NPS-NRCS Soil Survey
Pinnacles National Park

Quantitative Integration of Geographic Data and Pedon Observations:
Describing Soil Properties Within the Map Unit

D. E. Beaudette and A. T. O'Geen

June 19, 2006

Park City, UT

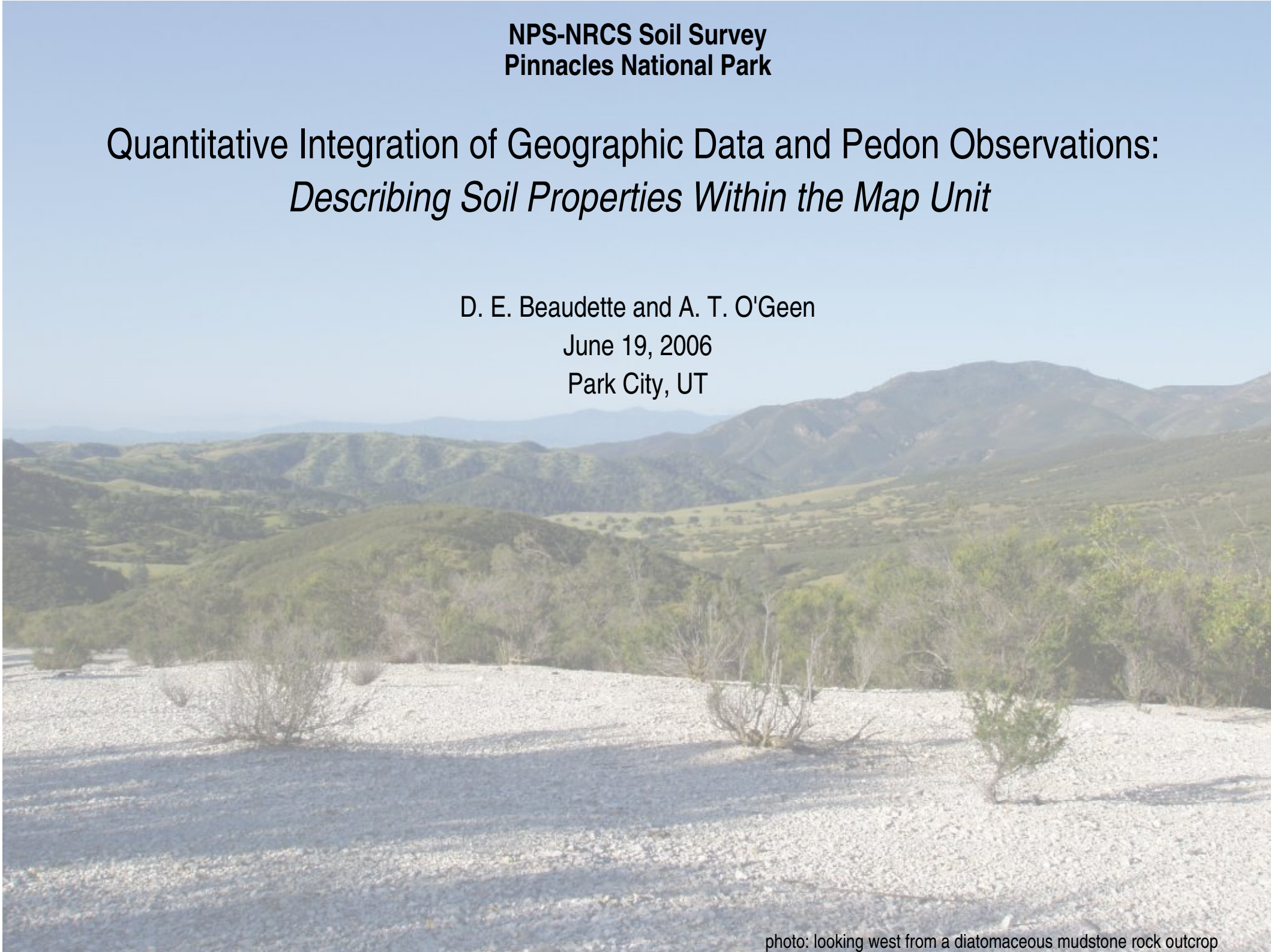


photo: looking west from a diatomaceous mudstone rock outcrop

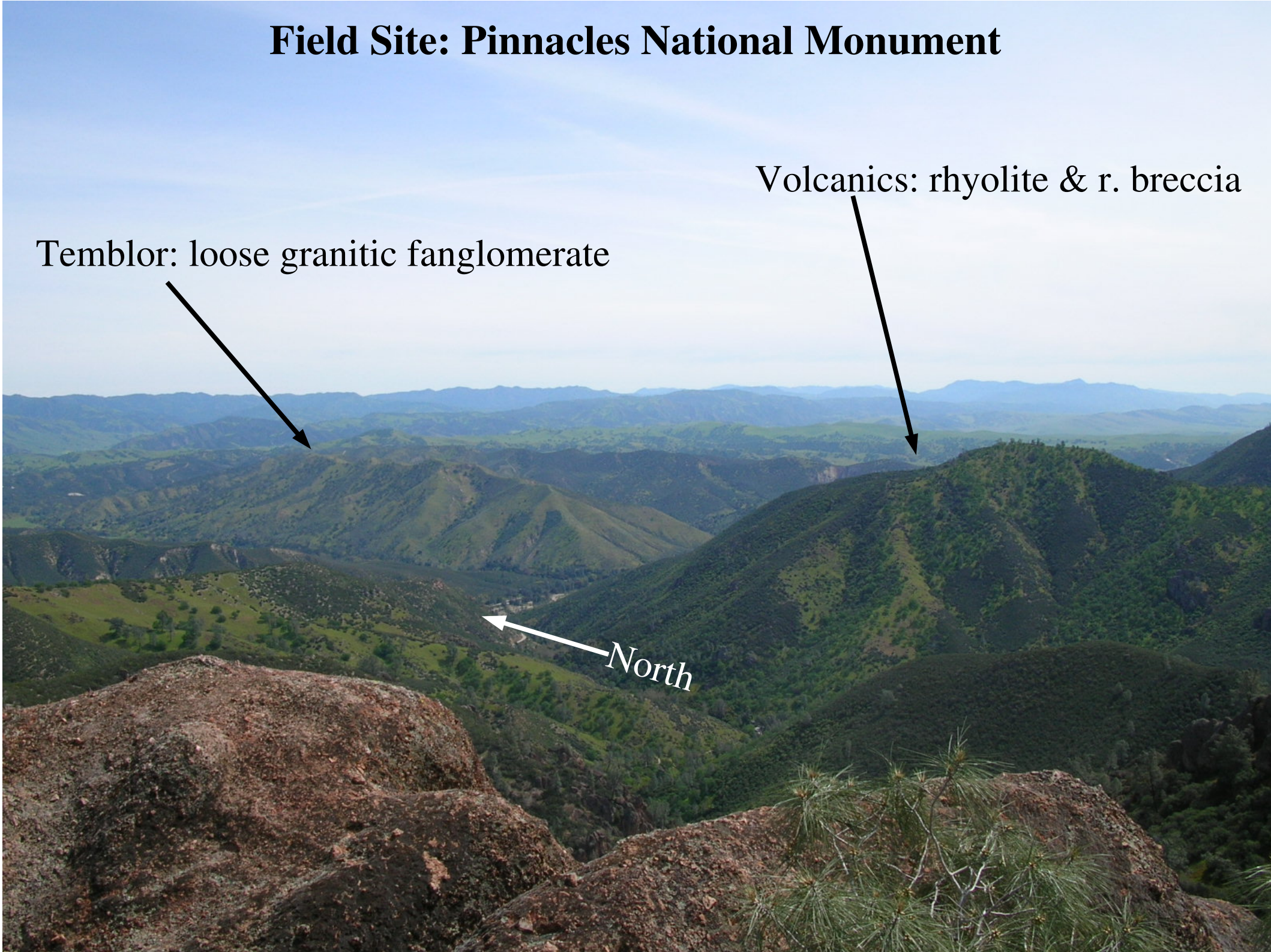
Background

Combined effort of NRCS, NPS, UC Davis at Pinnacles National Monument, CA

Production of a specialized order 2/3 soil survey for the park

Investigation of new approaches to processing, extrapolating, and presenting soil pedon data

Field Site: Pinnacles National Monument



Objectives

Digitize paper pedon description forms (300+)

- fast, efficient, mulit-user capabilities
- hierarchical storage of pedon data, accessible via SQL / web interface
- seamless association with GIS vector and raster data sources

Connect key soil properties with aggregated geodata (solar, veg, terrain, ...)

- aggregation of soil attributes via SQL-based queries
- spatial aggregation of raster geodata: scale parameters

Classify pedon data via divisive hierarchical cluster analysis

- identify natural soil classes, based on key soil properties
- create a visualization technique for a hierarchical, multi-dimensional data set (pedon data)

Extrapolation and estimation of soil classes where pedon data is missing

- explore various methods: GLM, cluster analysis, etc
- <u>create soil survey product at higher level of detail than normally possible</u>

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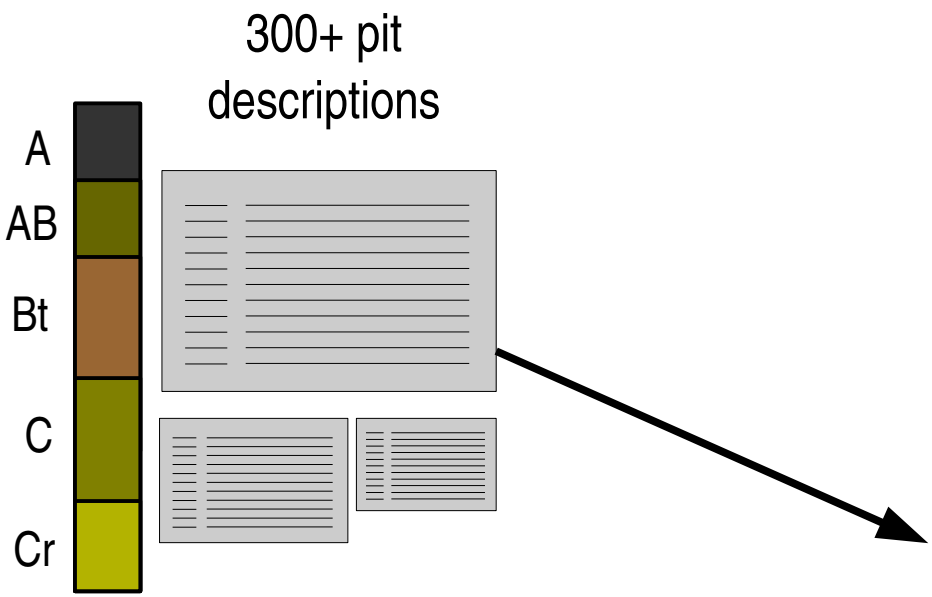
Paper pedon descriptions entered into

PedLogic



Database	Pedon Id	Cat	Horizon Data?	Date	Topo Quad
pinn	S05CA069293V	201	YES	2004-05-04	N Chalone Pk
pinn	S05CA069022K	70	YES	2005-01-20	
pinn	S05CA069117K	149	YES	2005-03-23	
pinn	SSGG-spring-05-P006	226	YES	2005-03-25	North Chalone Peak
pinn	SSGG-spring-05-P007	227	YES	2005-03-25	North Chalone Peak
pinn	SSGG-spring-05-P008	228	YES	2005-03-25	North Chalone Peak
pinn	SSGG-spring-05-P009	229	YES	2005-03-25	North Chalone Peak
pinn	S05CA069317V	222	YES	2005-03-31	North Chalone Peak
pinn	S05CA069271V	178	YES	2005-04-06	Bickmore Canyon
pinn	S05CA069270V	177	YES	2005-04-10	North Chalone Peak
pinn	S05CA069060K	92	YES	2005-04-10	
pinn	S05CA069059K	91	YES	2005-04-11	North Chalone Peak
pinn	S05CA069061K	93	NO	2005-04-11	North Chalone Peak

UTM East	UTM North	Pos.Diff (m)	Clay Capacity	Classification		Delete
658585	4038838	2	96 kg/m^3			Pedon Horizons
663815	4039029	5	33.84 kg/m^3			Pedon Horizons
661569	4034714	1	77.59 kg/m^3	clayey-skeletal, mixed, superactive, thermic Typic Argixeroll		Pedon Horizons
665079	4038784	0	52.97 kg/m^3	Coarse-loamy, mixed, superactive, thermic, Entic Haploxeroll		Pedon Horizons
665057	4038838	0	25.96 kg/m^3	Sandy, mixed, thermic Entic Haploxeroll		Pedon Horizons
665072	4038759	0	46.07 kg/m^3	Sandy, mixed, thermic, Entic Haploxeroll		Pedon Horizons
665072	4038695	0	39.4 kg/m^3	Sandy, mixed, thermic Entic Haploxeroll		Pedon Horizons
665811	4039775	11	416.02 kg/m^3	Fine-loamy, mixed, superactive, thermic, Cumulic Haploxeroll		Pedon Horizons
664920	4041723	2	0 kg/m^3			Pedon Horizons
665287	4037059	2	223.68 kg/m^3	Fine, mixed, superactive, thermic, Typic Haploxeralf		Pedon Horizons
665830	4039520	5	135.59 kg/m^3	Coarse-loamy, mixed, superactive, thermic Typic Haploxerept		Pedon Horizons
665739	4039452	0	88.5 kg/m^3	Coarse-loamy, mixed, superactive, thermic, Typic Haploxeralf		Pedon Horizons
665930	4039697	0	0 kg/m^3	Coarse-loamy, mixed, superactive, thermic, Typic Haploxeralf		Pedon Horizons

Digitize paper pedon description forms (300+)

Pedon Description Form

*Describers: KC and VB
* Date: Month Day Year — Apr 12 2005
Time: 24hr-style 14:45:00
Air Temp: 16 deg C
Soil Temp: 10 C @ 50 cm
GPS Geographic Location (Lat/Long) *Lat: *Lon: *Datum

GPS Geographic Location (UTM) *Zone: 10 *E: 665001.00 *N: 4038145.00 *Datum NAD83
Topo Quad: North Chalone Peak
*Pedon ID: S05CA069273V
Transect: Bearing Stop: Interval: m

Landscape: 3-11 HI
Landform: 3-11 HI
Elevation: (m) ft->m 326 meters
Aspect: 1-5 (Deg from North, North=0) 33.000
Slope: 43.0 %
Slope Complexity: 1-5 Simple (S)
Slope Shape Down: 1-6 Convex (V)
Slope Shape Across: 1-6 Convex (V)

Hillslope Prof. Position 1-6 Back Slope (BS)
Geomorhpic Comp 1-7 Side Slope (SS)
Microrelief 1-8

Drainage 1-9
Flooding 1-10 None (NO)
Ponding 1-11 None (NO)
Soil Moisture Status 1-12 moist 0-100cm
Permeability 2-63
Land cover/use 1-14 THW

Parent Material 1-16 RES
Bedrock: 1-18 Kind: GRA Fracture Class: Depth:
Lithostratic Units, group, formation, member

Erosion kind 1-20
Erosion degree 1-20
Surface frags: (% cover) 1-22 0 GR 0 CB 0 ST 0 BD 0 CN 0 FL

Diagnostic Horizons: *Epipedon: Mollic *Top: 0 cm *Bottom: 60 cm
Diagnostic 1: Argillic Top: 60 cm Bottom: 88 cm
Diagnostic 2: Top: cm Bottom: cm
Diagnostic 3: Top: cm Bottom: cm

Particle Size control section: depth *Top: 60 cm *Bottom: 88 cm
Classification: Fine-loamy, mixed, superactive, thermic Typic Argixeroll

Vegetation

	Common Name	% Cover
1.	blue oak	45 %
2.	annual grasses	30 %
3.	buckbrush	15 %
4.	manzanita	5 %
5.	chamise	5 %
6.		%
7.		%

Notes

1. check classification, may not be an argillic horizon at dep
2. check classification: may not be mollic epipedon
3. dark surface horizons over red clay: discontinuity?
4.
5.
6.
7.

Memo

on oak savanha, north slope

Input form closely matches NRCS form for speedy entry

Digitize paper pedon description forms (300+)

*Describers: KC and VB

* Date: *Month Day Year* Apr 12 2005

Time: *24hr-style* 14:45:00

Air Temp: 16 deg C

GPS Geographic Location (UTM)
*Zone: 10 *E: 665001.00 *N: 4038145.00 *Datum NAD83

Topo Quad: North Chalon

Landscape: 3-11 HI

Landform: 3-11 HI

Elevation: (m) ft->m 326 meters

Aspect: 1-5 (Deg from North, N 33.000

Hillslope Prof. Position 1-6 Back Slope (BS)

Geomorhpic Comp 1-7 Side Slope (SS)

Drainage 1-9

Flooding 1-10 None (NO)

Ponding 1-11 None (NO)

Soil Moisture Status 1-12 moist 0-100cm

Web-based, multi-user setup

Drop-down menus for quick entry of NRCS codes

Based entirely on open source software

Digitize paper pedon description forms (300+)

Horizon Morphologic Properties Form

	Observ Method 2-1	Depth(cm)	Hzn	Hz Boundary	Matrix Color Dry	Matrix Color Moist	Texture	Rock Frags Knd	Rock Frags %	Structure Grade	Structure Sz	Structure Type	Consistance Dry	Consistance Mst	Consistance Stk	Consistance Pls
2.	Bucket Auger (BA) Screw Auger (SA) Push Tube (PT) Shovel Slice (SS) Small Pit (SP) Trench (TR) Beveled Cut (BC) Cut (CU) Large Pit (LP)	6 cm TO 17 cm	A	V A C G D / S W I B	H: 7.5YR V: 4.0 C: 2.0	H: 10YR V: 2.0 C: 2.0	LS	GR	10	1	F	GR	L S SH MH HA VH EH R VR	L VFR FR FI VFI EF SR R VR	SO SS MS VS	PO SP MP VP

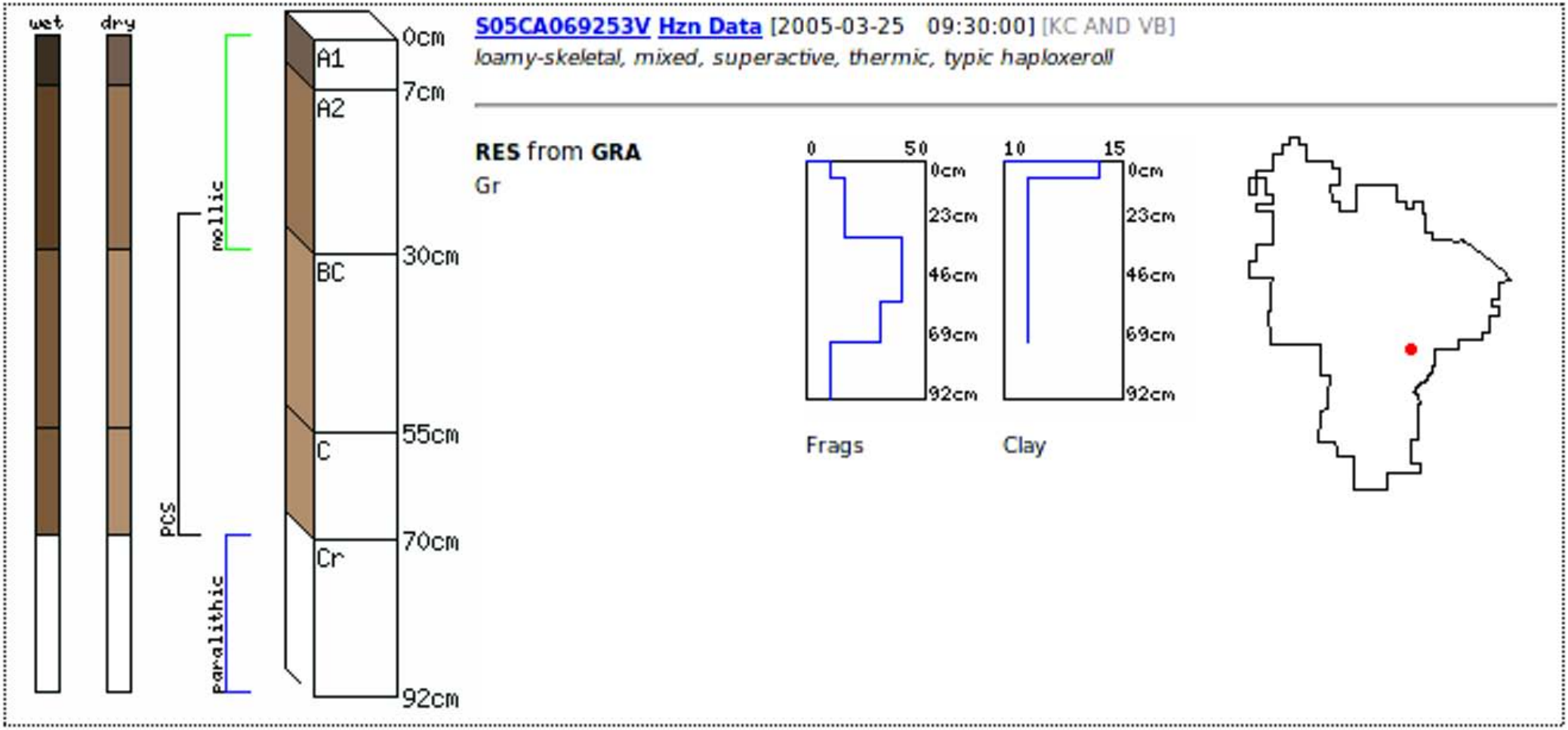
Parts to?

Mottles	RMF	Concentrations	Ped Srf Feats	Roots	Pores	pH	Effer	Clay	Notes
				3,VF,T;2		pH:	reaction:	clay: 2 %	ring and CC bulk density samples

Horizon	Name	Depths	Dry Color	Wet Color	Texture	Pct Clay	Pct Frags	Notes
Horizon 1	Oi	0 - 6 cm		7.5YR 2.0/2.0		0	5	ring and CC bulk density samples
Horizon 2	A	6 - 17 cm	7.5YR 4.0/2.0	10YR 2.0/2.0	LS	2	10	ring and CC bulk density samples
Horizon 3	AB1	17 - 49 cm	7.5YR 5.0/3.0	7.5YR 3.0/2.0	LS	5	14	
Horizon 4	AB2	63 - 90 cm	7.5YR 5.0/3.0	7.5YR 3.0/2.0	LS	7	14	
Horizon 5	AB3	63 - 90 cm	7.5YR 5.0/3.0	7.5YR 3.0/2.0	LS	5	10	
Horizon 6	C1	90 - 130 cm	7.5YR 6.0/3.0	7.5YR 3.0/2.0	LS	5	14	
Horizon 7	C2	130 - 150 cm	7.5YR 6.0/3.0	7.5YR 3.0/3.0	LS	6	14	
Horizon 8	2C1	150 - 160 cm	7.5YR 5.0/4.0	7.5YR 3.0/2.0	SL	10	14	1st discontinuity
Horizon 9	2C2	160 - 170 cm	7.5YR 6.0/4.0	7.5YR 3.0/2.0	SL	15	12	
Horizon 10	3C	170 - 200 cm	7.5YR 5.0/3.0	7.5YR 4.0/2.0	LS	12	9	clay value too high, 2nd discontinuity

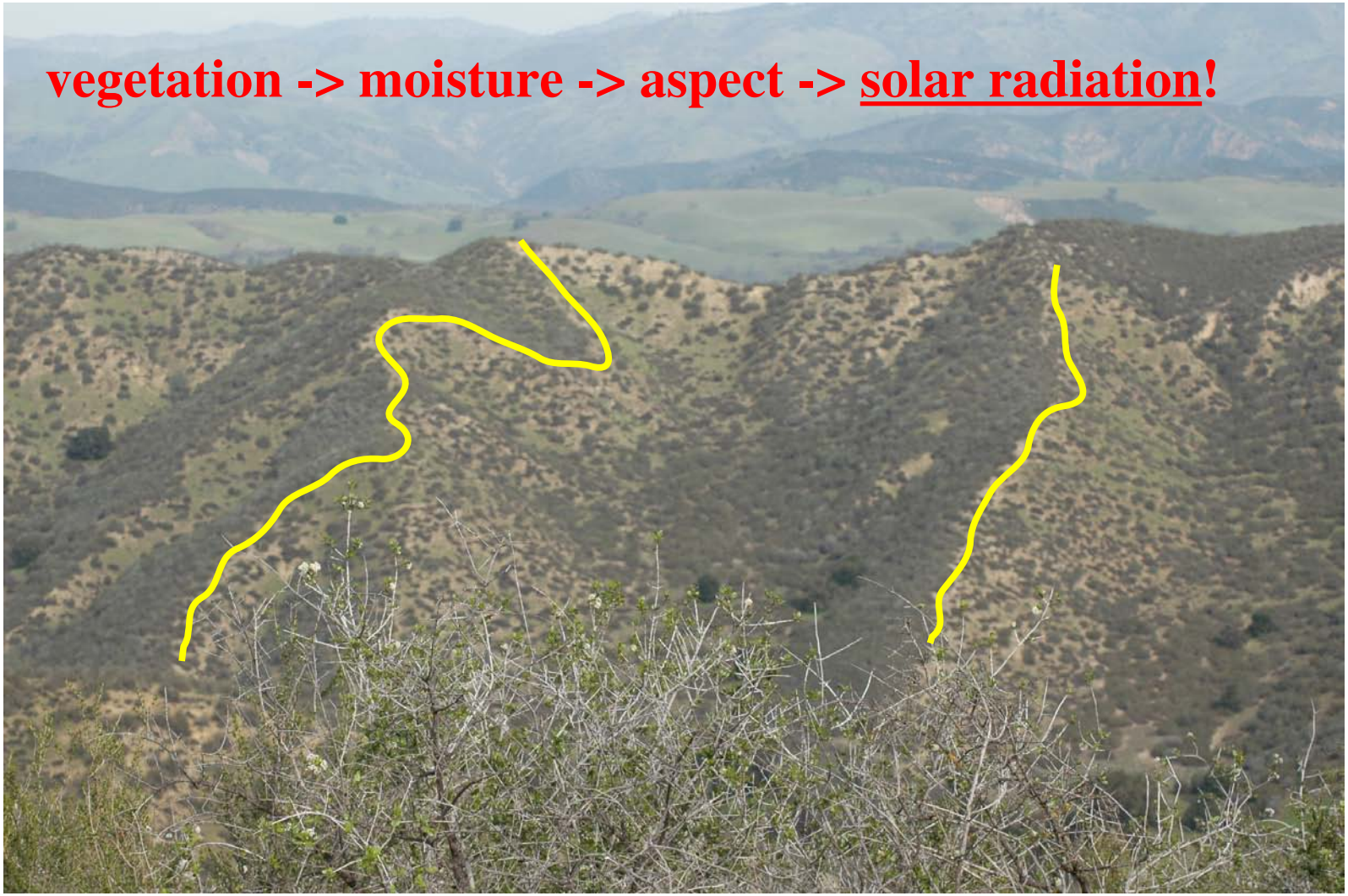
Working with horizon attributes

Visualization of Pedon Description Data



Web-based framework: integration of components from Online Soil Survey as an automated visualization engine

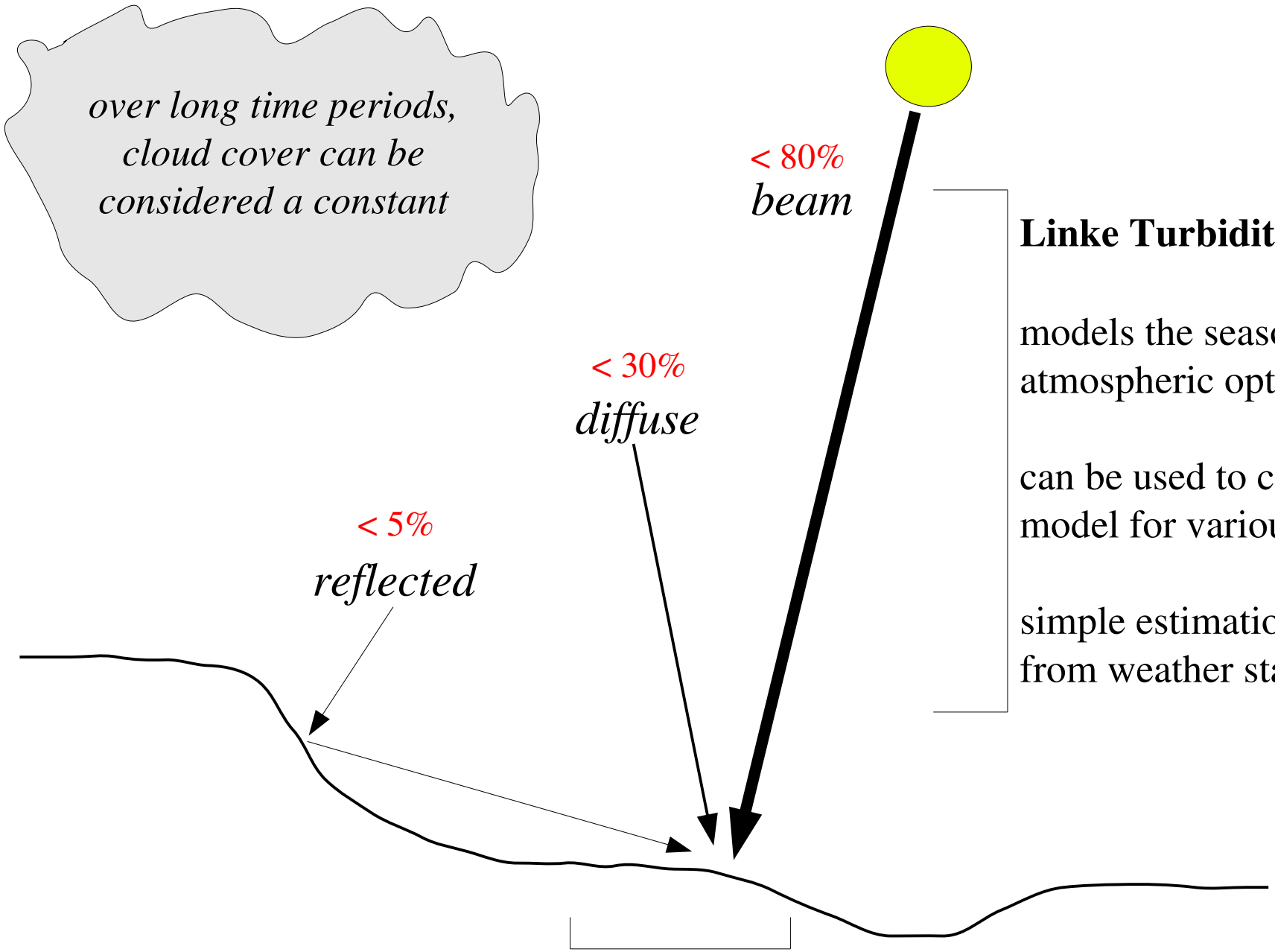
Connect key soil properties with geodata



Which geodata to integrate?

Depends on known environmental relationships at the site

Calculating solar radiation values with a *clear-sky* model



Linke Turbidity Factor:

models the seasonal changes in atmospheric optical properties

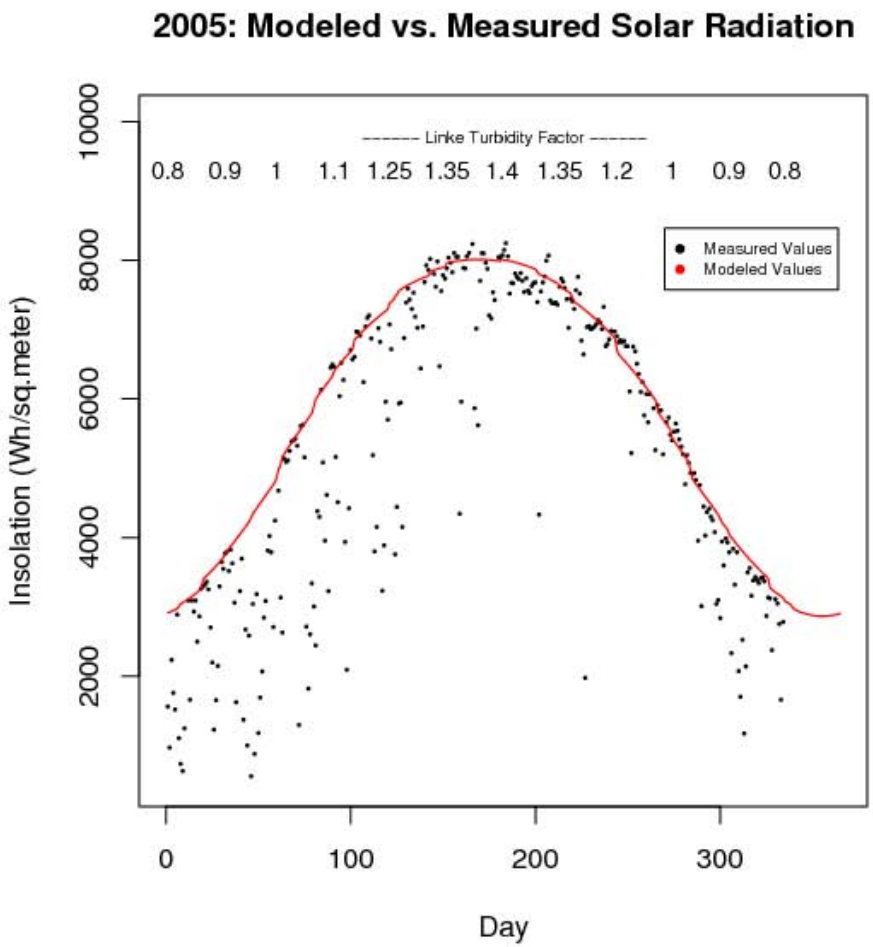
can be used to calibrate the model for various regions

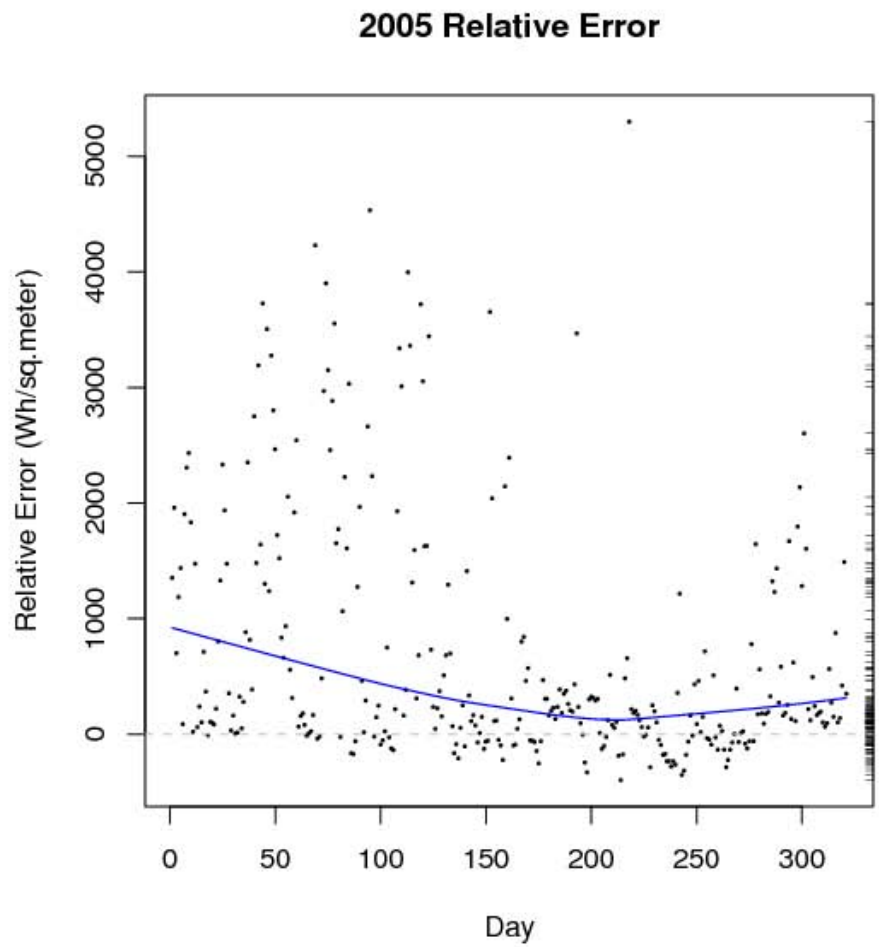
simple estimation / calculation from weather station data

surface albedo:

models spatial patterns in reflectance

Connect key soil properties with geodata



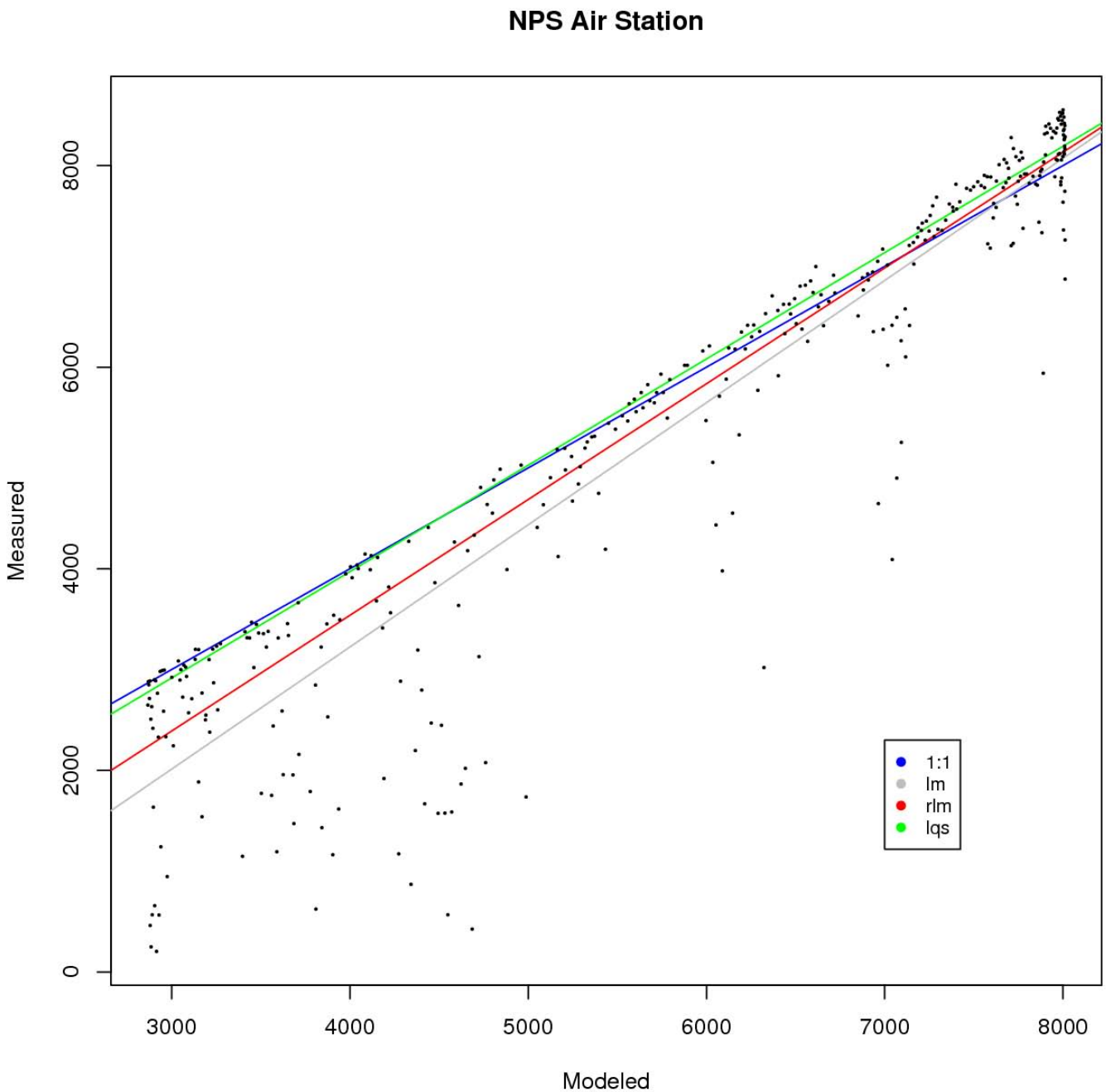


Solar radiation budgets are a convenient parameter to model at PINN:

-mature numerical methods

-historical weather station data for calibration and validation

Connect key soil properties with geodata



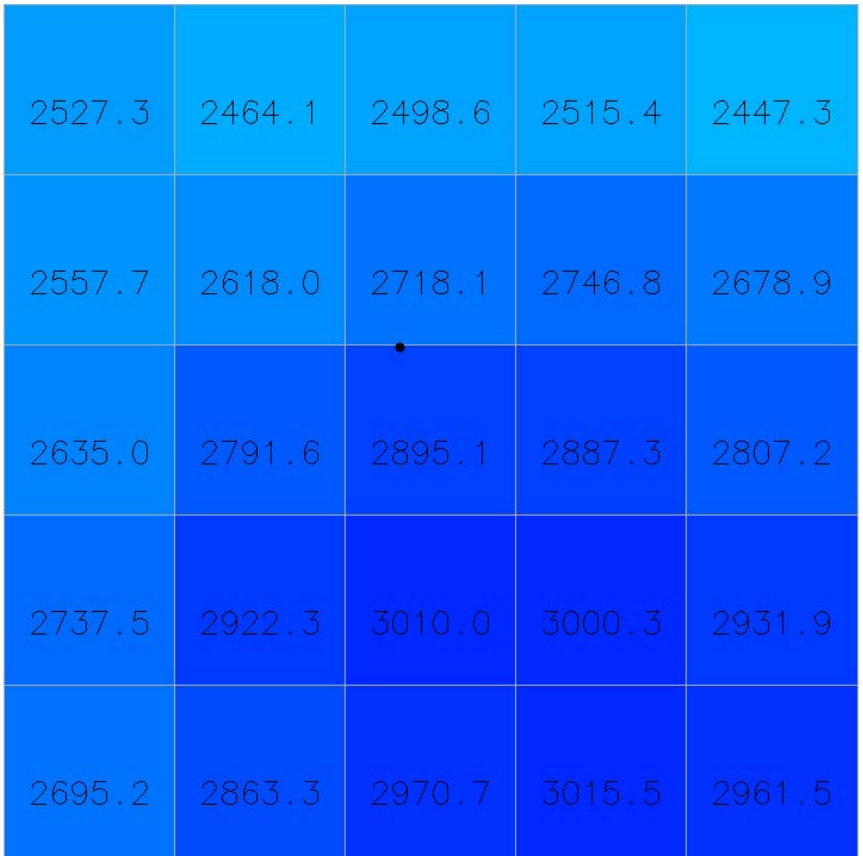
Excellent results:

note 1:1 line (blue)

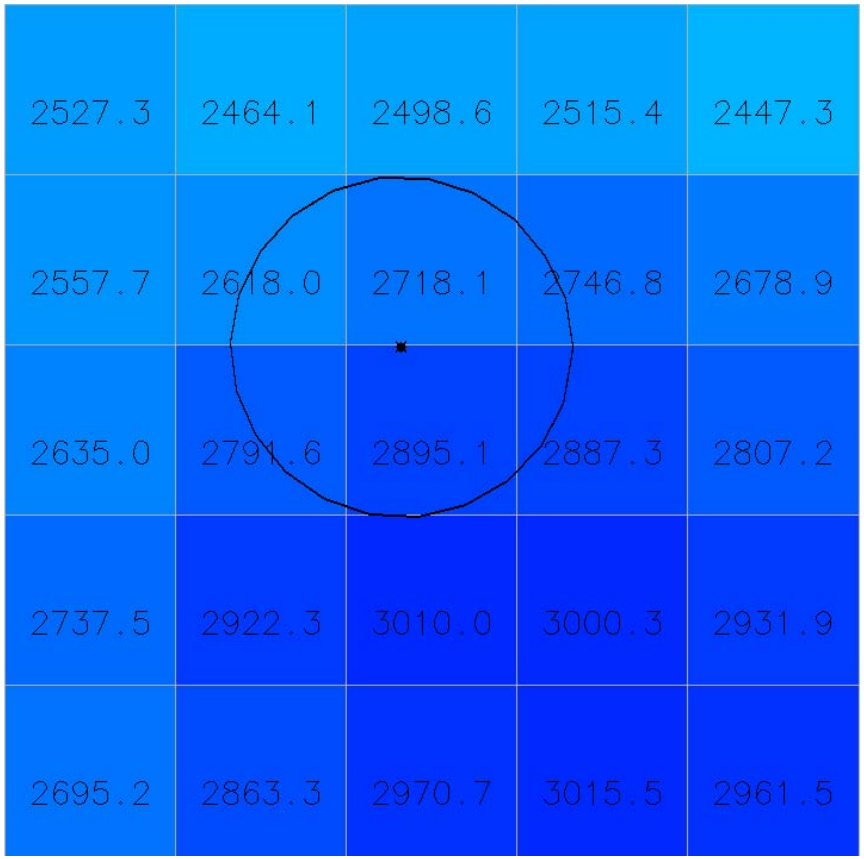
simple linear model (gray)
R^2 = 0.876

Accurate modeling:
requires reasonable monthly average values for the Linke Turbidity factor

Connect key soil properties with geodata



Correlation of WX station data and modeled solar data: *how can we compare point data with continuous raster data?*

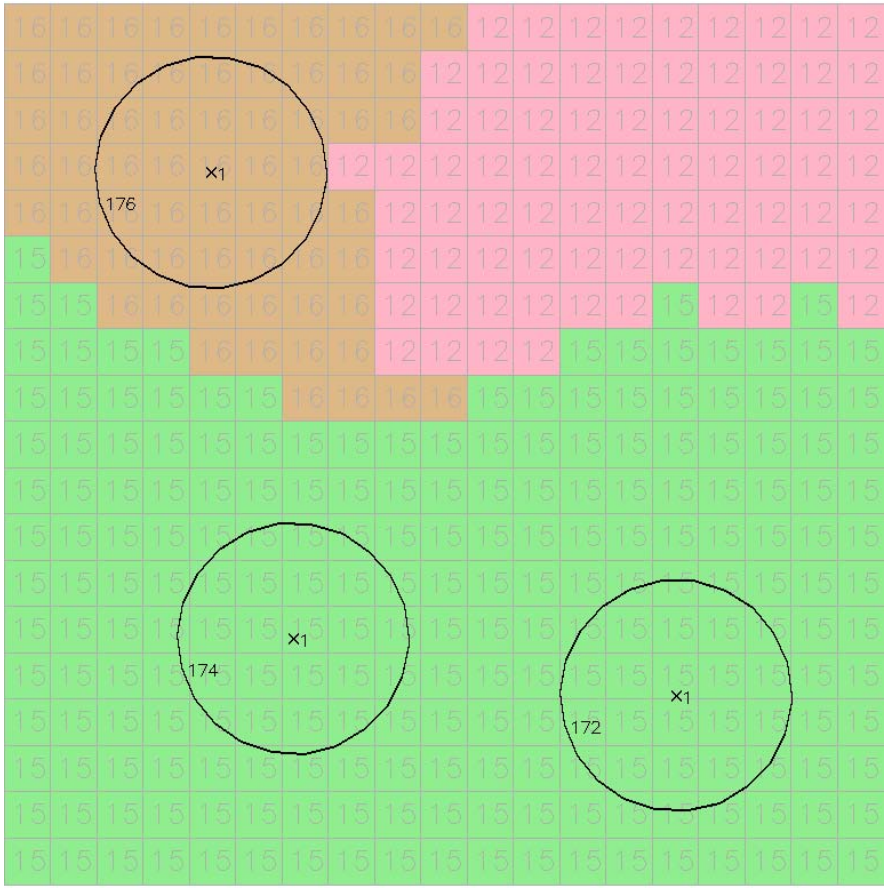


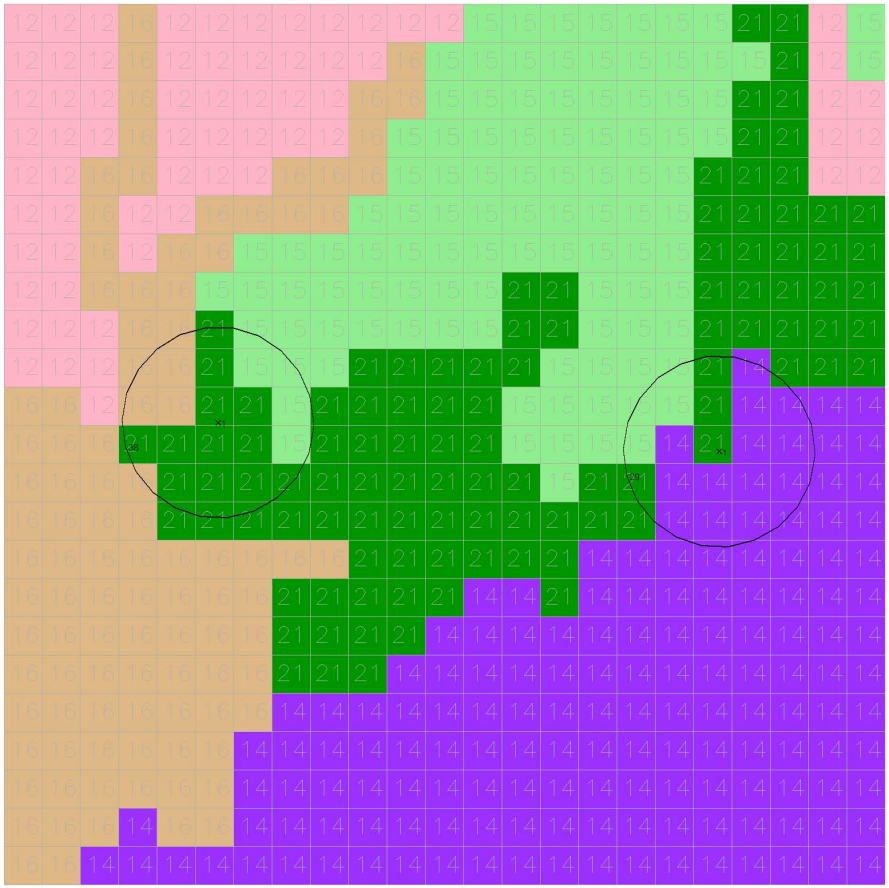
Sample all cells within a given radius, and average cell values.

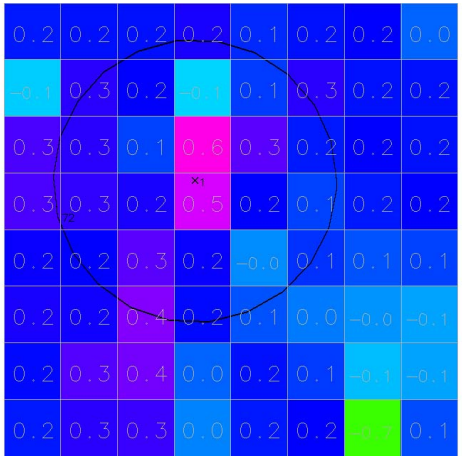
Automated sampling, buffering, and averaging of intersecting cells via 'starspan'.

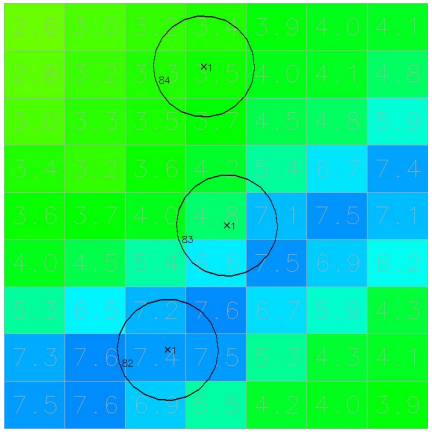
```
starspan --vector air_quality_station --raster beam_01 \
         --buffer 10
         --stats linke-air_quality_st-beam_01.csv avg
```

Connect key soil properties with geodata









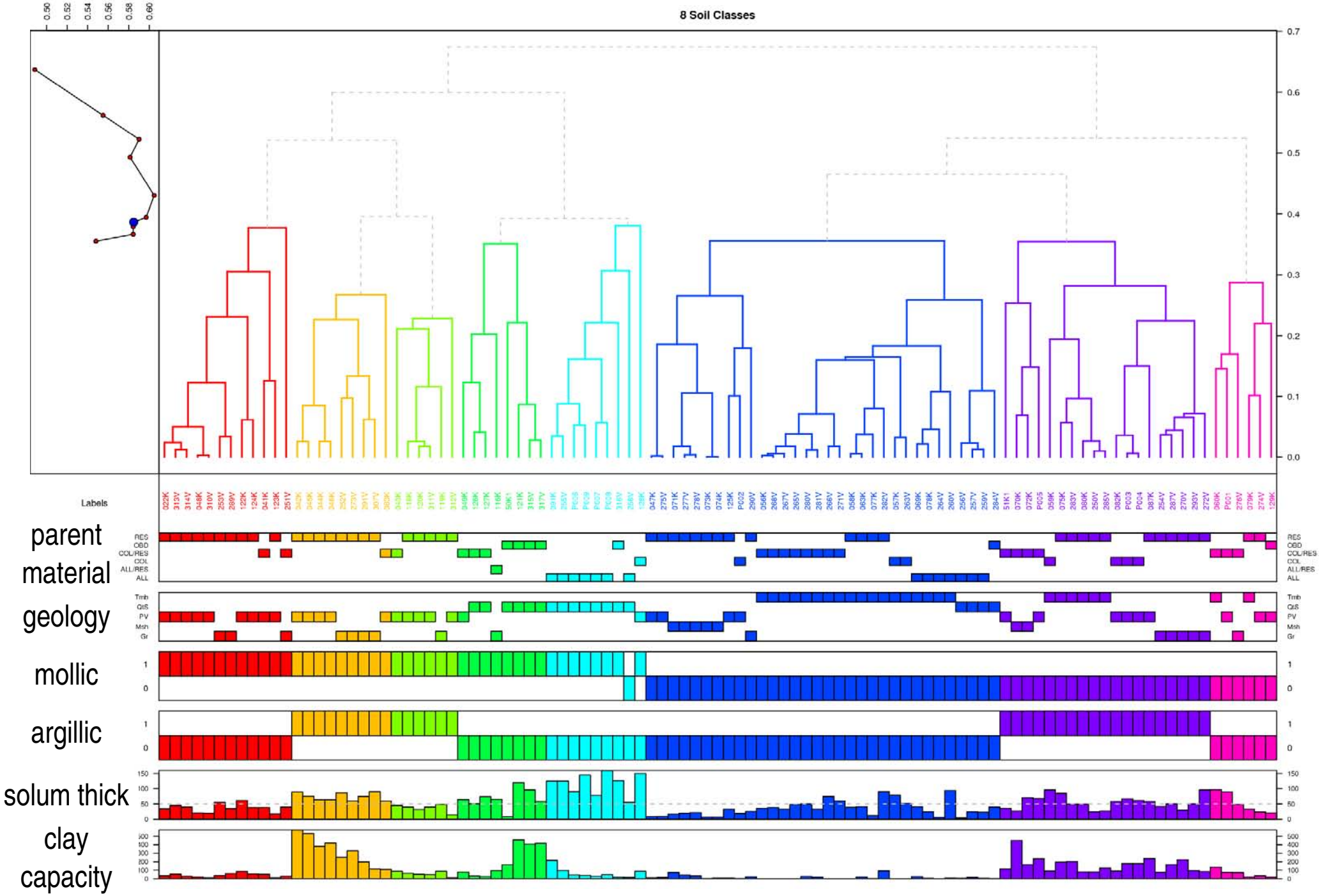
Correlation of pedon data collected in the field and continuous data products?

Sample all cells within a given radius- based on the data's resolution, then compute:

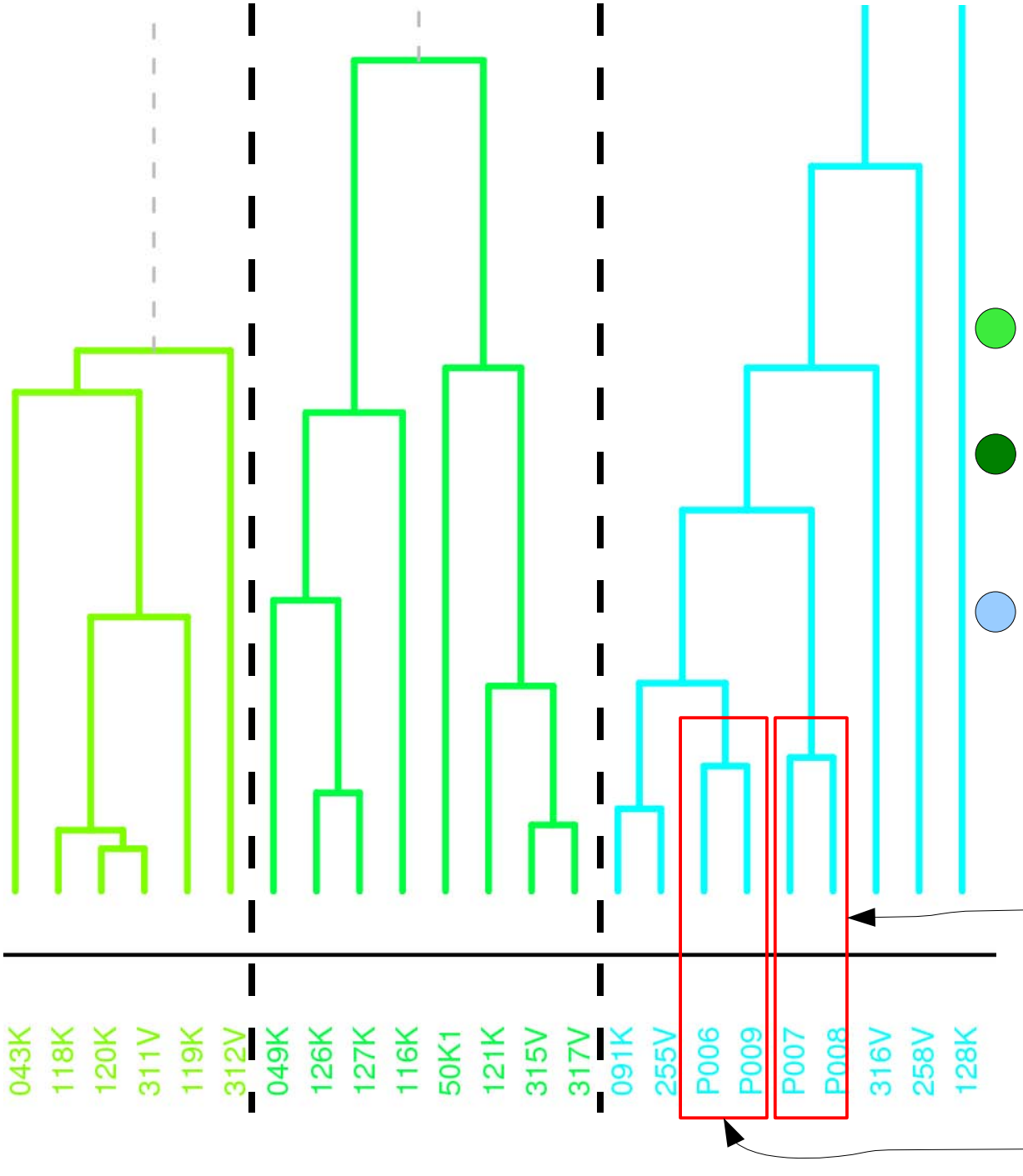
average: *continuous data*

mode: *categorical data*

Classify pedon data



Classify pedon data



3 Lithic Argixerolls from PV/GRA

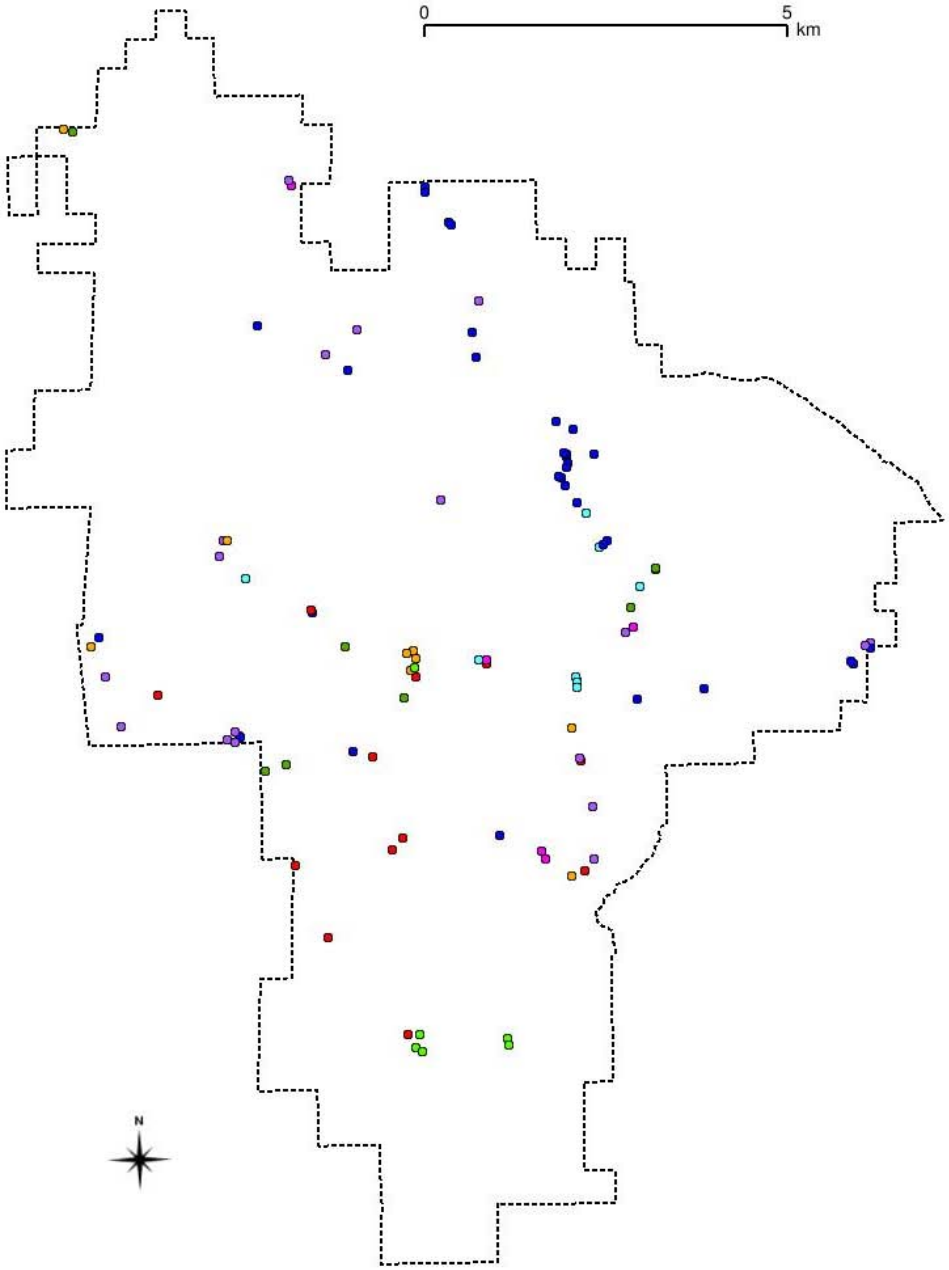
4 Alluvial / Colluvial,
Cumulic / Pachic Haploxerolls:
coarse-loamy to fine-loamy

5 Deep to Very Deep Haploxerolls: from QtS

pits from adjacent buckwheat ecosystems

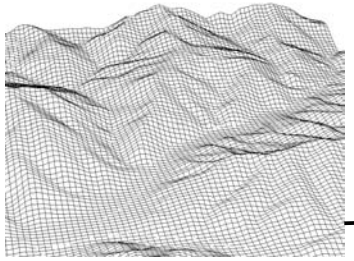
pits under adjacent oak trees

Classify pedon data

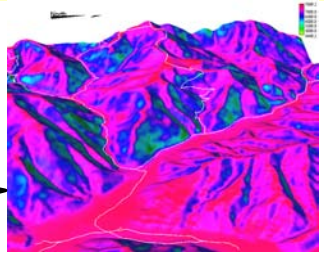


- **1** Residual Mollisols: mod. shallow from PV/GRA
- **2** Residual Argixerolls: thick mollic, from PV/GRA
- **3** Lithic Argixerolls from PV/GRA
- **4** Alluvial / Colluvial, Cumulic / Pachic Haploxerolls: coarse-loamy to fine-loamy
- **5** Deep to Very Deep Haploxerolls: from QtS
- **6.1** Lithic Xerothents: Misc. Marine Sedimentary
- **6.2** Xeropsamments: Temblor Formation
- **7** Fine to Fine-loamy Xeralfs
- **8** Misc. Inceptisols: mixed lithology

Extrapolation and estimation of soil classes

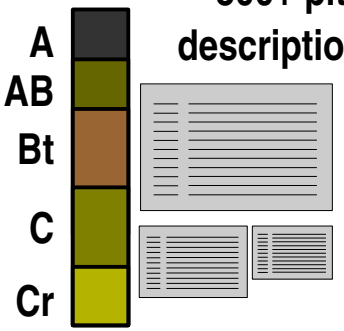


Digital Elevation Model

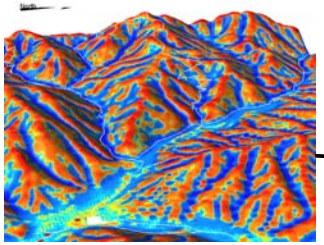


Solar Radiation Model

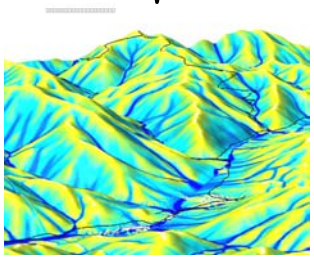
geology
vegetation
remotely sensed data



300+ pit descriptions



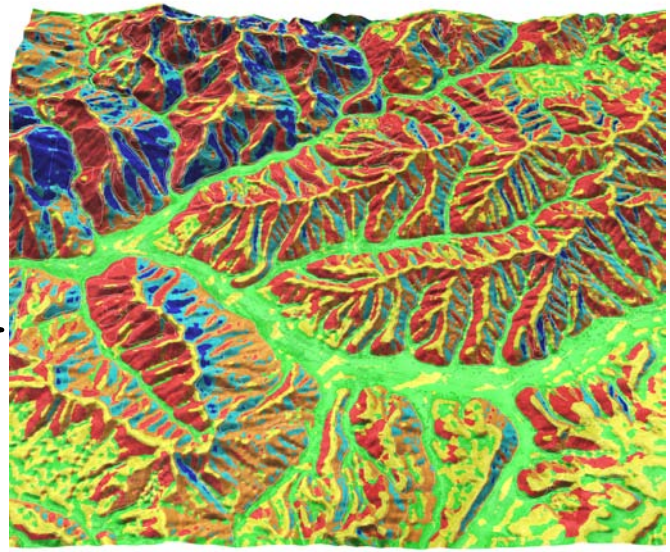
Surface Shape



Water and Sediment Transport

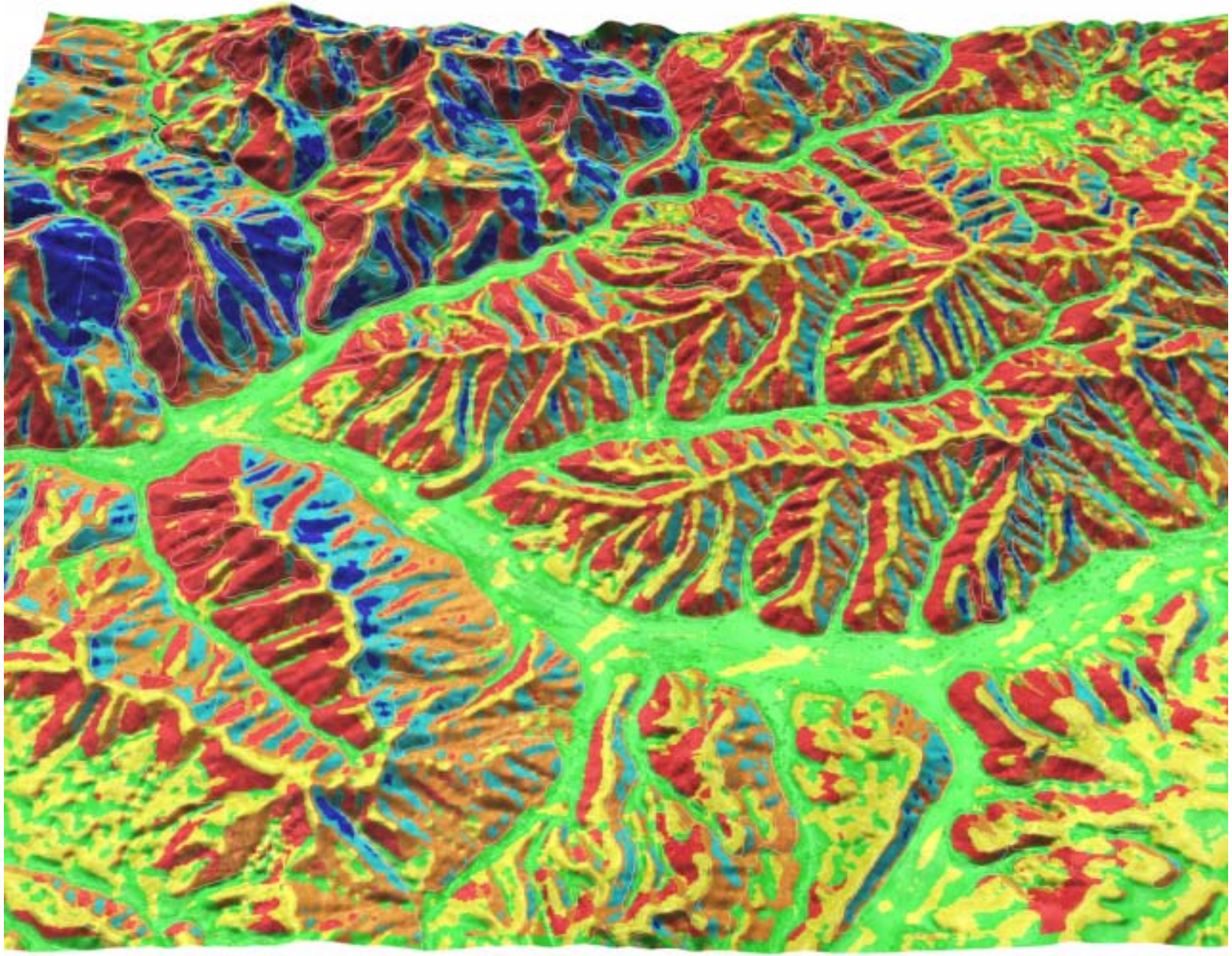
process-based & factorial models

field observation and validation



Example model output of soil component distribution.

Extrapolation and estimation of soil classes



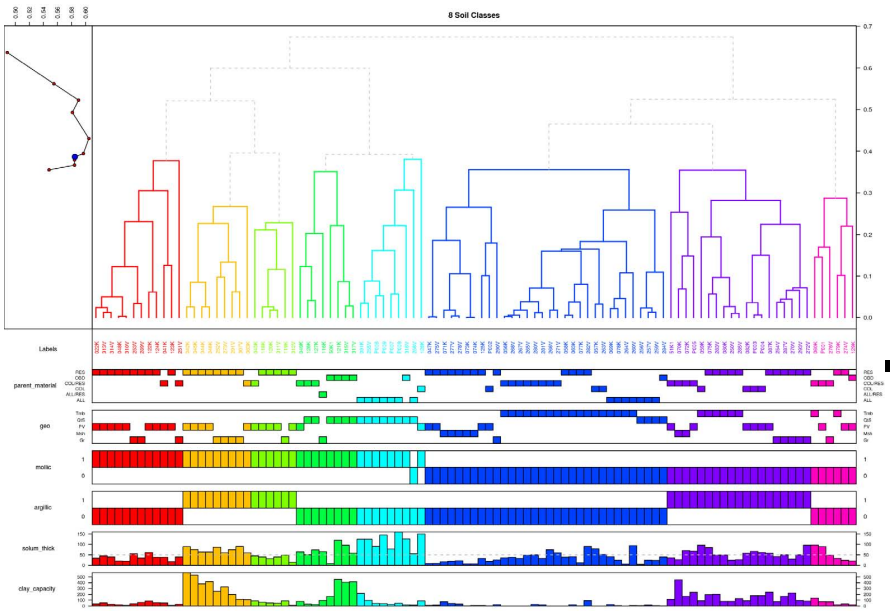
Example model output of soil component distribution.

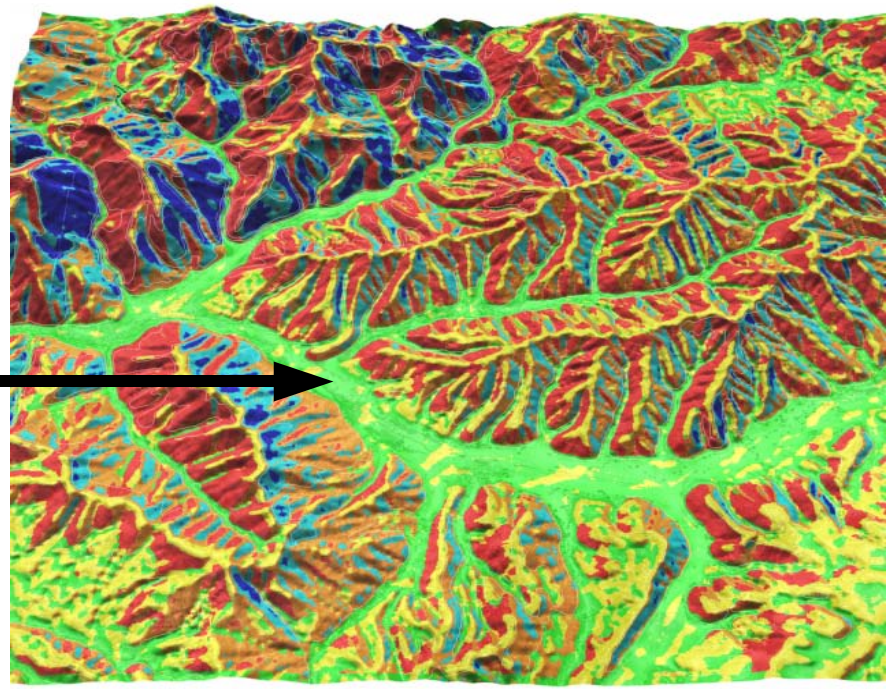
In progress...

Extrapolation and estimation of soil classes where pedon data is missing

explore various methods: GLM, cluster analysis, etc

create soil survey product at higher level of detail than normally possible





details at:

http://casoilresource.lawr.ucdavis.edu