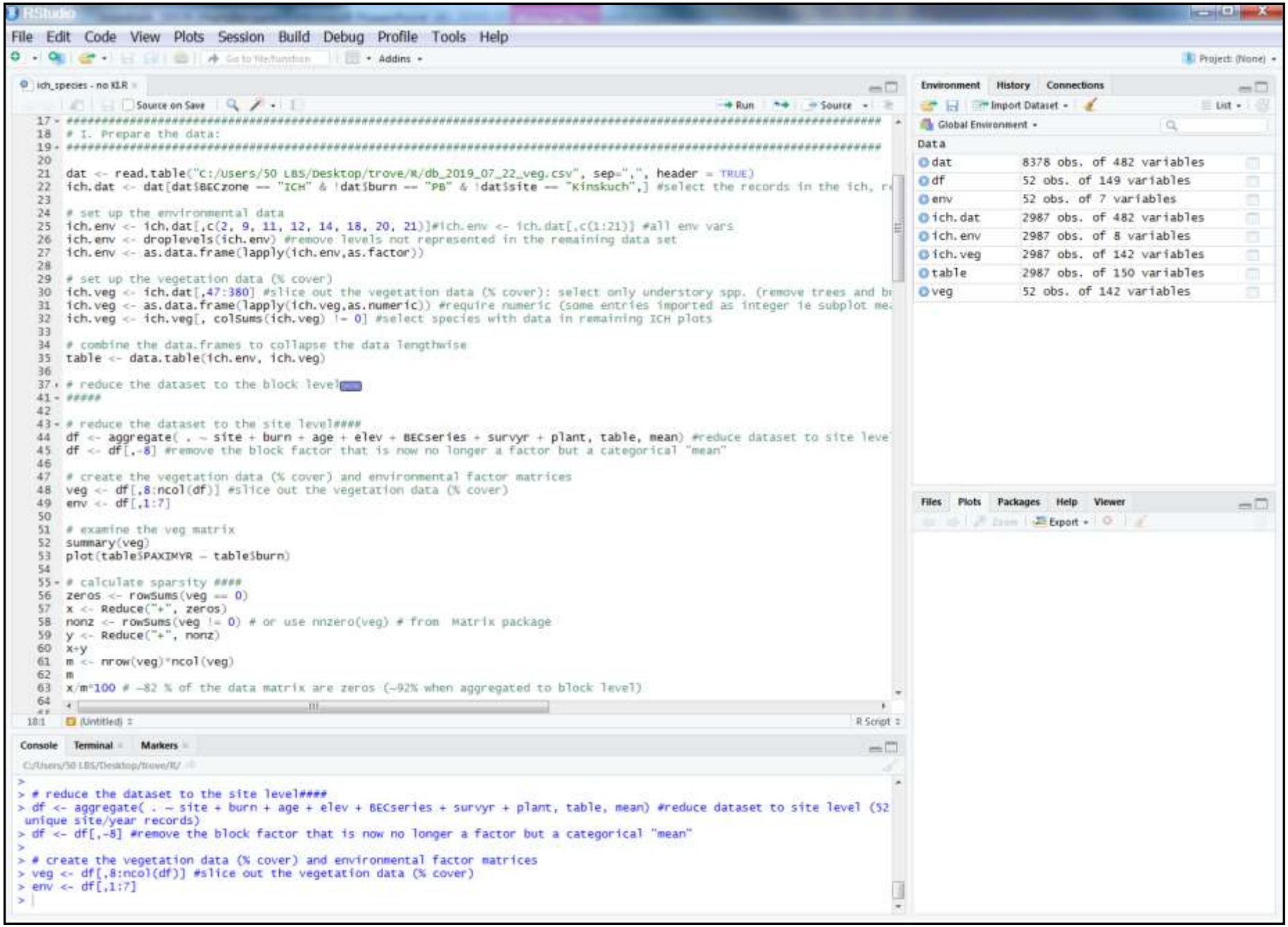


Latitude	Longitude	Elev	BEC Zone	Site Series	Site Group	db	Site Code	Site	Dropbox folder Site name	Dropbox subfolder name Site name	Relevant Documents	Type of files	Description of study Treatments
54.383039	-122.054599	980	SBS	SBSvk1	1	1	MG	McGregor	Mcgregor Model Forest (Driscoll MSC)			paper	comparison of st
54.214402	-123.8711836	790	SBS	SBSdw3/01-06	2	1	SR	Stuart River	Stuart River Prov Park	Stuart RPP 2016 Deliver		data, photos, reports	grassland restora
54.040128	-125.600831	780	SBS	SBSdk/81	2	1	RH	Red Hills	Red Hills	Uncha Mountain Red	deGroot Haeussler Red	data, site maps, reports	8 year post burn
54.2293495	-125.8542561	710	SBS	SBSdk/01-10	2	1	SF	Swiss Fire	Swiss Fire	Swiss fire (Morice ER)		data, report	monitoring veg d
54.664372	-120.981099	536	SBS	SBSdk/81	2	1	HH	Hubert Hill	Hubert Hill	Tudinay (Toodienia) H	Report: Helkenberg & H	data	grassland restora
54.566454	-120.7637331	865	SBS	SBSdk/81	2	1	DI	Dieleman	Dielemann-Grouse Mt		DeGroot and Haeussler	data, 3 reports	burned (2002), l
56.40602009	-125.0168271	852	BWBS	BWBSdk2/02	3	1	ME	Mesilinka	Mesilinka fire S of	Chase Pro Pk	Rapai et al (ChuCho)20	data, photos reports	3 parts - pilot, lic
55.96666667	-120.4666667	720	BWBS	BWBSmw/101	4	1	BO	Boreal LTSP	Peace River Bore	Peace LTSP			logged vs unlogg
56.5842	-121.6038	890	BWBS	BWBSmw/101	4	1	IL	Inga Lake	Peace River Bore	Peace Inga Lk			
56.6	-122.317	920	BWBS	BWBSmw/111	4	1	IR	Iron Creek	Peace River Bore	Peace Iron			
					5	0	PR	prospect/comme	Peace River Boreal				
					5	0		prospect/comme	Peace River Bore	Peace W			
56.72	-121.8	900	BWBS	BWBSmw/111	5	1	WO	Wonowon	Peace River Bore	Peace Wond			
					5	0		prospect/comment3		Smith			
					5	0		prospect/comment4			Lousier et al 2009 response of wildlife to prescribed fire in the Peac		
56.58531544	-121.4723735	865	BWBS	BWBSmw/111	5	1	FA	Farrell	Peace River Bore	Peace Wildfire		data	wildfire
56.58531544	-121.4723735	865	BWBS	BWBSmw/111	5	1	BL	Blair	Peace River Bore	Peace Wildfire		data	wildfire
56.58531544	-121.4723735	865	BWBS	BWBSmw/111	5	1	ON	Osborn	Peace River Bore	Peace Wildfire		data	wildfire
56.5853154					5	1	SI	Siphon	Peace River Bore	Peace Wildfire		data	wildfire
						0	NI	Nithi	Nithi				
						0	BP	Besa Prophet		Besa Prophet			
						0	LC	Laidman Caribou	Laidman Caribou Trial				burned 2004, mc
50.						1	TW	Transcan West, B	Dupuis ICH	Transcan W Bell Pole	Dupuis MSC thesis (was another name)		wildfire
51.6131					6	1	FC	French Creek	Dupuis ICH	French Creek	Dupuis MSC thesis (was another name)		wildfire
51.375094					6	1	DO	Downie, Oak Stre	Dupuis ICH	Downie Oak Street	Dupuis MSC thesis (was another name)		wildfire

Latitude, Longitude, Elevation, BECZone, Site Series, Site Group, db, Site Code, Site, Dropbox Folder, Treatment, Monitoring Dates, Relevant Documents, File Types, Description of Study, Sampled Dates, General Location, Data Collected, Expt Layout, #Plots, Agency or Funder Responsible, Team Contact, Latest Contact Info, Comments, To Do

DB2020


db_2019_07_22.xlsx - Microsoft Excel
recordID
Site Code
Code
Site
Latitude
Longitude
Easting
Northing
UTM Zone
Elevation
BEC Zone
Site Series
Scientific Name
English Name
Life Form
Native
Taxon Level
J Chandler:
Life Form (Growth Form of the Species):
1 = coniferous tree
2 = broadleaved tree
3 = evergreen shrub
4 = deciduous shrub
5 = fern or fern-ally
6 = graminoid
7 = forb
8 = parasite or saprophyte
9 = moss
10 = hepatic
11 = lichen
12 = dwarf woody plant
13 = macro algae


File Edit Code View Plots Session Build Debug Profile Tools Help
ich_species - no KLR
Source on Save
Run
Source
17 ##
18 # I. Prepare the data:
19 ##
20
21 dat <- read.table("C:/Users/50 LBS/Desktop/trove/R/db_2019_07_22_veg.csv", sep=",", header = TRUE)
22 ich.dat <- dat[dat$BECzone == "ICH" & !dat$burn == "PB" & !dat$site == "Kinskuch",] #select the records in the ich, r
23
24 # set up the environmental data
25 ich.env <- ich.dat[,c(2, 9, 11, 12, 14, 18, 20, 21)]#ich.env <- ich.dat[,c(1:21)] #all env vars
26 ich.env <- droplevels(ich.env) #remove levels not represented in the remaining data set
27 ich.env <- as.data.frame(lapply(ich.env,as.factor))
28
29 # set up the vegetation data (% cover)
30 ich.veg <- ich.dat[,47:380] #slice out the vegetation data (% cover): select only understory spp. (remove trees and br
31 ich.veg <- as.data.frame(lapply(ich.veg,as.numeric)) #require numeric (some entries imported as integer ie subplot me
32 ich.veg <- ich.veg[, colSums(ich.veg) != 0] #select species with data in remaining ICH plots
33
34 # combine the data.frames to collapse the data lengthwise
35 table <- data.table(ich.env, ich.veg)
36
37 # reduce the dataset to the block level
41 #####
42
43 # reduce the dataset to the site level####
44 df <- aggregate(. ~ site + burn + age + elev + BECseries + survyr + plant, table, mean) #reduce dataset to site leve
45 df <- df[,-8] #remove the block factor that is now no longer a factor but a categorical "mean"
46
47 # create the vegetation data (% cover) and environmental factor matrices
48 veg <- df[,8:ncol(df)] #slice out the vegetation data (% cover)
49 env <- df[,1:7]
50
51 # examine the veg matrix
52 summary(veg)
53 plot(table$PAXIMYR ~ table$burn)
54
55 # calculate sparsity ####
56 zeros <- rowSums(veg == 0)
57 x <- Reduce("+", zeros)
58 nonz <- rowSums(veg != 0) # or use nnzero(veg) # from Matrix package
59 y <- Reduce("+", nonz)
60 x+y
61 m <- nrow(veg)*ncol(veg)
62 m
63 x/m*100 # ~82 % of the data matrix are zeros (~92% when aggregated to block level)
64
18:1
(Untitled)
R Script
Console
Terminal
Markers
C:/Users/50 LBS/Desktop/trove/R/
> # reduce the dataset to the site level####
> df <- aggregate(. ~ site + burn + age + elev + BECseries + survyr + plant, table, mean) #reduce dataset to site level (52
unique site/year records)
> df <- df[,-8] #remove the block factor that is now no longer a factor but a categorical "mean"
>
> # create the vegetation data (% cover) and environmental factor matrices
> veg <- df[,8:ncol(df)] #slice out the vegetation data (% cover)
> env <- df[,1:7]
>
Environment
History
Connections
Import Dataset
List
Global Environment
Data
dat 8378 obs. of 482 variables
df 52 obs. of 149 variables
env 52 obs. of 7 variables
ich.dat 2987 obs. of 482 variables
ich.env 2987 obs. of 8 variables
ich.veg 2987 obs. of 142 variables
table 2987 obs. of 150 variables
veg 52 obs. of 142 variables
Files
Plots
Packages
Help
Viewer
Export

PLOT PHOTOS

Genevieve Lake (SBSdk)

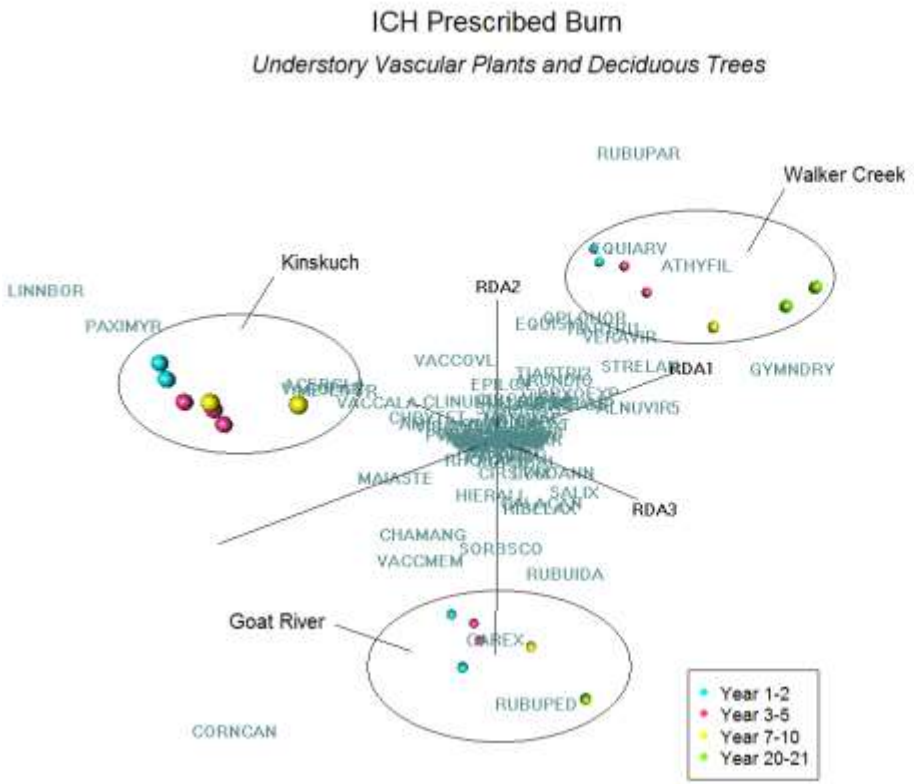
Year 10

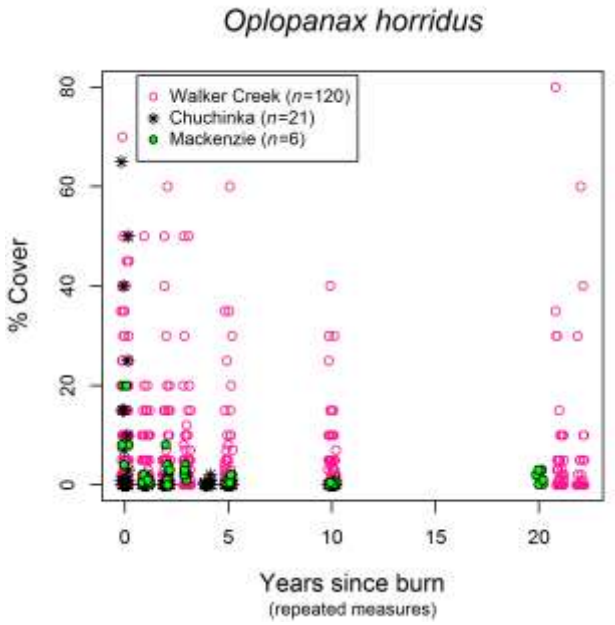
Year 20

Analytical Approaches

Multivariate and univariate analysis and data visualization were used to identify vegetation response. We addressed questions related to:

- Comparisons of plant community response between ecosystems
- Plant community response to treatments within a single ecosystem
- Single species response





Comparisons of Plant Community Response *Between* ICH, ESSF and SBS Ecosystems

- 20 years after clearcut and slashburn -

1. *Diagnostic Combinations of Species (DCS)*

   – In the wet South-Central Interior, cover of plants associated with mature forests increased forming >40% cover

   -> (abundance and composition matter!)

2. *Plant Functional Types (PFT)*

   – There was faster conifer growth and greater, more persistent deciduous tree & tall shrub cover in SBS compared to ESSF

   – Ericaceous shrubs were prominent in ESSF

3. *Indicator Species*

   – *Oplopanax horridus* (Devil's club) was the only species with complete specificity and fidelity through all time periods

Photo: © Dee E. Warenycia

Meta-analyses *within* Interior Cedar-Hemlock

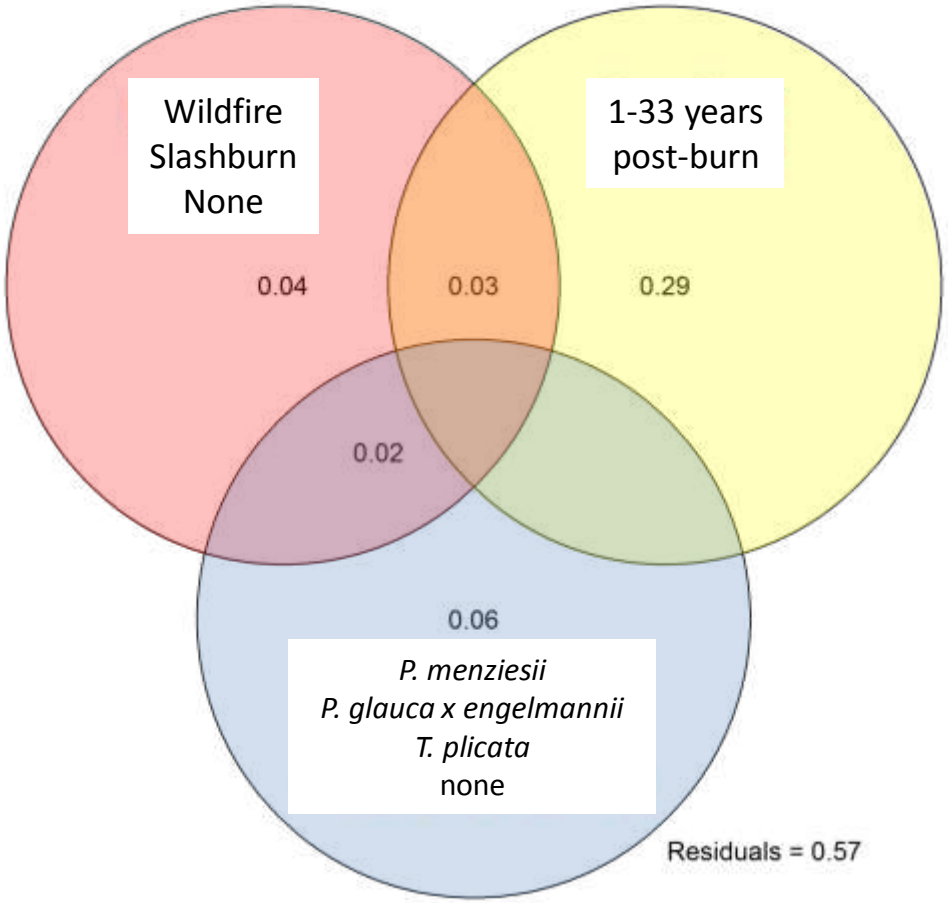
1. Distribution free multivariate analysis of variances (using distance matrices) to describe how variation is attributed to different experimental treatments or uncontrolled covariates (*n* = 505).

```
adonis(formula = veg ~ burn + age + plant,
data = env, permutations = 999, strata =
env$block, transfo = "hellinger")
Blocks: strata
Number of permutations: 999

Plant R² = 0.06747 p = < 0.001
Burn  R² = 0.08535 p = < 0.001
Age   R² = 0.29308 p = < 0.001
```

2. Variance Partitioning to partition the variation of the community matrix by the 3 explanatory factors

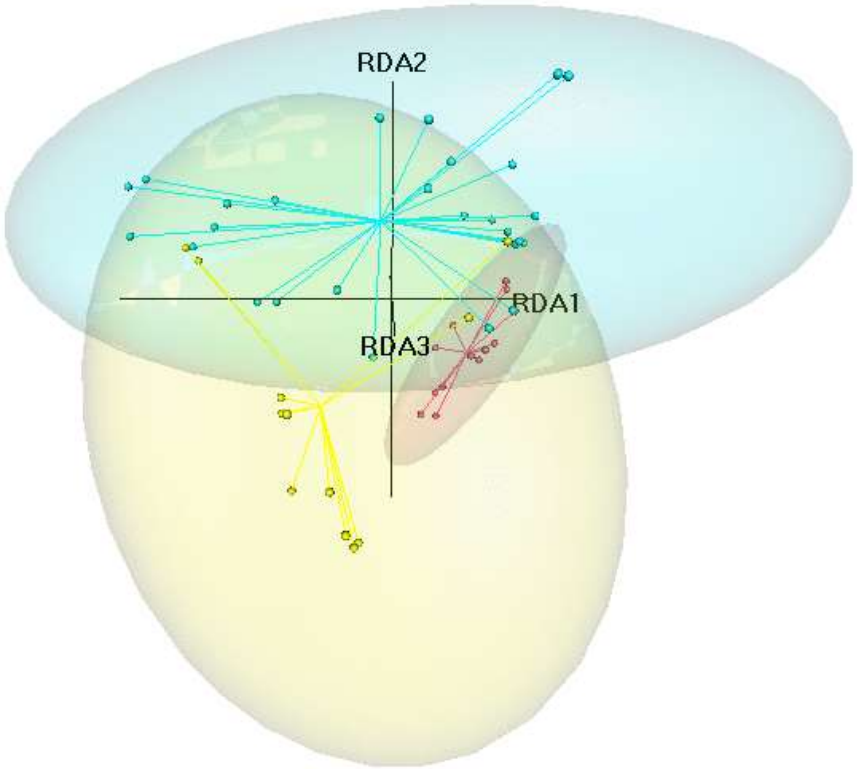
3. RDA to test significance of fractions of interest individually
   - ➢ all tests result in *p* = < 0.001



Burn Class

- Wildfire
- Prescribed Burning
- No Burn

*Interior Cedar-Hemlock (ICH)**



- 95% confidence ellipses were added to visualize the uniqueness and/or overlap of *BURN TYPE*
- High response variability to burn type even within the same ecosystem
- Plant communities in the ICH have distinct responses to fire type, stand age and reforestation species selection

*41 sites

Shepherdia canadensis (soapberry)

- Soapberry (an important food plant for First Nations and wildlife) on drier SBS and BWBS sites increased in cover over the 20 years after fire or clearing, and average cover is slightly higher on burned compared to unburned sites

- Our results are consistent with previous studies that found it moderately fire resistant and enhanced by burning
- Overall management implications: moderate to low severity broadcast burning is consistent with maintaining ecological values in these ecosystems.

Pine Blister Rust Alternate Hosts

Genevieve Lake (SBSdk) 20 years after clearcut and slashburn

Photo: © JR Chandler

- 5 *Ribes* species in the database
- 2 rare species with 5 records total: *R. hudsonianum* (Mackenzie River - year 20 at 1%); and *R. oxyacanthoides* (Genevieve Lake - year 20 at 2% and Helene - years 1, 2 at 0.5% and 3 at 1%)

Overall % cover for all years at each site by *Ribes* spp.

	R. lacustre		*R. laxiflorum*		*R. glandulosum*	
	mean	sd	mean	sd	mean	sd
Brinks Mill (*n*=18)	1.3	(2.7)	0.3	(0.6)	0*	(0.0)
Francis Lake (*n*=36)ŦŦ	1.3	(2.3)	0.3	(0.4)	0.2	(0.5)
Genevieve Lake (*n*=24)Ŧ	0.6	(0.7)	0.5	(1.1)	0*	(0.0)
Goat River (*n*=42)^	0.1	(0.3)	2.6	(2.3)	0*	(0.0)
Helene (*n*=135)Ŧ	0.4	(0.6)	0.3	(0.6)	0.6	(1.0)
Herron (*n*=70)^Ŧ	1.4	(3.2)	0.6	(1.1)	0.6	(0.8)
Mackenzie (*n*=42)^	2.0	(1.9)	1.0	(2.0)	0*	(0.0)
Otter Creek (*n*=224)^Ŧ	2.3	(2.8)	0.0	(0.1)	0*	(0.0)
Walcott (*n*=130)Ŧ	0.1	(0.4)	0.3	(1.0)	1.3	(1.6)
Walker Creek (*n*=840)^	1.8	(4.4)	3.8	(6.4)	0.0	(0.0)

^ These sites have preburn measures

Ŧ Site was planted with *P. contorta* var. *latifolia*

* Species not recorded on site

Analysis included 10 sites (1561 plots) with repeated measures (years 1, 5, 10, and 20)

Management Implications

Future outcomes include providing fully accessible information to guide management decisions such as:

1. which wildfires to target in suppression actions
2. when and where to prescribe burn to reduce flammability or increase habitat values
3. what areas should be left un-salvaged after wildfire
4. where and how intensive reforestation should be avoided or otherwise implemented

Wildfire on a logging road ~20 km southwest of Fort St. James, B.C., on Aug. 15, 2018. (Darryl Dyck/Canadian Press)

Project Conclusions and Looking Ahead

Photo: © E Hamilton

- BC ecosystems are adapted to and fairly resilient to fire. Responses are variable and largely determined by ecosystem, site factors and adaptation to fire. Predictable to a degree.
- Importance of well designed research/monitoring that includes controls, exclosures, with pre- and post-treatment survey and multi-year sampling
- There is need for an entity to serve as a nexus for data and information
- Research/monitoring is stand level, decision making at landscape level - need to bridge scale difference.








We would like to thank FESBC and FLNRO for funding and the many dedicated people conducting fieldwork and those who provided questions and answers in the form of data and insight.

For more information please see our website: [DB2020.net](DB2020.net)

To provide feedback or for more information, contact Dr. Julia Chandler:
juliarchandler@gmail.com
(c) 412 999 3885

THANK YOU for your interest!

Abstract

Forest ecosystems providing habitat for species whose populations are in decline (e.g. moose, grizzly bears, caribou, birds) are affected in various ways by fire, post-fire salvage and intensive reforestation. Changing climatic conditions are expected to lead to an increase in these activities; indeed, the last few years have witnessed significant increases in mega fires in North America. Efforts to reduce GHG and protect communities and resources will likely lead to increased use of prescribed fire and managed wildfire to reduce the likelihood of mega fires, and to intensive salvage and reforestation to fast track post-disturbance carbon sequestration. To date there has been limited synthesis to help resource managers avoid adverse implications for wildlife. With the Burning Questions project, we identified all *in situ* plant-fire datasets from central British Columbia and collated them into a single database (db2020). Next, we consulted land managers to identify their foremost questions about ecosystem response to fire. Meta-analysis of db2020 addressed many of those Burning Questions, and we relayed our results back to the land managers involved in the consultation process.