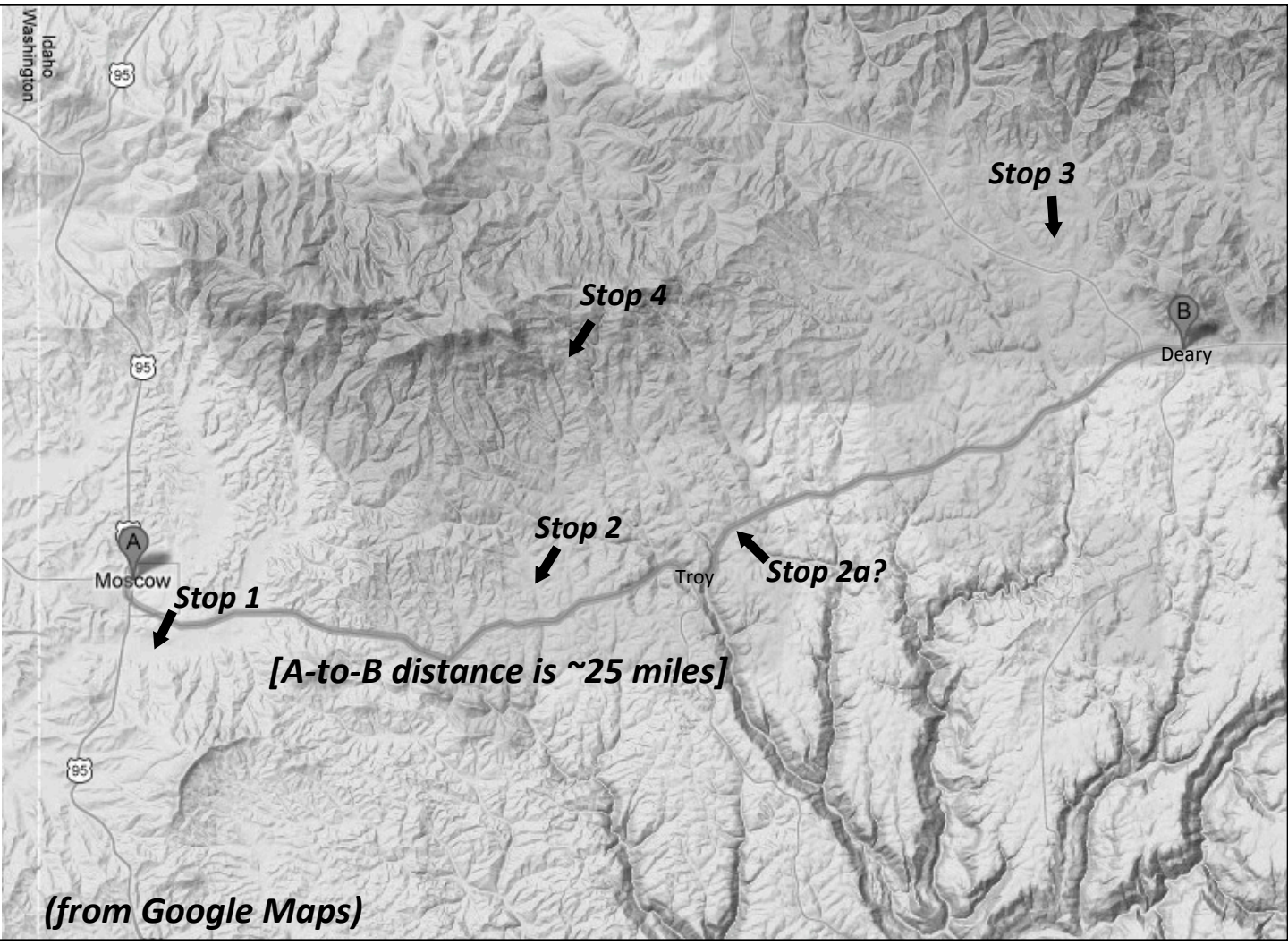
# SOIL 557 – Field Trip Guide
# Eastern Palouse/Moscow Mountain
# Fall 2012




***Questions to consider:***

1. What are some of the changes in soil morphology that occur along a transect from the western to the eastern part of the Palouse region?
2. What is meant by a 'welded' soil profile? Why are they more prevalent in the eastern part of the Palouse region?
3. What effects do fragipans and horizons with fragic properties have on landscape hydrology?
4. How do you explain the modern-day distribution of volcanic ash?

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***Much of the following information is taken from field trip guides originally prepared for the 2001 Washington Society of Professional Soil Scientist field tour and the 2001 Western Soil Science Society field tour. These guides were prepared by Alan Busacca and Paul McDaniel. Newer information has been added to reflect more recent work.***

**STOP 1: PALOUSE SERIES SOIL PROFILE**

(*fine-silty, mixed, superactive mesic Pachic Ultic Haploxeroll)*

This exposure illustrates the thick, dark surface (mollic epipedon) associated with this part of the Palouse. Prior to cultivation, this soil supported an Idaho fescue-dominated bunchgrass prairie. Even after a century of farming, much of the original epipedon is still present.

**STOP 2: SOUTHWICK SERIES SOIL PROFILE**

(*fine-silty, mixed, superactive mesic Oxyaquic Argixeroll)*

From Moscow, head east out of town on Idaho 8 toward Troy. Just after passing mile marker 11, you will turn left onto Wallen Road at the bottom of the hill. Drive 1.0 mile to where the road makes a 90°-right-hand turn. There is a road cut on the right just past the 90° turn that has been smoothed off by the highway department. In the spring, you can see the perched water table zone. If you continue up the road a couple hundred yards further, there is another road cut that has been excavated. With a little bit of digging, you can get into the Btb horizon.

In the eastern part of the Palouse region here, overall loess thickness begins to decrease and the mean annual precipitation increases. The topography is more subdued and the native vegetation, where present, is now open forest rather than grassland vegetation, specifically a ponderosa pine (*Pinus ponderosa*)–snowberry (*Symphoricarpos albus*) forest habitat type. The existing soil/landscape/vegetation model developed by the NRCS suggests that in this area with ~650 mm (25-26") of mean annual precipitation and a xeric moisture regime, ponderosa pine is the climax on the mesic, drier south-facing slopes and Douglas-fir is the climax on the frigid, moister north aspects. Many of these soils were cleared in the late 1800s and early 1900s and placed into agricultural production.

Selected soil morphological and physical properties of the soil at this site, a Southwick silt loam, are presented in the attached table. In general, the profile characteristics here are

transitional between the Mollisols to the west and the Alfisols to the east. A mollic epipedon and a cambic horizon have formed in the L1 loess at this site (Figure 1). The mollic epipedon contains less organic C and is not as thick as the one observed for the Palouse soil – this is due to the smaller proportion of biomass produced below ground in a forest versus a grassland ecosystem (McDaniel et al., 2011).

The Btxb horizon has formed in the upper part of the L2 loess and has several characteristics of a fragipan (Figure 1) (Kemp et al., 1998). It is dense and brittle, but is not classified as a fragipan according to Soil Taxonomy because the average horizontal distance separation between structural aggregates is less than 10 cm. Southwick soils are classified as fine-silty, mixed, superactive, mesic Oxyaquic Argixerolls.

From a land-use perspective, these soils pose some interesting problems. The saturated hydraulic conductivity of the Btb horizon is extremely low –measured at this site indicate it is on the order of 0.01-0.1 cm/day (Reuter et al., 1998) Our research has shown that perched water tables are present in these soils for as much as 6-7 months per year (e.g. McDaniel et al., 2001; Kemp et al., 1998). In addition, Eh measurements have shown that seasonal reduction of Fe may occur during the months of March-May. Perched water tables rise and fall rapidly in response to periods of rainfall and snow melt, and rise to the soil surface on several occasions during the winter and early spring months (Figure 2). This creates the potential for rapid lateral transport of agrichemicals, such as fall-applied nitrogen fertilizers. Studies at this site have shown that applied bromide tracers were transported an average of 0.5 m/day and moved as much as 65 m in two months (Reuter et al., 1998).

**STOP 3: SANTA SERIES SOIL PROFILE**

(*coarse-silty, mixed, superactive, frigid Vitrandic Fragixeralf*)

From Moscow, drive east on Highway 8. Pass through Troy and continue almost to the town of Deary. At mile marker 25, there is a good exposure of loess paleosols on the left. Several buried soils are visible. Approximately 0.5 mile past this roadcut, turn left onto State Highway 9. Continue for 2.3 miles and turn right onto Forest Road 3347 (Mica Mountain Road). Drive ~0.6 miles and turn left onto N. Avon Road at the bottom of the hill. Practice Site #3 is located in a roadcut on the right ~0.2 miles from the turn.

This stop illustrates pedogenesis in the extreme eastern part of the Palouse region under grand fir forest and ~830 mm (32") of mean annual precipitation; this soil represents the moist end of the xeric soil moisture regime. The soil here belongs to the Santa series of

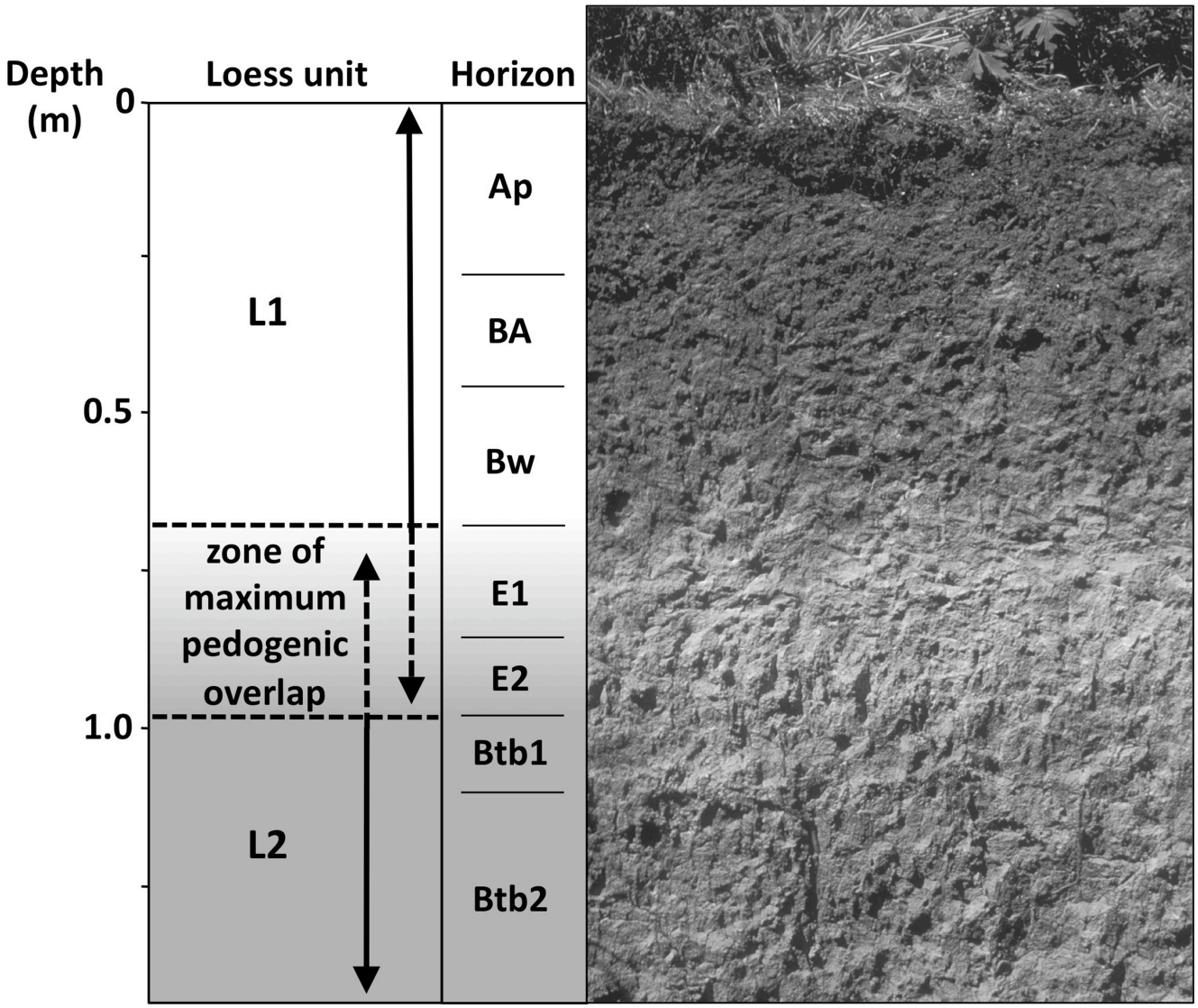
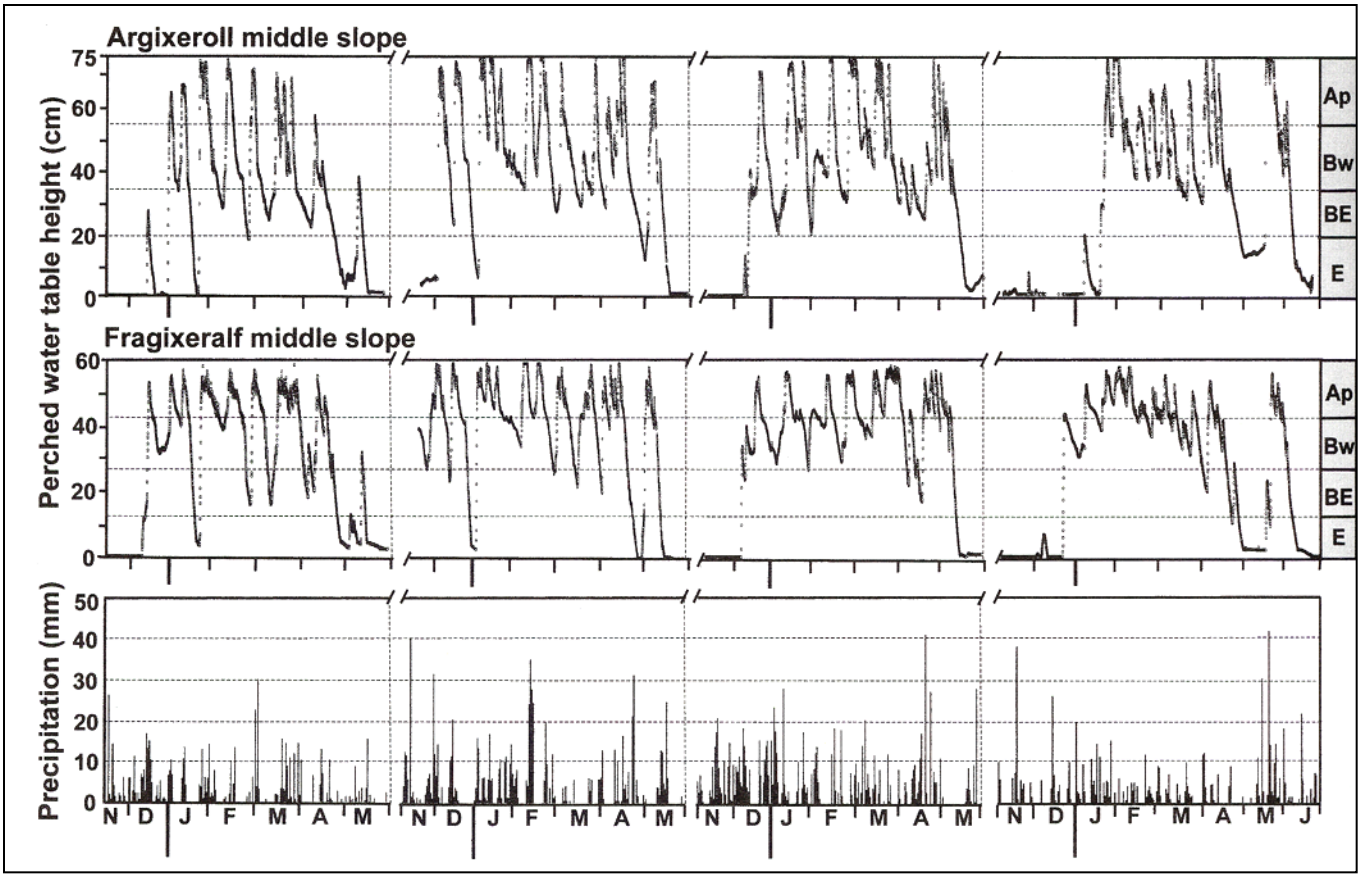



Figure 1. Loess stratigraphy, horizonation, and polygenetic Mollisol of an aggrading loessial landscape. Pedogenesis in the younger L1 unit (~0-15ka) has formed a mollic epipedon and a cambic horizon, which overlie an argillic horizon form in the L2 (gray shading) unit (~15-75ka). Albic E horizons have developed in the lower L1 and upper L2 units as a result of episaturation. The soil is an Oxyaquic Argixeroll (Southwick series). (Adapted from Kemp et al. 1998; McDaniel and Hipple 2010).



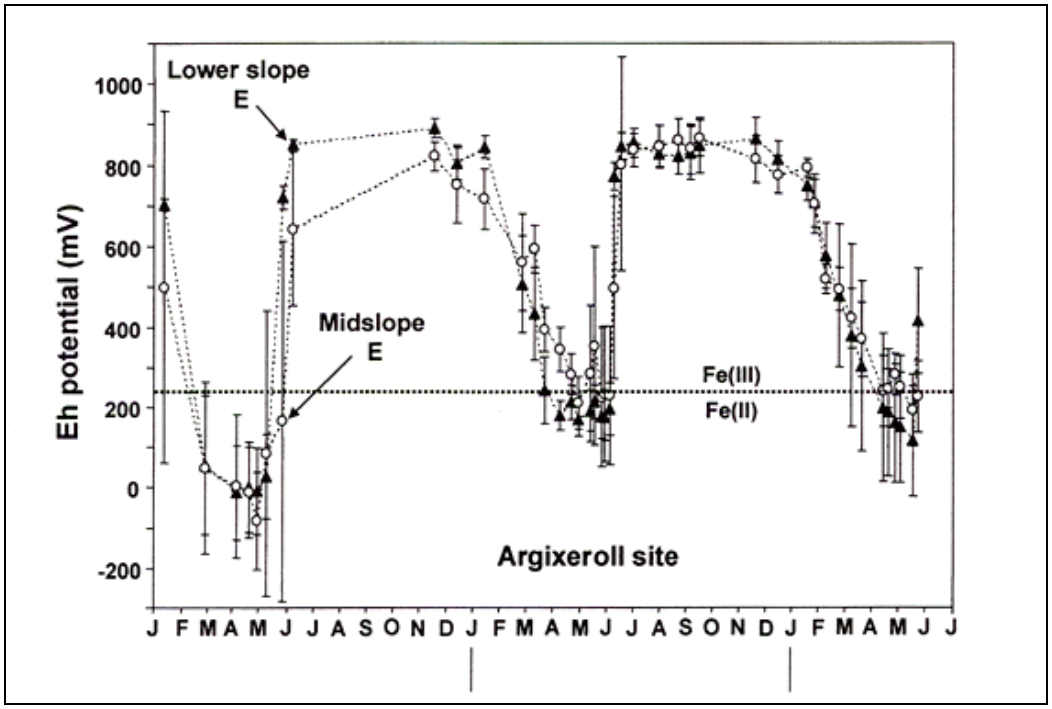




Figure 2. Perched water table heights at Southwick (Argixeroll) and Santa (Fragixeralf) sites. Perched water table heights are expressed relative to the top of the Btb or Btxb horizons. Eh measurements for the Southwick soil are reported relative to a standard $H_2$ electrode (from McDaniel et al., 2001).

coarse-silty, mixed, superactive, frigid Vitrandic Fragixeralfs. Over 64,000 acres of Santa soils are mapped in eastern Latah County (Barker, 1981).

While the stratigraphy at this site is comparable to that at the Southwick site, there are significant differences in morphology. The most striking feature of this soil is arguably the well-developed fragipan – this is one of the best examples we have found in the area. The fragipan has formed in the upper part of the L2 loess, has a bulk density of ~1.64-1.75 g/cm$^3$, is extremely hard when dry, and has very coarse prismatic structure. Thick organo-clay coatings can be seen along the faces of the prisms along with a flattened mat of very fine roots. The mollic epipedon developed in the L1 loess at the Southwick site has given way to an ochric epipedon at this site, as the forest canopy has become more closed and grass species are no longer a significant component of the understory. Some Mazama tephra in the upper part of soils mapped as Santa, resulting in the classification as Vitrandic Fragixeralfs.

From a management perspective, Santa soils are quite similar to the Southwick soils at the previous site. The fragipan limits water movement and rooting, and perches water for up to 7 months of the year. Our monitoring has shown that perched water tables may form up to 3 weeks earlier in Santa soils compared the Southwick soils, there appears to be no difference in the timing of perched water table disappearance in the late spring (McDaniel et al., 2001). Additionally, as much as 90% of the incident precipitation leaves hillslopes as subsurface lateral flow during the winter months; only ~2% of the annual precipitation leaves the site through deep percolation (McDaniel et al., 2007). The limited amount of deep percolation indicates that very little groundwater recharge occurs on uplands dominated by soils with fragipans and similar horizons (Murray et al., 2003).

Movement of solutes via perched water tables has been documented near this site, with tracer movement ranging from 2.9 to 18.7 m/day (Figure 3)(McDaniel et al., 2007). Canopy removal associated with timber harvesting and conversion to agriculture has significantly altered the moisture regime of many of these soils. Seasonal PWTs develop 2 to 8 weeks sooner under cleared areas compared to forested areas and it takes as much as four months before PWTs in forested soils to reach an equivalent height as those in the cleared soils (Rockefeller et al., 2003). These results suggest that land-use interpretations based on duration and proximity of a seasonal PWT to the soil surface may need to be adjusted when vegetation cover is altered. It may also be useful to distinguish between cleared and forested phases of fragipan-containing soil series when developing hydrologic interpretations (Rockefeller et al., 2003). Blowdown in thinned timber stands is a

management concern with Santa soils, as is the poor performance of deep-rooted crops such as alfalfa.

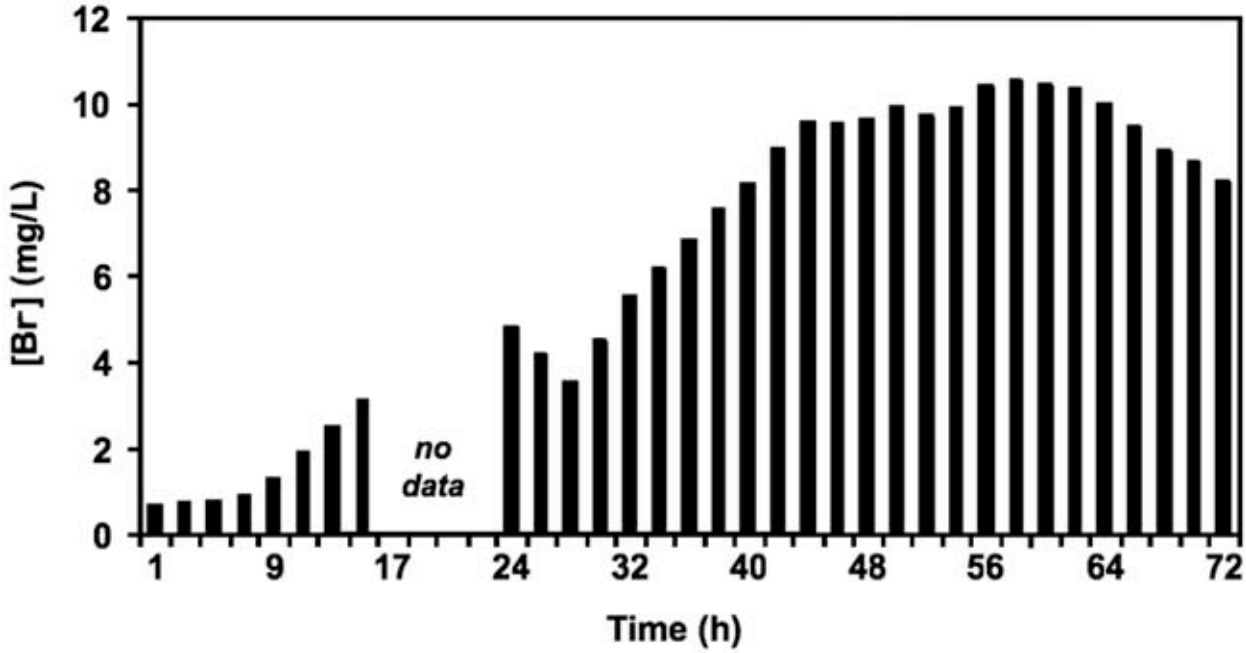


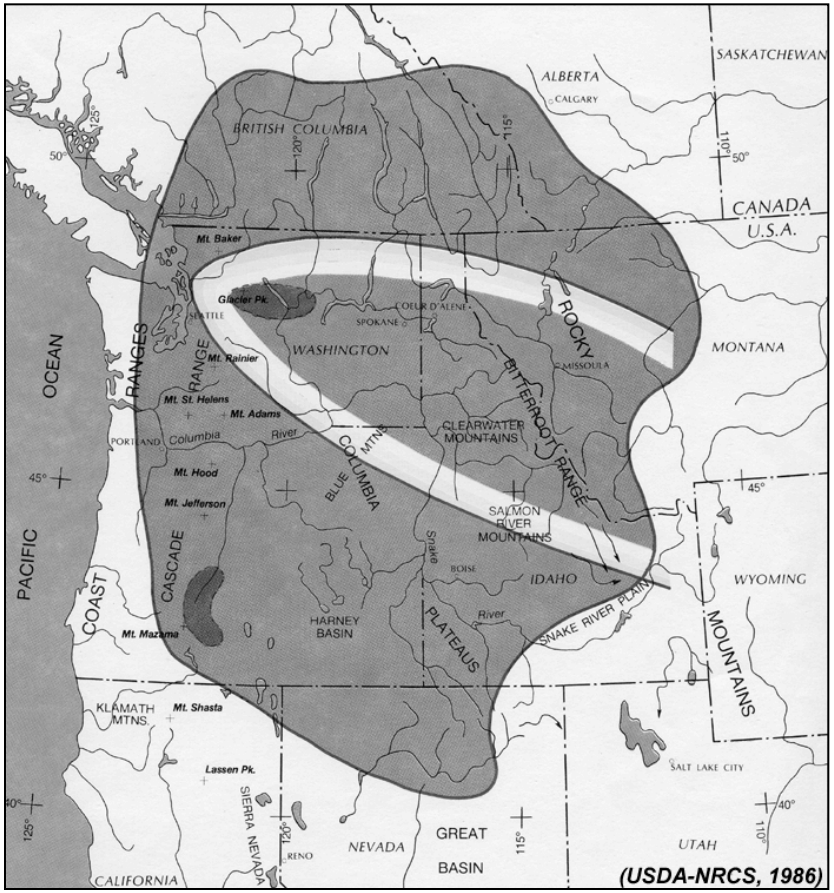

Figure 3. Hourly Br concentration in perched water flowing out of hillslope plot on top of a fragipan; Br was applied at time = 0, approximately 7m upslope from water sample collector (from McDaniel et al., 2007).

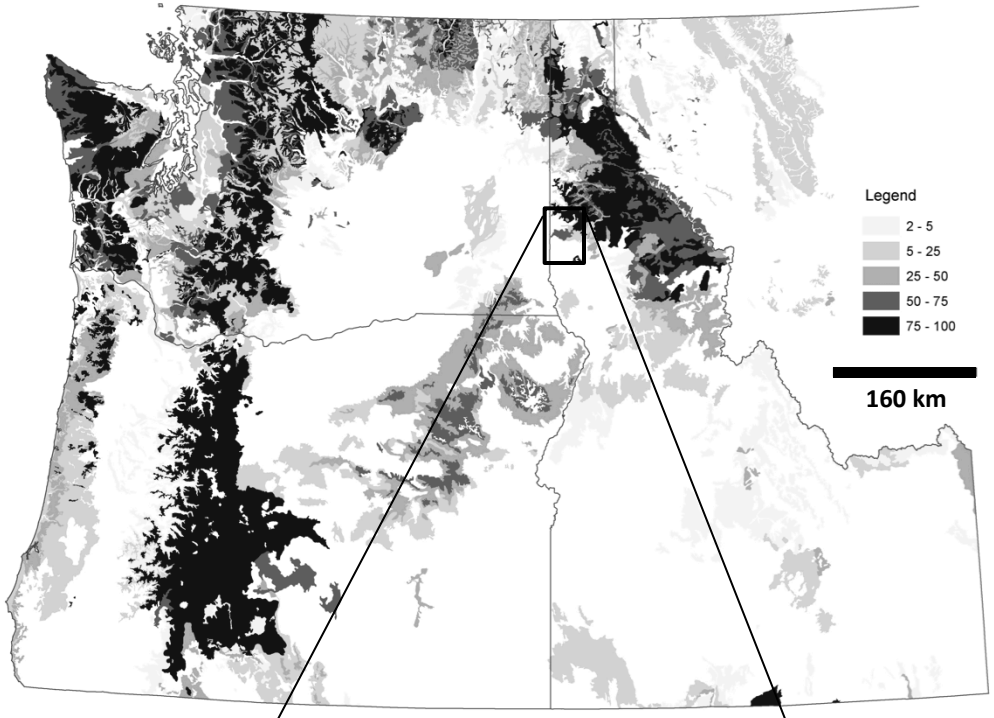
**STOP 4: JACOT SERIES SOIL PROFILE**

(*ashy over loamy, amorphic over isotic, frigid Alfic Udivitrand)*

From Moscow, get on State Highway 8 and drive east toward Troy. As you come in to Troy, turn left on Randall Flat Road (immediately before the Troy welcome sign and across from the gas station). Follow Randall Flat Road for ~2.4 miles (it will turn to gravel). Turn right onto Tamarack Road and drive ~3 miles. You will see a road coming in on the left – it has a cable across it. Park along the main road (don't block the drive) and walk in along the road ~250 yards, ignoring the KEEP OUT sign - this is actually UI Experimental Forest property. The Jacot site is located in an old logging road cut on the right – look for the pile of excavated soil.

This stop is technically not part of the Palouse physiographic region, but nevertheless provides an opportunity to observe an Andisol. The mantle of volcanic ash came from the climactic eruption of Mount Mazama ~7600 cal. yrs BP, during which ~119 $km^3$ of tephra was spread over 5000 square miles of the Pacific Northwest (Figure 4) (Zdanowicz et al.,



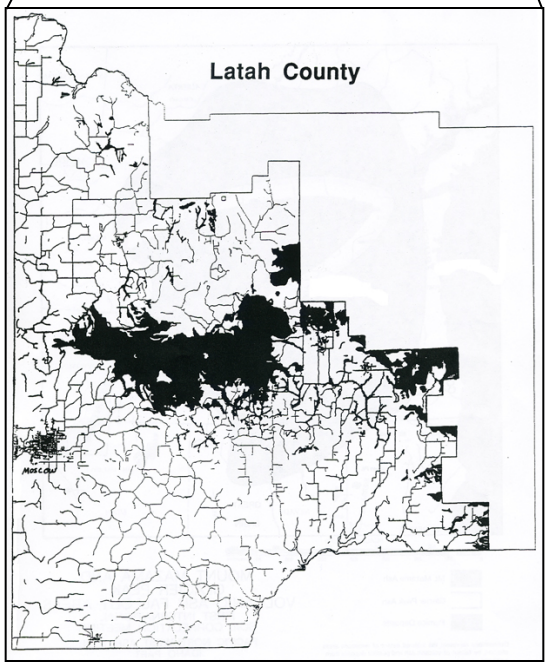




Figure ?. Above - approximate distribution of ash from Mount Mazama. Upper right – distribution of Andisols in the Pacific Northwest (from USDA-STATSGO database; McDaniel and Hipple, 2010). Lower right – Andisol distribution in Latah County, ID (from Soil Survey of Latah County Area, Idaho).

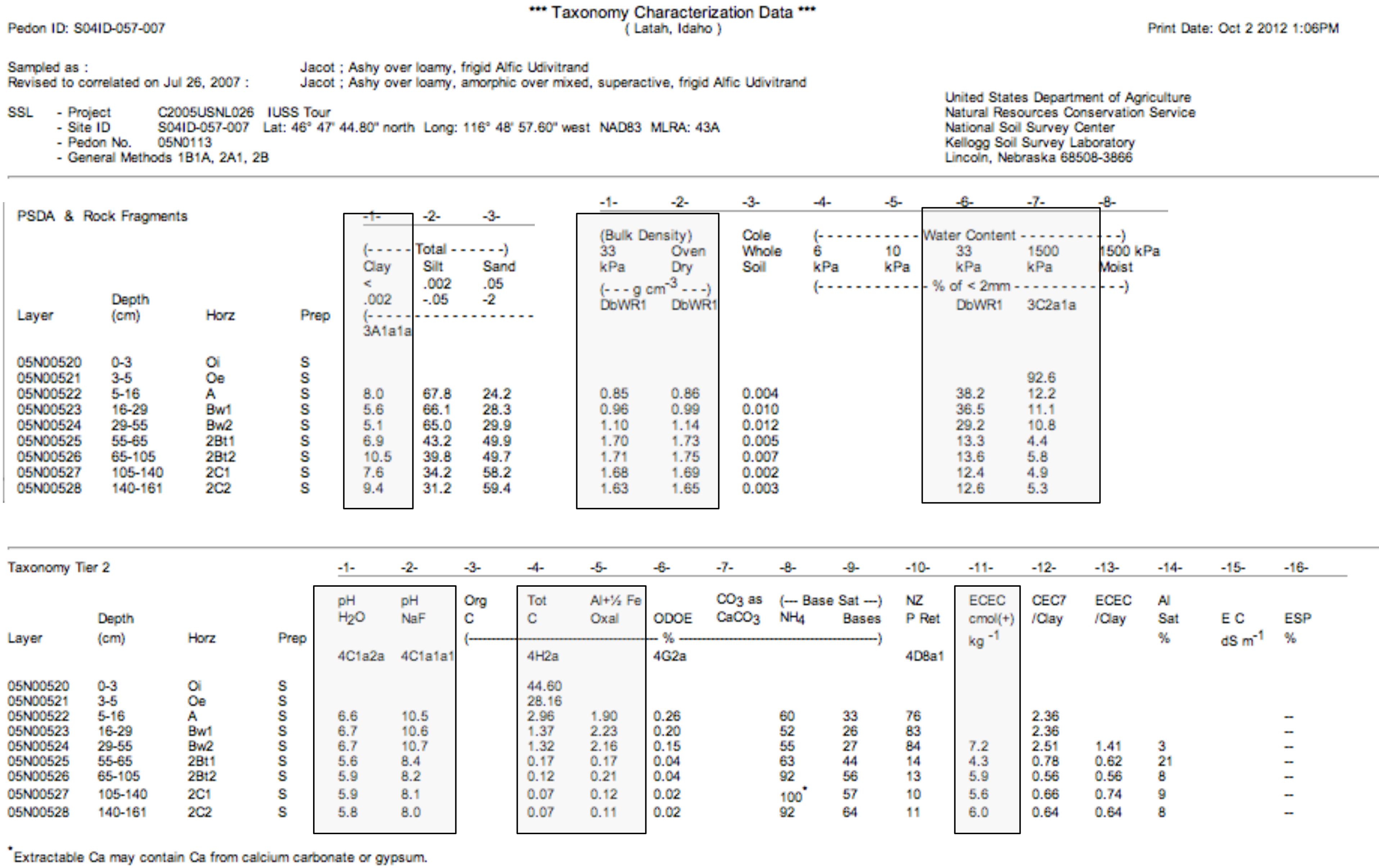
1999; Bacon, 1983). This mantle of tephra can be found throughout most of the forested mountainous areas of northern Idaho, eastern Washington, and western Montana (McDaniel and Hipple, 2010). It is believed that the canopy structure and thick litter layer associated with moister forest communities has played an important role in retaining the ash mantle (Brown et al., 2012; McDaniel et al., 2005). In this area, any soils supporting western redcedar (will undoubtedly contain significant quantities of Mazama tephra. If you look carefully at the base of the O horizons in the vicinity, you can probably find some of the light gray ash from the 1980 eruption of Mt. St. Helens as well.

Andisols formed in Mazama ash typically have a very thin A horizon and a reddish-brown cambic Bw horizon (McDaniel et al., 1993). The composition of the ash mantle is typically only ~30-40% glass – the remainder is quartz, feldspar, and mica. This suggests that considerable quantities of loess were mixed with the tephra during deposition and, perhaps, re-deposition. At this site, the ash mantle overlies Bt horizons formed in granitic colluvium.

Soils such as these represent some of the most productive forest soils in the Inland Northwest region (Kimsey et al., 2008). One explanation for this high level of productivity is that the weathering tephra is imparts greater water-holding capacity to soils, particularly those derived from coarse-grained parent materials (McDaniel et al., 2005). This is certainly true in some cases, such as the soil here. However, an alternative explanation is that following deposition, there has been better retention of the tephra at the more productive sites (Brown et al. 2012). These more-productive sites have provided the best protection against erosion, thereby preserving the ash mantles.

At this site, mean annual precipitation is estimated to be 900 mm (~35") and the NRCS considers this a udic moisture regime. For classification purposes, the 1500 kPa water retention in these soils is less than 15% (typically 12-15%), resulting in suborder classification as a Vitrand. Because of the udic moisture regime, these soils are placed in the Udivitrand great group. The presence of clay films underneath the ash mantle results in classification as Alfic Udivitrands at the subgroup level.

Selected lab data for this pedon illustrate some of the typical chemical and physical properties of Andisols of the region (Figure 5). These include low measured clay content, low bulk density, high water retention, low effective cation exchange capacity (ECEC), and high P retention.



*** Taxonomy Characterization Data ***
( Latah, Idaho )

Pedon ID: S04ID-057-007

Print Date: Oct 2 2012 1:06PM

Sampled as : Jacot ; Ashy over loamy, frigid Alfic Udivitrand
Revised to correlated on Jul 26, 2007 : Jacot ; Ashy over loamy, amorphic over mixed, superactive, frigid Alfic Udivitrand

SSL - Project C2005USNL026 IUSS Tour
- Site ID S04ID-057-007 Lat: 46° 47' 44.80" north Long: 116° 48' 57.60" west NAD83 MLRA: 43A
- Pedon No. 05N0113
- General Methods 1B1A, 2A1, 2B

United States Department of Agriculture
Natural Resources Conservation Service
National Soil Survey Center
Kellogg Soil Survey Laboratory
Lincoln, Nebraska 68508-3866

PSDA & Rock Fragments

| Layer | Depth (cm) | Horz | Prep | -1- Clay < .002 (Total) 3A1a1a | -2- Silt .002 -.05 (Total) | -3- Sand .05 -2 (Total) | -1- Bulk Density 33 kPa (g cm$^{-3}$) DbWR1 | -2- Bulk Density Oven Dry (g cm$^{-3}$) DbWR1 | -3- Cole Whole Soil | -4- Water Content 6 kPa (% of < 2mm) | -5- Water Content 10 kPa (% of < 2mm) | -6- Water Content 33 kPa (% of < 2mm) DbWR1 | -7- Water Content 1500 kPa (% of < 2mm) 3C2a1a | -8- Water Content 1500 kPa Moist (% of < 2mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05N00520 | 0-3 | Oi | S | | | | | | | | | | | |
| 05N00521 | 3-5 | Oe | S | | | | | | | | | | 92.6 | |
| 05N00522 | 5-16 | A | S | 8.0 | 67.8 | 24.2 | 0.85 | 0.86 | 0.004 | | | 38.2 | 12.2 | |
| 05N00523 | 16-29 | Bw1 | S | 5.6 | 66.1 | 28.3 | 0.96 | 0.99 | 0.010 | | | 36.5 | 11.1 | |
| 05N00524 | 29-55 | Bw2 | S | 5.1 | 65.0 | 29.9 | 1.10 | 1.14 | 0.012 | | | 29.2 | 10.8 | |
| 05N00525 | 55-65 | 2Bt1 | S | 6.9 | 43.2 | 49.9 | 1.70 | 1.73 | 0.005 | | | 13.3 | 4.4 | |
| 05N00526 | 65-105 | 2Bt2 | S | 10.5 | 39.8 | 49.7 | 1.71 | 1.75 | 0.007 | | | 13.6 | 5.8 | |
| 05N00527 | 105-140 | 2C1 | S | 7.6 | 34.2 | 58.2 | 1.68 | 1.69 | 0.002 | | | 12.4 | 4.9 | |
| 05N00528 | 140-161 | 2C2 | S | 9.4 | 31.2 | 59.4 | 1.63 | 1.65 | 0.003 | | | 12.6 | 5.3 | |

Taxonomy Tier 2

| Layer | Depth (cm) | Horz | Prep | -1- pH $H_2O$ 4C1a2a | -2- pH NaF 4C1a1a1 | -3- Org C (%) | -4- Tot C (%) 4H2a | -5- Al+½ Fe Oxal (%) | -6- ODOE (%) 4G2a | -7- $CO_3$ as $CaCO_3$ (%) | -8- Base Sat $NH_4$ (%) | -9- Base Sat Bases (%) | -10- NZ P Ret 4D8a1 | -11- ECEC cmol(+) kg$^{-1}$ | -12- CEC7 /Clay | -13- ECEC /Clay | -14- Al Sat % | -15- E C dS m$^{-1}$ | -16- ESP % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05N00520 | 0-3 | Oi | S | | | | 44.60 | | | | | | | | | | | | |
| 05N00521 | 3-5 | Oe | S | | | | 28.16 | | | | | | | | | | | | |
| 05N00522 | 5-16 | A | S | 6.6 | 10.5 | | 2.96 | 1.90 | 0.26 | | 60 | 33 | 76 | | 2.36 | | | | -- |
| 05N00523 | 16-29 | Bw1 | S | 6.7 | 10.6 | | 1.37 | 2.23 | 0.20 | | 52 | 26 | 83 | | 2.36 | | | | -- |
| 05N00524 | 29-55 | Bw2 | S | 6.7 | 10.7 | | 1.32 | 2.16 | 0.15 | | 55 | 27 | 84 | 7.2 | 2.51 | 1.41 | 3 | | -- |
| 05N00525 | 55-65 | 2Bt1 | S | 5.6 | 8.4 | | 0.17 | 0.17 | 0.04 | | 63 | 44 | 14 | 4.3 | 0.78 | 0.62 | 21 | | -- |
| 05N00526 | 65-105 | 2Bt2 | S | 5.9 | 8.2 | | 0.12 | 0.21 | 0.04 | | 92 | 56 | 13 | 5.9 | 0.56 | 0.56 | 8 | | -- |
| 05N00527 | 105-140 | 2C1 | S | 5.9 | 8.1 | | 0.07 | 0.12 | 0.02 | | 100* | 57 | 10 | 5.6 | 0.66 | 0.74 | 9 | | -- |
| 05N00528 | 140-161 | 2C2 | S | 5.8 | 8.0 | | 0.07 | 0.11 | 0.02 | | 92 | 64 | 11 | 6.0 | 0.64 | 0.64 | 8 | | -- |

*Extractable Ca may contain Ca from calcium carbonate or gypsum.

Figure 5. Selected data for Jacot (S04ID057007). Data are from the Kellogg Soil Survey Laboratory.

**REFERENCES**


Bacon, C.R. 1983. Eruptive history of Mount Mazama and Crater Lake caldera, Cascade Range, U.S.A. *Journal of Volcanology and Geothermal Research* 18 (1-4): 57-115.

Barker, R.J. 1981. Soil survey of Latah County area, Idaho. USDA-SCS. US Govt. Print. Office, Washington, DC.

Brooks, E.S, J. Boll, and P.A. McDaniel. 2007. Distributed and integrated response of a GIS-based hydrologic model in the eastern Palouse region, Idaho. *Hydrological Processes* 21:110-122.

Brown, R.A., P.A. McDaniel, and P.E. Gessler. 2012. Terrain attribute modeling of volcanic ash distributions in northern Idaho. *Soil Sci. Soc. Am. J.* 76: 179-187.

Kemp, R.A., P.A. McDaniel, and A.J. Busacca. 1998. Genesis and relationship of macromorphology and micromorphology to contemporary hydrological conditions of a welded Argixeroll from the Palouse in Idaho. *Geoderma* 83: 309-329.

Kimsey, M.J., J. Moore, and P.A. McDaniel. 2008. A geographically weighted regression analysis of Douglas-fir site index in north central Idaho. *Forest Science* 54: 356-366.

McDaniel, P.A., and A.L. Falen. 1994. Temporal and spatial patterns of episaturation in a Fragixeralf landscape. *Soil Sci. Soc. Am. J.* 58: 1451-1456.

McDaniel, P.A., R.W. Gabehart, A.L. Falen, J.E. Hammel, and R.J. Reuter. 2001. Perched water tables in Argixerolls and Fragixeralfs. Soil Sci. Soc. Am. J. 64: 805-810.

McDaniel. P.A., M.A. Wilson, R. Burt, D. Lammers, T.D. Thorson, C.L. McGrath, and N. Peterson. 2005. Andic soils of the Inland Pacific Northwest, USA: Properties and ecological significance. *Soil Science* 170: 300-311.

McDaniel, P.A., M.P. Regan, E. Brooks, J. Boll, S. Barndt, A. Falen, S.K. Young, and J.E. Hammel. 2008. Linking fragipans, perched water tables, and catchment-scale hydrological processes. *Catena* 73: 166-173.

McDaniel, P.A., and K.W. Hipple. 2010. Mineralogy of loess and volcanic ash mantles in Pacific Northwest (USA) landscapes. *Geoderma* 154: 438-446.

McDaniel, P.A., R.G. Darmody, J.C. Bell, and D.G. McGahan. 2011. Mollisols. pp. 33:97–113 *In* P.M. Huang, Y. Li, and M.E. Sumner (Eds.) *Handbook of Soil Science*. 2nd ed. CRC Press, Boca Raton, FL

Murray, J., A.T. O'Geen, and P.A. McDaniel. 2003. Development of a GIS database for groundwater recharge assessment of the Palouse Basin. *Soil Science* 168: 759-768.

O'Geen, A.T., P.A. McDaniel, J. Boll, and C.K. Keller. 2005. Paleosols as deep regolith: Implications for ground-water recharge across a loessial climosequence. *Geoderma* 126: 85-99.

Reuter, R.J., P.A. McDaniel, J.E. Hammel, and A.L. Falen. 1998. Solute transport in seasonal perched water tables in loess-derived soilscapes. *Soil Sci. Soc. Am. J.* 63: 977-983.

Rockefeller, S.L., P.A. McDaniel, and A.L. Falen. 2003. Perched water table responses to forest clearing in northern Idaho. *Soil Sci. Soc. Am. J.* 67: 168-174

Wilson, M.A., S.H. Bare, and P.A. McDaniel. 2006. Southwick soil of the Idaho Palouse. *Soil Surv. Horiz.* 47: 3-4.

Zdanowicz, C.M., Zielinski, G.A. and Germani, M.S., 1999. Mount Mazama eruption: Calendrical age verified and atmospheric impact assessed. *Geology* 27: 621-624.