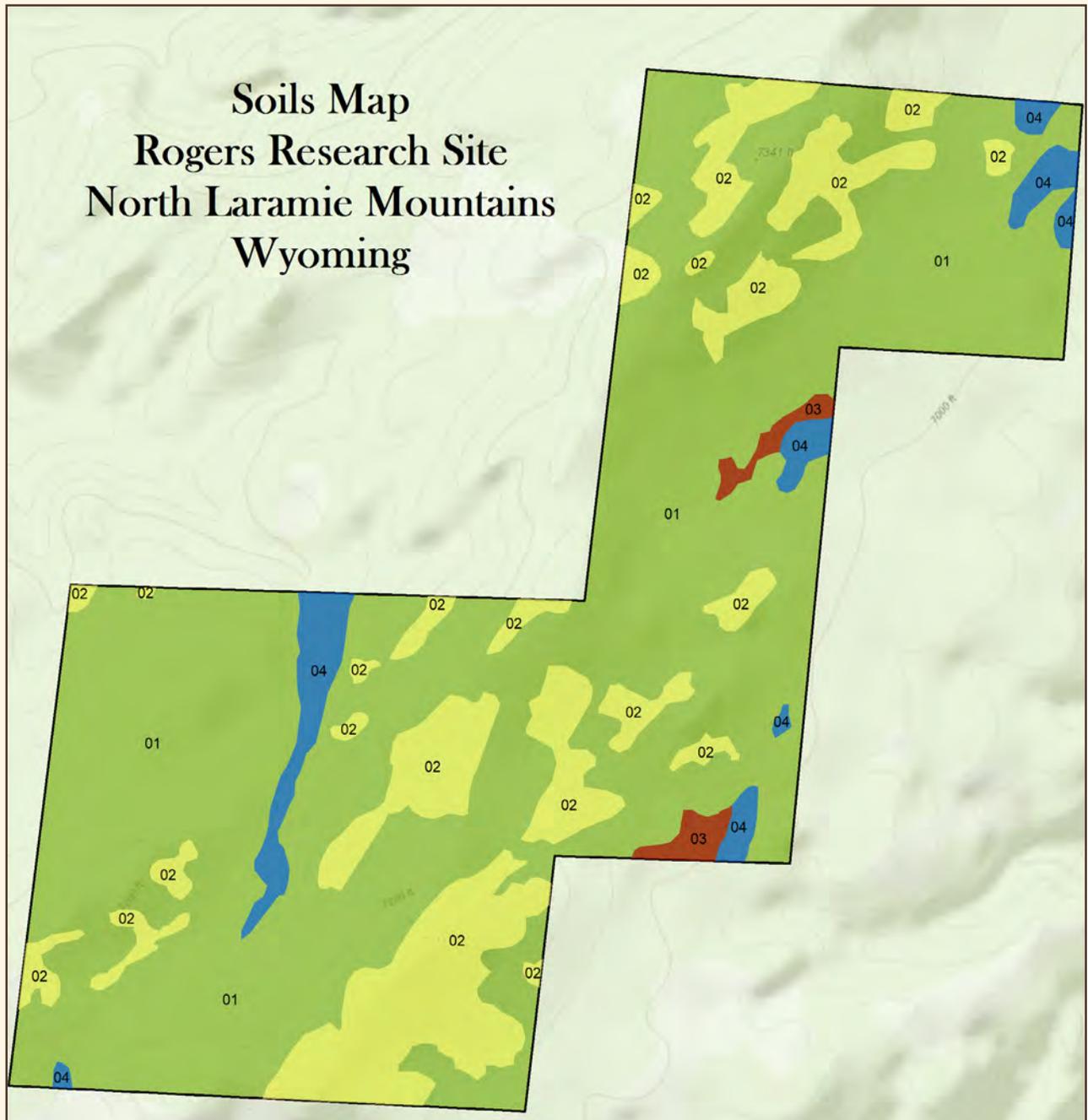


Soils of the UW Rogers Research Site

NORTH LARAMIE MOUNTAINS, WYOMING

By Larry C. Munn, Stephen E. Williams, Michael A. Urynowicz, and Robert W. Waggener



ROGERS RESEARCH SITE BULLETIN 6: Soils of the University of Wyoming's Rogers Research Site, north Laramie Mountains, Wyoming

By Larry C. Munn, Stephen E. Williams, Michael A. Urynowicz, and Robert W. Waggener

Layout and design by Tanya Engel

University of Wyoming College of Agriculture and Natural Resources

Wyoming Agricultural Experiment Station

This is Bulletin 6 in an ongoing series focusing on research, teaching, extension, and other activities at the University of Wyoming's Rogers Research Site (RRS) in the Laramie Mountains, north Albany County, Wyoming. The approximate 320-acre site was bequeathed to UW in 2002 by Colonel William Catesby Rogers.

Colonel Rogers spent much of his retirement time at the mountainous, remote property, which he called the Triple R Ranch. UW renamed the property "Rogers Research Site" in memory of Colonel Rogers, who passed away in 2003 at age 96.

The February 16, 2002, amended living trust of Colonel Rogers states that:

said ranch be used for the public benefit as a center for studies, a retreat for conducting meetings, conducting conferences, or conducting research in connection with the improvement of wildlife and forestry, or to hold as a natural wooded area in its original state with specific instructions that no part of it be subdivided or sold for residential or private business purposes but held as an entire tract. Said restriction is to continue in perpetuity. If violated, said property shall revert to the ownership of the U.S. Forest Service.

Overseeing management of RRS is the Wyoming Agricultural Experiment Station (WAES), UW College of Agriculture and Natural Resources. RRS is placed administratively under one of the WAES research and extension centers, the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle, Wyoming.

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ON THE COVER

General soils map of the Rogers Research Site, showing the boundaries of the Alderon (01), Cathedral (02), Dalecreek (03), and Kovich (04) series. (Soils mapping by lead author Larry Munn; digital GIS and cartography work by Shawn Lanning, Wyoming Geographic Information Science Center [WyGIS]; base map from Esri World Topographic Map).

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ABOUT THE AUTHORS

LARRY C. MUNN

Lead author Larry Munn is a professor emeritus of soil science in the University of Wyoming's Department of Ecosystem Science and Management. He started as an



assistant professor at UW in 1981, and was promoted to associate professor in 1986 and professor in 1992. Munn conducted his soils studies at the Rogers Research Site (RRS) from 2009 through 2014, both before and after the high-intensity Arapaho Fire. Since retiring in 2014, he completed his writing and mapping work for this bulletin. He is among the more than 40 UW faculty members and students who have been directly or indirectly involved in a variety of soils- and forestry-related studies at RRS. He says the site has good potential for additional research, and encourages both graduate and undergraduate students to develop and carry out studies with their faculty mentors. "I believe there are many opportunities up there, for example a soil genesis project and the post-fire restoration of organic matter in the forest soils over time," Munn says.

While at UW, Munn focused his research across Wyoming on soil genesis, morphology, and classification; soil-native plant community relationships; mine land reclamation; and the effects of coal-bed methane development on soils and landscapes. Munn also taught a number of undergraduate and graduate classes at UW, including "Introduction to Soil Science" and "Genesis, Morphology, and Classification of Soils." Additionally, he led a number of special-topic courses focused on the research of soil-geology-plant relationships in

native, agricultural, and drastically disturbed ecosystems. He received the John P. Ellbogen Meritorious Classroom Teaching Award in 1993 and was named the UW College of Agriculture's¹ "Outstanding Teacher" in 1999.

Munn earned a B.S. in agronomy (emphasis on soils) in 1972 from The Ohio State University, an M.S. in natural resources (forest soils) from OSU in 1974, and a Ph.D. in crop and soil science (range soils) from Montana State University in 1977. After joining the faculty at UW, Munn served on the western regional coordinating committee of the National Cooperative Soil Survey (NCSS), including two years as committee chair; the soil taxonomy and soil interpretations committees of the NCSS; and the soils and geomorphology committee of the American Society of Agronomy.

Munn is a member of the Board of Supervisors of the Laramie Rivers Conservation District, one of 34 conservation districts across Wyoming. In his volunteer work with LRCD, Munn believes that the district plays an important education role in Albany County when it comes to helping landowners conserve natural resources. Additionally, he says, "It is vital to assist youths and young adults with agriculture production and living on small-acreage plots within the county."

STEPHEN E. WILLIAMS

Professor Emeritus Steve Williams oriented his teaching and research career at the University of Wyoming toward soil microbiology, forest and range



¹ In 2009, the UW Board of Trustees approved renaming the college the College of Agriculture and Natural Resources.

soils, and soil chemistry/biochemistry so he felt right at home when digging his first soil pit at the mountainous Rogers Research Site.

“Late in my career at UW, I started work at the RRS, a new site slated for forestry- and wildlife-related research in the Laramie Peak area of southeast Wyoming. The ecosystems at RRS have taught me much, but I am cowed in the face of what we do not know.”

Williams has been intimately involved with the early research at RRS, including the post-fire ponderosa pine restoration project that was detailed in Bulletin 5, as well as soils-related studies contained in this bulletin and two upcoming bulletins that are nearing completion.

Williams earned a B.S. in biology at New Mexico State University (1970), an M.S. in agronomy from NMSU (1972), and a Ph.D. in soil science from North Carolina State University (1977).

His career at UW spanned from 1976 through 2013, and since retiring he and his wife, UW Professor Emeritus Karen Cachevki Williams, have operated an environmental and educational consulting business.

MICHAEL A. URYNOWICZ

Michael Urynowicz is a professor of environmental engineering in the University of Wyoming's Department of Civil and Architectural Engineering. He joined the faculty at UW in 2002 as an assistant professor, and was promoted to associate professor in 2008 and full professor in 2014. He has authored or co-authored more than 35 journal articles, books, and book chapters, and he holds three patents.



Michael Urynowicz enjoys a trekking adventure to the Annapurna Himalayas of north-central Nepal in 2006. The prominent mountain in the background is Machhapuchhre, elevation 22,943 ft (6,993 m). Also spelled Machapuchare, the mountain is considered sacred and is closed to climbers.

Urynowicz directs the Center for Biogenic Natural Gas Research within the UW School of Energy Resources. The center develops and commercializes technologies that enhance the production of renewable, clean burning natural gas in coal seams and other fossil fuel reservoirs using indigenous microorganisms.

He earned a B.S. in chemical engineering at Michigan State University in 1990, an M.S. in civil and environmental engineering at the University of Wisconsin in 1995, and master's and doctorate degrees in environmental science and engineering at the Colorado School of Mines in 1998 and 2000.

His principal areas of teaching and research are chemical oxidation processes for the degradation of chlorinated solvents; in situ remediation of contaminated soil and ground water systems; stabilization of metals through redox technologies; onsite and alternative wastewater treatment systems; carbon sequestration within coal formations; and mitigation of coal bed methane produced water; among others.

ROBERT W. WAGGENER

Wyoming native Robert Waggener has spent four-plus decades exploring Wyoming's mountain ranges, from the Wind River, Wyoming and Absaroka ranges in western Wyoming, to the Bighorn Mountains in the north-central part of the state, to the Medicine Bow and Laramie mountains in southeast Wyoming. During trips to the Laramie Peak area of the north Laramie Mountains, he was awed by the rugged beauty—a mix of towering ponderosa pines and massive granite boulders. It was this same beauty, along with the isolation, that drew Colonel William C. Rogers to Wyoming, where he found that perfect place to retire just a short distance from that prominent peak that Waggener and his brother, John, would hike up years later.

When Waggener was hired by the Wyoming Agricultural Experiment Station to coordinate the Rogers Research Site bulletin series, it was a project that would blend his personal interests in the state's great outdoors,

wildlife, and plants along with his professional career as a writer, photographer, and editor, work that now focuses on agriculture and natural resources in Wyoming and the West. When Waggener began working with others on the RRS project, he faced one recurring question: “Who is Colonel William C. Rogers?” People knew that he donated his mountainous land near Laramie Peak to the University of Wyoming, but beyond that he was a mystery. Since these bulletins are not only for a scientific community, but a general audience, too, Waggener felt compelled to answer the question he began facing at every turn in the project. “Who is Colonel Rogers?” Since this fell outside of the scope of his work directly tied to the Rogers Research Site bulletin series, he voluntarily spent many, many hours tracking down and then interviewing people who knew The Colonel. Their stories of this most fascinating, remarkable man have provided an introduction to each bulletin, and it’s Waggener’s hope that readers are not only finding these stories



Robert Waggener on top of Laramie Peak (10,272 ft [3,131 m]) in southeast Wyoming’s north Laramie Mountains. He and his brother, John, hiked up Laramie Peak in 2001, accessing the mountain from the west side at Friend Creek. Rogers Research Site is approximately 5 mi (8 km) southeast of the peak.

interesting and educational, but that they also bring a personal side to the land he donated to UW. “I have had the opportunity to read the will of Colonel Rogers, and it was obvious he believed in the education of young people,” Waggener notes. “The Colonel would be proud knowing that undergraduate and graduate students, working with their faculty mentors and others, are now hiking across that very land, conducting studies that are furthering their educations while bolstering our knowledge base about forest ecosystems and their importance to our state and beyond.”

STANDING ON THE COLONEL'S SHOULDERS

Colonel Rogers turned cow patties into compost for his garden in the mountains

By Robert W. Waggener

*“The fairest thing in nature, a flower,
still has its roots in earth and manure.”*

Decorated Army officer William Catesby Rogers loved reading plays, poetry, and prose by authors like D. H. Lawrence, who penned that famous quote. He relished walking through the ponderosa pine forests and meadows covered with wildflowers growing in the rocky soils (Fig. 1). And he enjoyed laboring on his retirement property in Wyoming’s rugged environment, where he worked on rustic cabins (Fig. 2), chopped firewood, and collected cow manure for his vegetable garden and strawberry patch. The north Laramie Mountains is a tough place to grow plants—high elevation, a fleeting growing season, and rocky soils lacking organic matter. And Rogers, like Lawrence, knew that the roots would require a little attention, that the hard soil would need softening so they could breathe.

“Even though the property is at 7,100 feet and the growing season is short, Bill and his hired hand, Jim O’Brien, had a very nice vegetable garden,” recalls Colleen Hogan, who spent many summer days on

The Colonel’s hilly property with her mother, Levida Hileman. “They grew onions, garlic, green beans, sweet peas, tomatoes, kale, and lettuce. They also grew strawberries. For every strawberry we picked, Bill told us that we would have to pull two weeds. I remember pulling a lot of weeds,” adds Colleen, laughing. “The Colonel didn’t police us, but he made it known that pulling weeds was a requirement for eating strawberries and staying on his land.”

The Colonel scoured his land for cow patties, collected sawdust from the portable mill on his property, and drove up and down the alleys of nearby Wheatland, Wyoming, for bags of green grass and dried leaves, knowing that mixing these ingredients together with a little water would result in rich, dark compost—and bigger, better, more plentiful strawberries. This eccentric millionaire could have hired someone to haul dump truck loads of commercially made compost to his 320-acre Triple R Ranch, but instead he made it himself. And that started with understanding the principles behind compost, like getting the carbon-to-nitrogen ratio right, which meant mixing a certain amount of carbon-rich dried

leaves and sawdust with a certain amount of nitrogen-rich cow manure and green grass. “The Colonel knew folks all over the world, and he wrote to monks in Tibet or somewhere to get their opinions on how to make good compost,” says Brock Hileman, who began visiting Colonel Rogers in the mid-1980s after meeting Levida and later marrying (Fig. 3). “He led a very simple life while living on the land up

Figure 1. A variety of wildflowers and grasses grow in the rocky soils at Rogers Research Site, named in memory of Colonel William C. Rogers. This photo was taken in June 2015, approximately three years after the Arapaho Fire burned across nearly 100,000 acres of the north Laramie Mountains, including RRS. (Photo by Mollie Herget)





Figure 2. Colonel William C. Rogers, along with his hired hand, friends, and guests, stayed in rustic cabins, including ones that took a bit of labor to make them inhabitable, including this one, informally known as the ‘North House.’ (Photo by Colleen Hogan)

there despite having lots of money. Someone would pay him a fee to let them graze cattle, and those cattle would leave their big messes around. Then The Colonel would go pick them up.”

Brock and Levida share a laugh as the compost story continues. “Oh, yes, he would push his wheelbarrow around the property,

wearing old baggy boxer shorts but no shirt,” Levida recalls. “He would collect all the cow patties and put them in this old wheelbarrow (Fig. 4). You can imagine what he looked like. He was in his 70s, pretty skinny, walking around without a shirt. The Colonel could get away with it because he was so unique, so different.”



Figure 3. Colonel Rogers, left, enjoys a quiet afternoon visiting with friends Levida and Brock Hileman, along with Colleen Hogan (the picture taker), on his property in the north Laramie Mountains. This photo (from RRS Bulletin 1) was taken in the mid- to late-1980s. At the time, Colonel Rogers would have been about 80 years old. (Photo by C. Hogan)



Figure 4. The high-intensity 2012 Arapaho Fire burned the majority of ponderosa pine across nearly 100,000 acres in the north Laramie Mountains, including both young and mature trees at the Rogers Research Site. It also destroyed a number of homes and outbuildings in the mountains, including nearly all of the structures at RRS. Near the center of this photo, just to the left of the small storage shed, is the old wheelbarrow that Colonel Rogers used to collect cow patties for his compost pile. This photo was taken in March 2013, approximately nine months after the fire. (Photo by Jim Freeburn)

Brock adds: “And eccentric, too. Maybe other people didn’t think so, but I sure thought he was eccentric.”

The folks down in Wheatland certainly saw the unconventional behavior of Colonel Rogers. After washing clothes at the local laundromat, he would spread them across the grass and on bushes at the Platte County Library, where he would spend time reading novels, poetry, plays, and how to make money investing in stocks. Or, if he needed materials for his compost pile, he would drive up and down the alleys picking up bags of yard waste and putting them in the back of his new Ford Bronco. “Yes, he was a very kind man, but he had a lot of eccentricities, including how he lived,” Colleen Hogan says. “He was a very proud man, a very intelligent man, but he was a hoot.”

“Memories and memories,” Levida quips. “Can I share one more story about this kind, generous, eccentric man?”

Her story starts not far from the compost heap, strawberry patch, and vegetable garden,

where Colonel Rogers would entertain his friends and guests late each afternoon after a day spent reading, writing letters, and working the land. Sometimes they would sit around the campfire drinking Hamm’s beer and eating salted peanuts, or they would sip on mixed drinks in his meager, one-room cabin. “Yes, The Colonel liked bourbon. When I first took Brock up there to meet him, we went to his cabin and The Colonel offered him a drink,” Levida remembers. “Brock said, ‘Bourbon and water would be good.’ Now, The Colonel’s first home up there burned down, so when he moved into this cabin, he always kept a large open bucket of water by his stove. Of course this had ashes, flies, and wood chips floating in it. Well, Brock was stunned when The Colonel dipped an old glass into the bucket, filled it half full with water, and then topped it off with bourbon. Brock drank it, but when The Colonel offered him a second glass, he politely declined.”

SOILS OF THE UNIVERSITY OF WYOMING'S ROGERS RESEARCH SITE, NORTH LARAMIE MOUNTAINS, WYOMING

By Larry C. Munn,¹⁻² Stephen E. Williams,³ Michael A. Urynowicz⁴, and Robert W. Waggener⁵

INTRODUCTION

When Colonel William C. Rogers bequeathed his “Triple R Ranch” to the University of Wyoming in 2002, he stated in his will that the 320-ac (129.5-ha) parcel of forested land in southeast Wyoming’s Laramie Mountains (Fig. 1) should be used, in part, for research relating to the improvement of forestry and wildlife resources (Rogers, 2002). One could argue that such research begins with the study of air, water, and soil—three natural resources that wildlife and forests depend upon. This bulletin focuses on soil as a natural resource, which includes the water that provides nutrients, the air that supplies oxygen, and heat through conduction. Understanding the ability and capacity of soil to support an ecosystem plays an important role in land-management decisions (U.S. Forest Service, 2017), including those involving both forestry and wildlife resources.

The Laramie Mountains are home to a rich array of resident and migratory wildlife species, which, in turn, depend on a great diversity of plants (more than 1,000 taxa

have been identified) and habitats, including floodplains, grasslands, shrub lands, riparian areas, forests (Fig. 1), boulder outcrops, and rocky summits (Packer, 2000; Williams and Waggener, 2017a). The diversity of both animal and plant species across the range is largely due to wide ranging climatic variation associated with elevation and soils. Concerning the latter, five of the 12 orders of soil taxonomy are found in the Laramie Mountains: Alfisols, Aridisols, Entisols, Inceptisols, and Mollisols (Young and Singleton, 1977; Packer, 2000). Soils of the range are mostly moderately deep on hillslopes and generally low-nutrient status, shallow, and erodible. Along the water courses, soils are generally much deeper with higher organic matter, and they often have buried horizons. Erosion events can alter these soils periodically during periods of high rainfall, especially post-fire (Reckner, 1998). And soils can also be altered—in some cases quite dramatically—by fire itself.

In 2012, the lightning-caused Arapaho Fire (Fig. 2) burned approximately

KEY WORDS

Alfisols, Entisols, fire, Inceptisols, Laramie Mountains, Mollisols, ponderosa pine (*Pinus ponderosa*), Rogers Research Site, soils, soil mapping, taxajunct, University of Wyoming, vegetation, wildlife, Wyoming Agricultural Experiment Station

1 For specific questions about this report (along with general questions about RRS research, information about access, driving directions to RRS, access to high-resolution digital copies of the bulletin, maps, etc.) please contact the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) at sarec@uwyo.edu; 307-837-2000; or 2753 State Highway 157, Lingle, WY 82223-8543.

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Figure 1. When Colonel William C. Rogers bequeathed his land in the north Laramie Mountains, southeast Wyoming, to the University of Wyoming in 2002, it was covered with dense and sparse stands of ponderosa pine (*Pinus ponderosa*) in various age classifications, along with grassy meadows and other habitat types. As discussed later in the paper, the Alderon soil has historically occurred on ponderosa pine-covered slopes like this, and it is by far the dominant soil at RRS. The photo (from Waggener, 2017) was taken in 2010, two years before the high-intensity Arapaho Fire burned across RRS and surrounding lands. (Photo by Steve Williams)



Figure 2. The 2012 lightning-caused Arapaho Fire burned about 98,000 ac (~39,700 ha) in the Laramie Mountains near Laramie Peak in southeast Wyoming. It consumed approximately 95% of the ponderosa pine forest at RRS. This photo was taken on June 20, 10 days after the fire started. (Photo by Josh McGee)

98,000 ac (~39,700 ha) in the Laramie Mountains (InciWeb, 2012), including the Triple R Ranch, which UW officially named the Rogers Research Site (RRS) in memory of Colonel Rogers. This high-intensity fire, which occurred during a severe drought, reached temperatures upwards of 900°F (500°C), killing the majority of ponderosa pine (*Pinus ponderosa*) and other vegetation throughout the area (Fig. 3; National Drought Mitigation Center et al., 2017; Williams and Waggener, 2017a). Fortunately, researchers had already gathered a great deal of baseline data at RRS, including detailed mapping of vegetation (Seymour et al., 2017) and soils (Fig. 4; discussed below and in upcoming bulletins).

STUDY AREA

RRS is located on the eastern flank of the Laramie Mountains approximately 25 mi (40 km) northwest of Wheatland, Wyoming, and ~5 mi (8 km) southeast of the prominent Laramie Peak, the highest point in the range at 10,272 ft (3,131 m) (Fig. 5; Williams and Waggener, 2017a). The site is managed by the Wyoming Agricultural Experiment Station and one of its Research and Extension centers, the James C. Hageman Sustainable Agriculture R&E Center near Lingle, Wyoming.

TOPOGRAPHY

RRS has an average elevation of ~7,000 ft (2,100 m), with elevations ranging from about 6,700 to 7,300 ft (~2,000–2,200 m). Habitats include (1) riparian areas (there are approximately five springs on the property) that support stands of quaking aspen (*Populus tremuloides* [Fig. 4]); (2) grassy and forb-covered meadows, with noxious weeds present in some areas; (3) gentle to steep slopes covered with ponderosa pine (*P. ponderosa*) of various age classes (Figs. 1, 6 [most of the pine would die during the 2012 Arapaho Fire]); and (4) rocky outcrops (Fig. 6).

CLIMATE

The climate in the Laramie Mountains, including RRS, is semiarid with snowfall during at least half the year. Official National Weather Service data recorded at sites approximately 5 mi (8 km) southwest of RRS by rancher George Portwood indicate that the area received an average of 15.20 in (38.61 cm) of precipitation (rain and melted snow) per year from 1974 through 2015, while total snowfall averaged 83.23 in (211.40 cm) (Williams and Waggener, 2017b). These amounts are nearly double that of 2012, the year of the Arapaho Fire, when total precipitation measured 8.28 in (21.03 cm), and total snowfall was 47.50 in (120.65 cm) (G. Portwood, personal communication, 2017). The variations in temperature are also different (Table 1).

Table 1. Temperatures at Rogers Research Site, including the year of the Arapaho Fire (2012), and the average from 1974 through 2015.

	Year 2012	42-Yr Avg.
Average High (°F)	67.71	73.81
Average Low (°F)	34.63	10.72
Mean Temp (°F)	51.17	42.27

VEGETATION

Prior to the Arapaho Fire, RRS was predominately a ponderosa pine forest, with trees in various age classes covering approximately 80% of the land (Figs. 1, 6). The remainder of the site was mixed grass, forb, and shrub lands (10%), quaking aspen (4% [Fig. 4]), and other features, including rock outcrops, bare ground, and a reservoir fed by springs and natural precipitation (6%) (Seymour et al., 2017).

WILDLIFE

A variety of resident and migratory wildlife inhabit the area, including several economically important species: Rocky Mountain elk (*Cervus canadensis nelsoni* [syn. *C. elaphus nelsoni*]), mule deer (*Odocoileus hemionus*), bighorn sheep (*Ovis canadensis*), and wild turkey (*Meleagris gallopavo*). The area is also home to at least one species that is listed as “threatened” under the federal Endangered

Figure 3. The high-intensity Arapaho Fire reached temperatures upwards of 900°F (500°C), killing the majority of ponderosa pine and other vegetation at RRS and surrounding lands. (Photo by Jim Freeburn)



Figure 4. University of Wyoming student Michael Curran excavates a soil pit in a quaking aspen stand at one of the research plots at RRS. This photo (from Williams and Waggener, 2017a) was taken June 22, 2012, during a project to map soils at various locations at RRS. Less than two weeks later, the Arapaho Fire swept across RRS property, burning the majority of the vegetation.

This changed much of the research to post-fire, but some of the earlier studies involving vegetation and soil mapping are providing UW faculty, staff, students, and others with important baseline data. (Photo by Claire Wilkin)



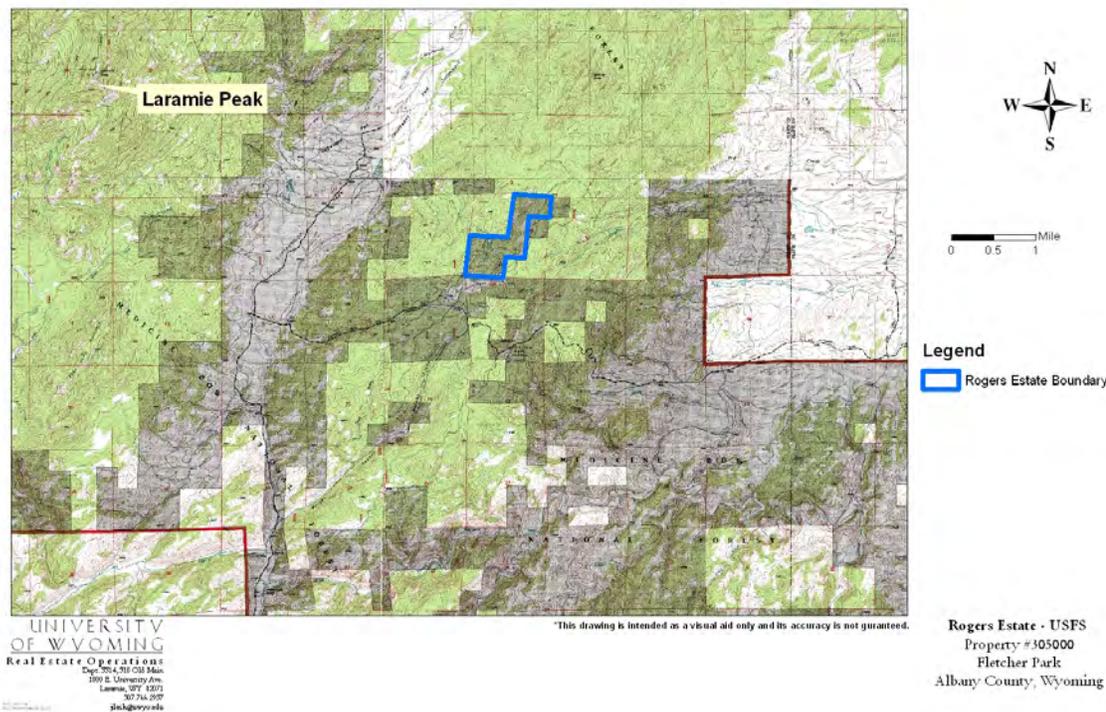


Figure 5. Location map (from Williams and Waggener, 2017a) showing the 320-ac (129-ha) Rogers Research Site (outlined in blue). The research site is approximately 5 mi (~8 km) southeast of Laramie Peak (10,272 ft [3,131 m]) in the northern reaches of the Laramie Mountains. Elevations at RRS range from about 6,700 to 7,300 ft (~2,042–2,225 m). The site is immediately surrounded by U.S. Forest Service (USFS) lands to the east, north, and west (light green) and state trust and private lands to the south (dark green). (Base map by USFS; RRS mapping by Josh Decker/UW Real Estate Operations)

Species Act, the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Williams and Waggener, 2017a).

SOILS

Research by authors L. C. Munn (Fig. 7) and S. E. Williams found that four of the 12 orders of soil are present at RRS: Alfisols, Entisols, Mollisols⁵, and Inceptisols, the latter of which were not mapped because of their small areal extent (see Appendix A for information about Inceptisols at RRS). Generally speaking (1) Alfisols result from weathering processes that leach clay minerals and other constituents out of the surface layer and into the subsoil, and form primarily under forest or mixed vegetative cover; (2) Entisols have little, if any, horizon development, and form in such locations as steep slopes; (3) Mollisols have a dark-colored surface horizon, are relatively high in organic matter, and characteristically form under grasslands; and (4) Inceptisols are the beginning of horizon development, and occur in a variety

of climates, including semiarid (U.S. Department of Agriculture, Natural Resources Conservation Service, 2017). Figure 8 illustrates a 'typical' soil profile. The four major horizons include: a shallow organic horizon at the surface (O); topsoil (A); subsoil (B); and the parent material for the soil, or substratum (C). Figure 9 shows a fairly well developed soil profile at RRS (from Williams and Waggener, 2017b). The O horizon is constituted almost entirely of organic debris and partially decomposed organic materials. It extends from the surface to about 4 cm (~1.5 in). The second interval—from ~4 to ~11 cm (~1.5–4.5 in)—is the A horizon, which contains minerals, but also considerable organic C. The third interval from the surface is the B horizon (in this case, a horizon of accumulated clay), and it extends from about 11 to 17 cm (~4.5–7 in). From 17 cm (7 in) and deeper (out of the photograph) is the C horizon; here, the parent material is a sandy substrate (Williams and Waggener, 2017b).

5 As discussed earlier in this bulletin, Aridisols, and perhaps others, are found elsewhere in the Laramie Mountains in addition to the four soil orders present at RRS.

Figure 6. Aerial image of RRS and surrounding lands taken in 2009, three years before the Arapaho Fire. It shows a variety of habitats, including dense and sparse stands of ponderosa pine on gentle to steep slopes, riparian areas, meadows, and rocky outcrops. (Aerial image from National Agriculture Imagery Program; RRS mapping by Zarifa Dushdurova, courtesy J. Decker, UW Real Estate Operations)



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ROGERS RESEARCH CENTER
ALBANY COUNTY, WY
NAIP 2009

This map is provided as a visual aid only and its accuracy is not guaranteed.
Dimensions and areas shown on this drawing were generated using digital data and do not reflect or include field survey data.
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Legend

 Rogers Research Site

SOILS OF THE ROGERS RESEARCH SITE

At the Rogers Research Site (RRS), soils on forested slopes are moderately developed Alfisols and shallow Entisols with low inherent fertility and low water-holding capacity due to coarse texture. They are developed from granitic substrate. Mollisols are found under herbaceous vegetation cover along streams and in areas of springs and under dense aspen stands. These soils are deeper, finer textured, and contain more organic matter.

RRS has (1) thin to moderately deep and coarse-textured soils, which support coniferous forests on hillsides and ridge tops; and (2) thick, dark, fine-textured soils in areas where the water table is high, which support herbaceous vegetation in meadows and riparian zones. The soils change character consistently at the boundary between the forest and meadows or riparian zones. More subtle change occurs at the shoulder of ridges within the forest, where soils become thinner on the ridges. Rock outcrops are common in the

RRS; in these areas, soils are very shallow and very low in organic matter. In the meadows, where the topography flattens along stream channels and the water table is closer to the surface, there are subtle changes in the soils, including textural (Fig. 10). Soils under the forest are light colored due to low organic matter contents and are acidic from the organic acids produced from the litter layer of conifer needles. The soils on the forest slopes are mostly “moderately deep” in soils terminology, 20 to 40 in (50 to 100 cm) thick. And, they have a layer of clay accumulation reflecting translocation from the surface mineral layer due to the acidity of the soil solution. Soils in the moist and wet meadows are dark colored because of below-ground organic matter accumulation and thick (50 in or more [100+ cm]) above the bedrock.

RRS SOILS DESCRIBED BY TWO SMUs

The soils of RRS are well described by two soil mapping units (SMUs) from the *Soil survey of Albany County area, Wyoming* (Reckner, 1998). The SMUs are 149, Dalecreek-Kovich



Figure 7. Lead author Larry Munn obtains Global Positioning System coordinates in 2012 at one of the sites in and adjacent to RRS where soils were sampled (the photo is from Waggener, 2017). This particular work was carried out shortly before the Arapaho Fire would burn across RRS and surrounding lands. (Photo by S. Williams)

Figure 8. A ‘typical’ soil profile showing the four major horizons: a shallow organic horizon at the surface (O); topsoil (A); subsoil (B); and the parent material for the soil, or substratum (C). (Illustration courtesy Natural Resources Conservation Service)

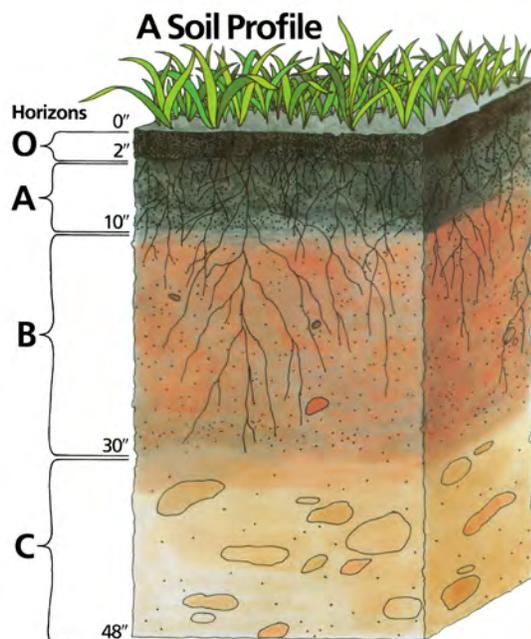


Figure 9. This photo shows a fairly well developed soil profile at RRS (from Williams and Waggener, 2017b). The O horizon is composed of organic debris and partially decomposed organic materials; it extends from the surface to about 4 cm (~1.5 in). The second interval, or A horizon, extends from 4 to 11 cm (~1.5–4.5 in); it contains minerals, but also considerable organic carbon. The third interval (B horizon) is a layer of accumulated clay extending from 11 to 17 cm (~4.5–7 in). From 17 cm (7 in) and deeper (out of the photograph) is the C horizon; here, the parent material is a sandy substrate. (Photo by S. Williams)



complex, 0 to 9% slopes; and 213, Cathedral-Alder complex, rock outcrops, 25 to 50% slopes. The representative soils for mapping units at RRS are classified as the following four series: Alderon (RRS-01), Cathedral (RRS-02), Dalecreek (RRS-03), and Kovich (RRS-04) (Fig. 11). Following are brief explanations (see Appendix A for detailed explanations; and please note that soil taxonomy has changed since publication of the *Soil survey of Albany County area, Wyoming*—the older classifications [from Reckner, 1998] are shown in parentheses before current terms [from Soil Survey Staff, 2014]):

1. Alderon (RRS-01): fine-loamy, mixed, superactive, frigid (subgroup: Typic Eutraboralfs; order Alfisols) Typic Haplustalfs moderately deep;
2. Cathedral (RRS-02): loamy-skeletal, mixed, micaceous, frigid (subgroup Lithic Haploborolls; order: Mollisols) Lithic Haplustolls shallow;
3. Dalecreek (RRS-03): fine-loamy, mixed, superactive, frigid (subgroup: Cumulic Haploborolls; order: Mollisols) Aquic Cumulic Haplustolls very deep;
4. Kovich (RRS-04): fine-loamy, mixed, superactive, frigid (subgroup: Cumulic Haplaquolls; order: Mollisols) Cumulic Endoaquolls very deep.

In the *Soil survey of Albany County area, Wyoming* (Reckner, 1998), the U.S. Department of Agriculture’s Natural Resources Conservation Service (NRCS) mapped 38,914 ac (15,747 ha) of SMU 213 (Cathedral-Alder), and 22,205 ac (8,986 ha) of SMU 149, Dalecreek-Kovich. We identified Entisols on the RRS as the Cathedral taxajunct. This is the shallow soil adjacent to rock outcrops under the conifers and is similar to the Cathedral Series mapped by NRCS during the Albany County soil survey except that it has lower organic matter content in the surface layer. Taxonomy for the Cathedral taxajunct is: loamy-skeletal, mixed, micaceous, frigid Lithic Ustorthents shallow (see Appendix A for detailed explanation).



Figure 10. This photo shows a soil profile under grasslands at RRS. (Photo by S. Williams)

WHY THESE SOILS?

For soil scientists an important question is: Why are “these” soils on “this” landscape, now? The early Russian soil scientist Vasily Dokuchaev (1883) stated in the late 19th century that soils were the result of five soil-forming factors: parent material, climate, biota, topography, and time. Although this often-referenced model is useful in thinking about soils on a landscape, it’s not as simple as it might seem. The complexity of this model lies in the interactions between the factors that commonly occur. For example, climate exerts a large influence on the biota (vegetation), which influences soil development through the types and amount of organic carbon added to the system, as well as protection from erosion provided by the plant canopy and root system. Both climate and vegetation may affect soil-forming over time. For instance, drought may shift vegetation from forest to grassland, or, from grassland to desert shrub land. Glaciation may allow a landscape to be scraped clean of soil by direct ice action during a glacial period, resetting the time for soil formation back to

zero. Segments not scoured by ice may be destabilized as a result of frequent freeze-thaw cycles and the action of frost. Or, if protected by forest and snow cover, they may retain pre-glacial soils throughout the glacial period. Even slopes that remain tree-covered with an insulating blanket of snow may undergo repeated mass wasting events. And, of course, forest fire also plays a critical role, offsetting the protection from erosion provided by living trees.

The soils of the RRS are also shaped by the interaction of the five soil forming factors. The geologic parent material at the site is primarily Precambrian granite, exposed by erosion after uplift of the region during the Laramide Orogeny (Snyder et al., 1995; Blackstone, 1996). The granite is very resistant to chemical weathering because of its chemical composition consisting of high silica content and, by default, lower concentrations of base cations calcium, magnesium, potassium, and sodium. It does, however, readily weather physically under the freeze-thaw cycles induced by the area’s climate, physically breaking up into particles of coarse sand and

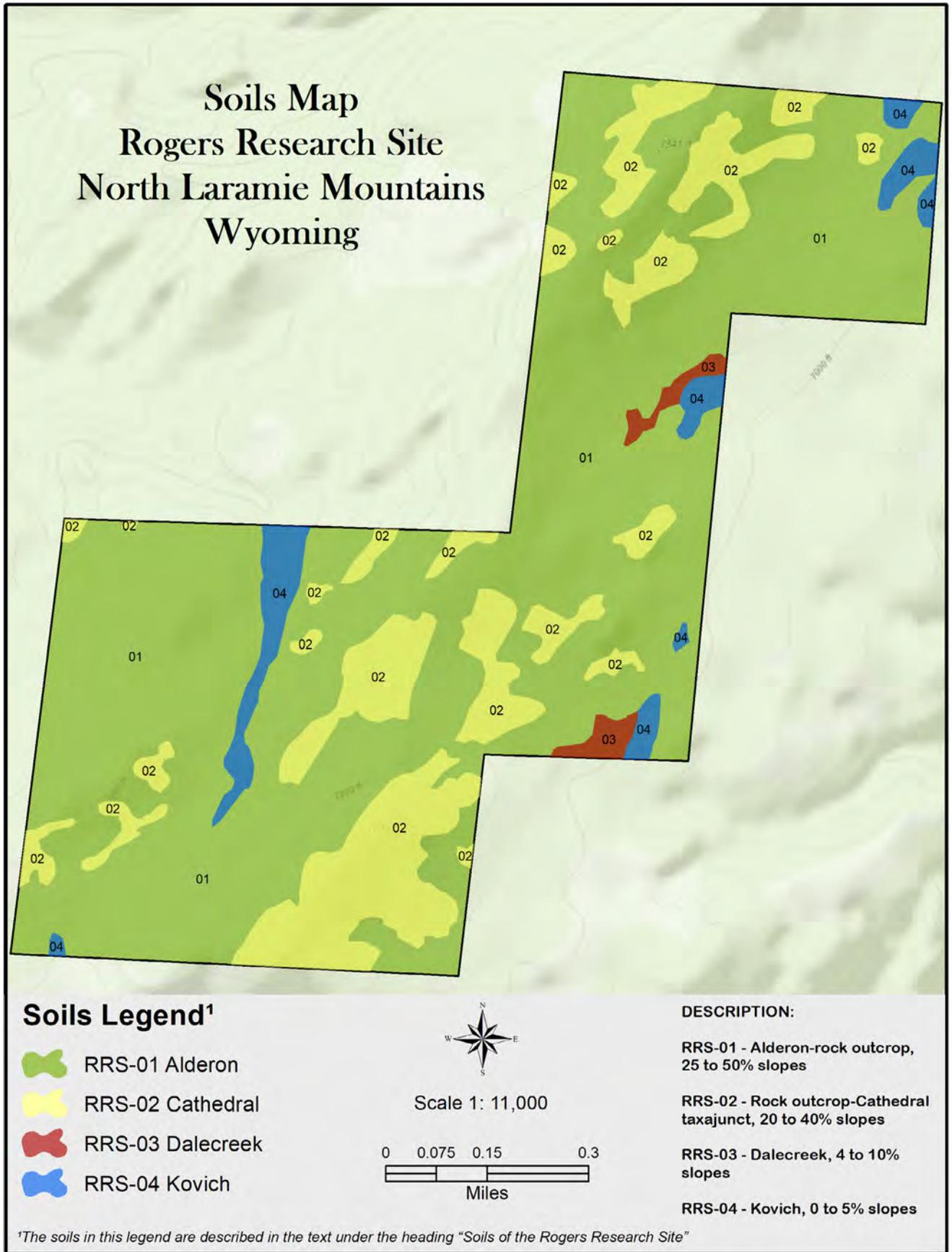


Figure 11. General soils map of the Rogers Research Site, showing the boundaries of the Alderon, Dalecreek, and Kovich soils, and the Cathedral taxajunct. (Soils mapping by lead author Larry Munn; digital GIS and cartography work by Shawn Lanning, Wyoming Geographic Information Science Center [WyGIS]; base map from Esri World Topographic Map)



Figure 12. Soils on forested slopes are prone to erosion following events like the 2012 Arapaho Fire. This photo was taken on July 18, 2012, approximately two weeks after the fire burned across RRS and surrounding lands. (Photo by S. Williams)

small gravel. The low clay content and coarse, gravelly texture make the resulting soils drought sensitive and erosive. The vegetation at the site provided inputs of organic material into the soil and erosion protection. This type of landscape, however, is also subject to periodic fires that expose the bare surface to erosion. This is particularly true in coniferous forests on hillsides (Fig. 12), where the direct movement and re-deposition of fine particles to low landscape positions occurs, including foot-slopes (the lower slopes of hillsides) as well as banks along streams.

Because of the erosive nature of the landscape, soils on the upland hillsides are moderately deep despite the fact that the area was not directly glaciated during the Pleistocene. The combination of an ustic soil moisture regime in the uplands and a frigid soil temperature regime presents a relatively harsh environment for plant growth and limits soil chemical weathering. The overall result is shallow and moderately deep, coarse-textured soils containing limited organic matter on

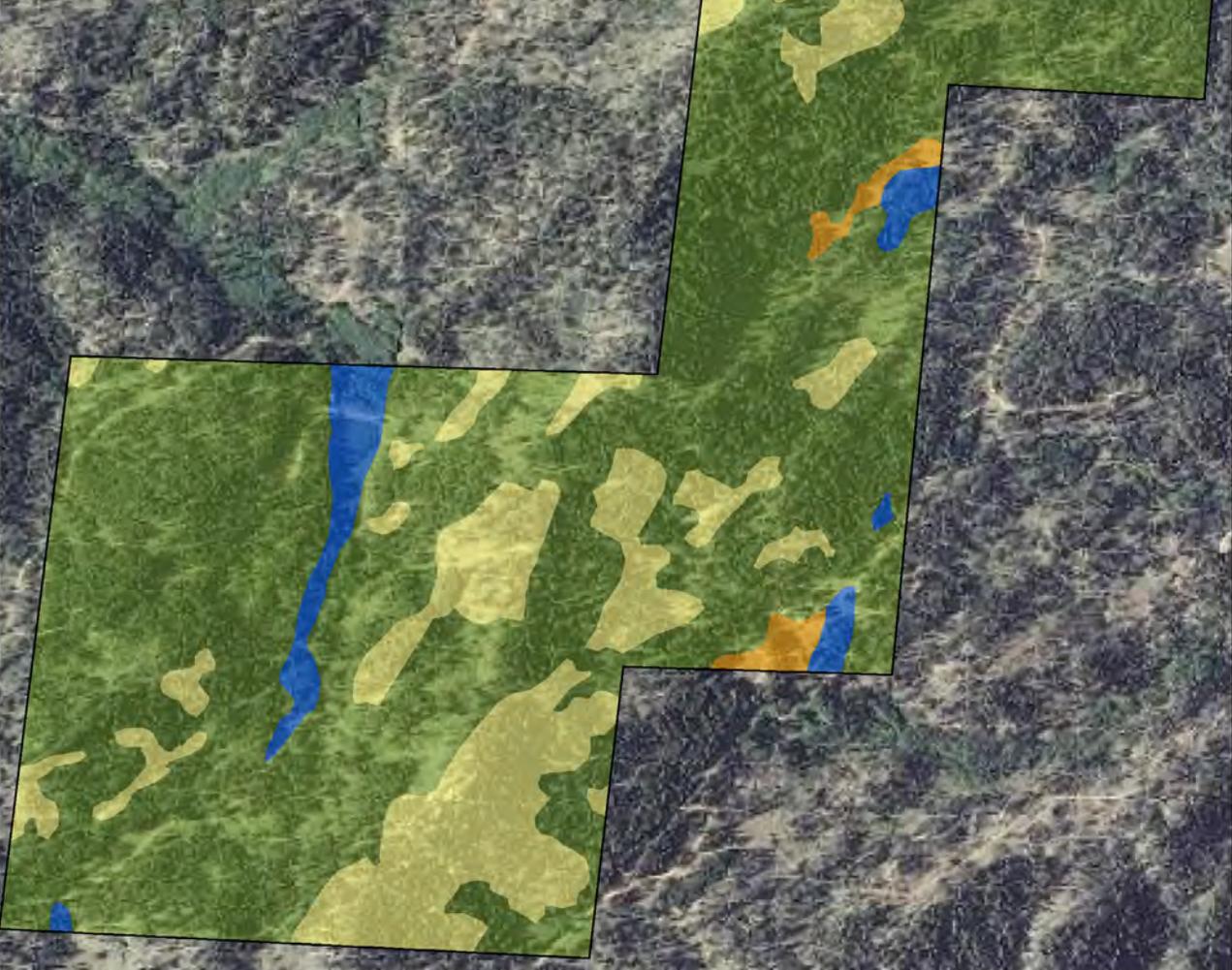
the steep slopes under coniferous forest and thicker, finer-textured soils with higher organic matter contents under herbaceous vegetation along the foot-slopes and stream channels. Aspen, a deciduous tree, occupies moist locations such as groundwater seeps and contributes significant leaf litter to the soil, which, in turn, further supports the growth of aspen (Fig. 4).

SOIL FORMATION BY SOIL SERIES

Alderon Series (RRS-01)

The Alderon soil occurs at RRS where ponderosa pine forest has historically occupied the steep, convex upper side slopes, which typically range from 25 to 50% (Figs. 1, 12–17). The pine forest contributes acid-forming litter to the surface and, prior to the 2012 Arapaho Fire, provided stability to the surface through canopy coverage and root mass (Fig. 18). The forest litter layer adds organic acids to the soil at the surface, which facilitates clay leaching into the subsoil,

Soils Map (Pre-Fire Imagery 2009)
 Rogers Research Site
 North Laramie Mountains
 Wyoming

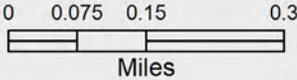


Soils Legend¹

-  RRS-01 Alderon
-  RRS-02 Cathedral
-  RRS-03 Dalecreek
-  RRS-04 Kovich



Scale 1: 11,000



- DESCRIPTION:**
- RRS-01 - Alderon-rock outcrop, 25 to 50% slopes**
 - RRS-02 - Rock outcrop-Cathedral taxajunct, 20 to 40% slopes**
 - RRS-03 - Dalecreek, 4 to 10% slopes**
 - RRS-04 - Kovich, 0 to 5% slopes**

¹The soils in this legend are described in the text under the heading "Soils of the Rogers Research Site"

Figure 13. General soils map of the Rogers Research Site, showing the boundaries of the Alderon, Dalecreek, and Kovich soils, and the Cathedral taxajunct. The backdrop aerial image was taken in 2009, three years before the Arapaho Fire. (Soils mapping by L. Munn; digital GIS and cartography work by S. Lanning/WyGIS; aerial base image from the National Agriculture Imagery Program; RRS boundary mapping by Z. Dushdurova, courtesy J. Decker, UW Real Estate Operations)

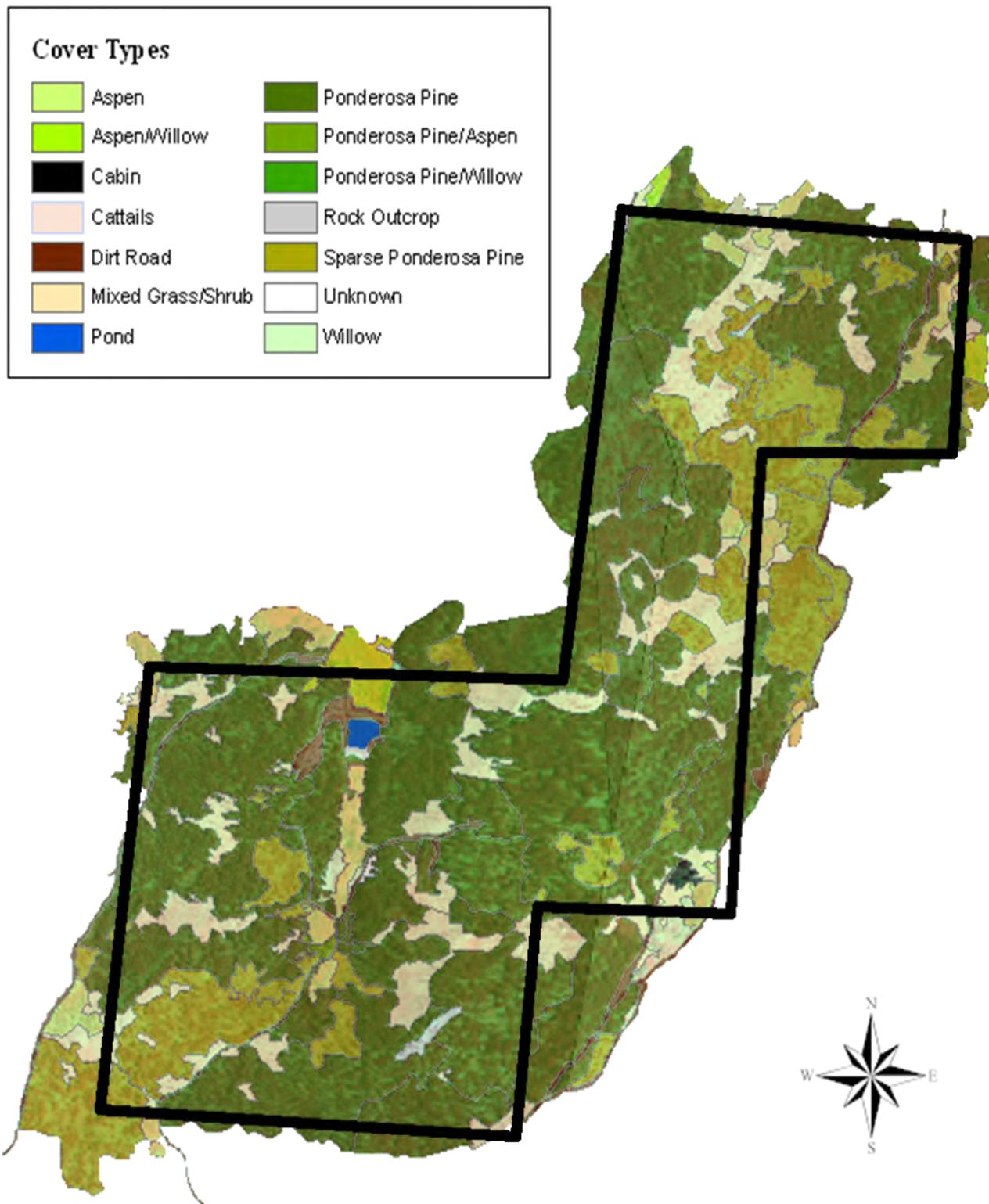


Figure 14. Vegetation map of the Rogers Research Site (from Seymour et al., 2017). The map was created in 2006, when RRS and surrounding lands were mostly forested with ponderosa pine. In 2012, the high-intensity Arapaho Fire burned across the area, consuming most of the vegetation. (Map by Mathew Seymour)

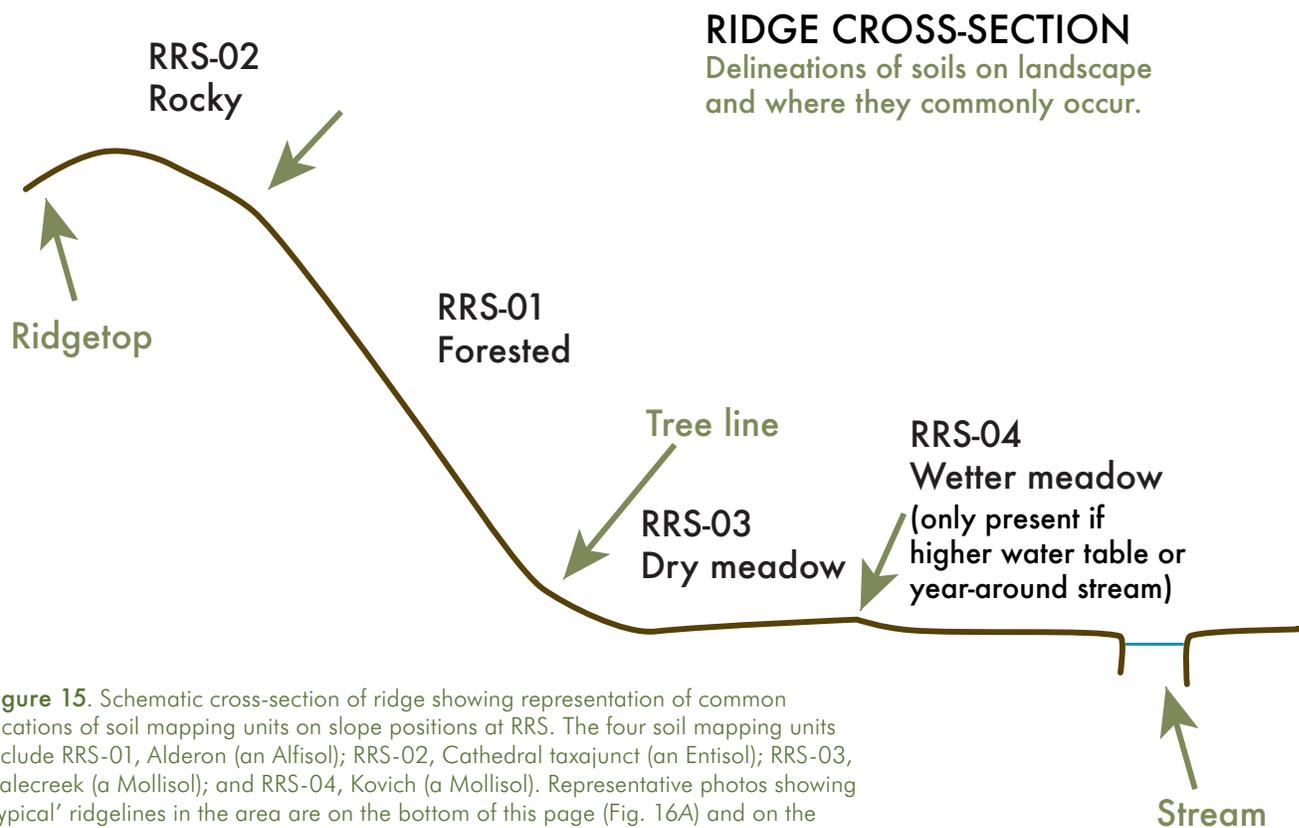


Figure 15. Schematic cross-section of ridge showing representation of common locations of soil mapping units on slope positions at RRS. The four soil mapping units include RRS-01, Alderon (an Alfisol); RRS-02, Cathedral taxajunct (an Entisol); RRS-03, Dalecreek (a Mollisol); and RRS-04, Kovich (a Mollisol). Representative photos showing ‘typical’ ridgelines in the area are on the bottom of this page (Fig. 16A) and on the next page (Fig. 16B). (Soil mapping by L. Munn; illustration by Tanya Engel)



Figure 16A. This photo is a good representation of the schematic cross-section in Figure 15. The dominant Alderon soil (RRS-01/ Alfisol) occurs at RRS where ponderosa pine forest historically occupied the steep, convex upper side slopes. The Cathedral taxajunct (RRS-02/Entisol) is shallow to bedrock and occurs intermixed among the bedrock outcrops and the deeper Alderon soils, usually on the upper portions of ridges. The Dalecreek soil (RRS-03/Mollisol) occurs on the concave slopes leading down to stream channels; this soil has a high water table within the profile, which drops during the growing season. The Kovich soil (RRS-04/Mollisol) is dominated by a high water table, organic matter buildup, and accumulation of fine particles (silt and clay) due to its position low in the landscape near springs and along streams. This photo was taken in July 2015, three years after the Arapaho Fire. (Photo by Michael Curran)



Figure 16B. This photo is a good representation of a major portion of the schematic cross-section of ridgeline shown in Figure 15. The dominant Alderon soil (RRS-01/ Alfisol) occurs at RRS where ponderosa pine forest historically occupied the steep, convex upper side slopes, which range from 25 to 50%. The Cathedral taxajunct (RRS-02/Entisol) is shallow to bedrock and occurs intermixed among the bedrock outcrops and the deeper Alderon soils, usually on the upper portions of ridges having slopes of 20 to 40%. The photo (from Williams and Waggener, 2017a) was taken in June 2007, five years before the Arapaho Fire. (Photo by S. Williams)



Figure 17. This photo shows Alderon soil on the slope across from the pond and a small area of Cathedral-rock outcrop. The image (from Seymour et al., 2017) was taken in the 1980s, when ponderosa pine in various age classes dominated the landscape. The small reservoir is fed by spring water and natural runoff. (Photo by Colleen Hogan)

and the soil profile shows a light-colored leached mineral layer over a reddish-brown subsoil layer where clay and iron oxides have accumulated. Historically, coniferous forests have been subject to wildfire on a more frequent basis than deciduous forests. After fire, surface protection is greatly reduced, and there is further loss of stability as the roots of the fire-killed trees begin to decay, usually in two to three years (Figs. 3, 12, 19). A combination of coarse-textured soils with low water-holding capacity and moderate clay content lowers water available to support tree biomass. This and the periodic times of low stability after fires results in the soils being only moderately deep to bedrock, approximately 50 to 100 cm (~20–40 in).

Figure 18. The Alderon soil (RRS-01/Alfisol) occurs where ponderosa pine trees historically occupied slopes at RRS. The trees contributed acid-forming litter to the surface and provided stability to the surface through canopy coverage and root mass. This photo was taken prior to the 2012 Arapaho Fire. (Photo by S. Williams)

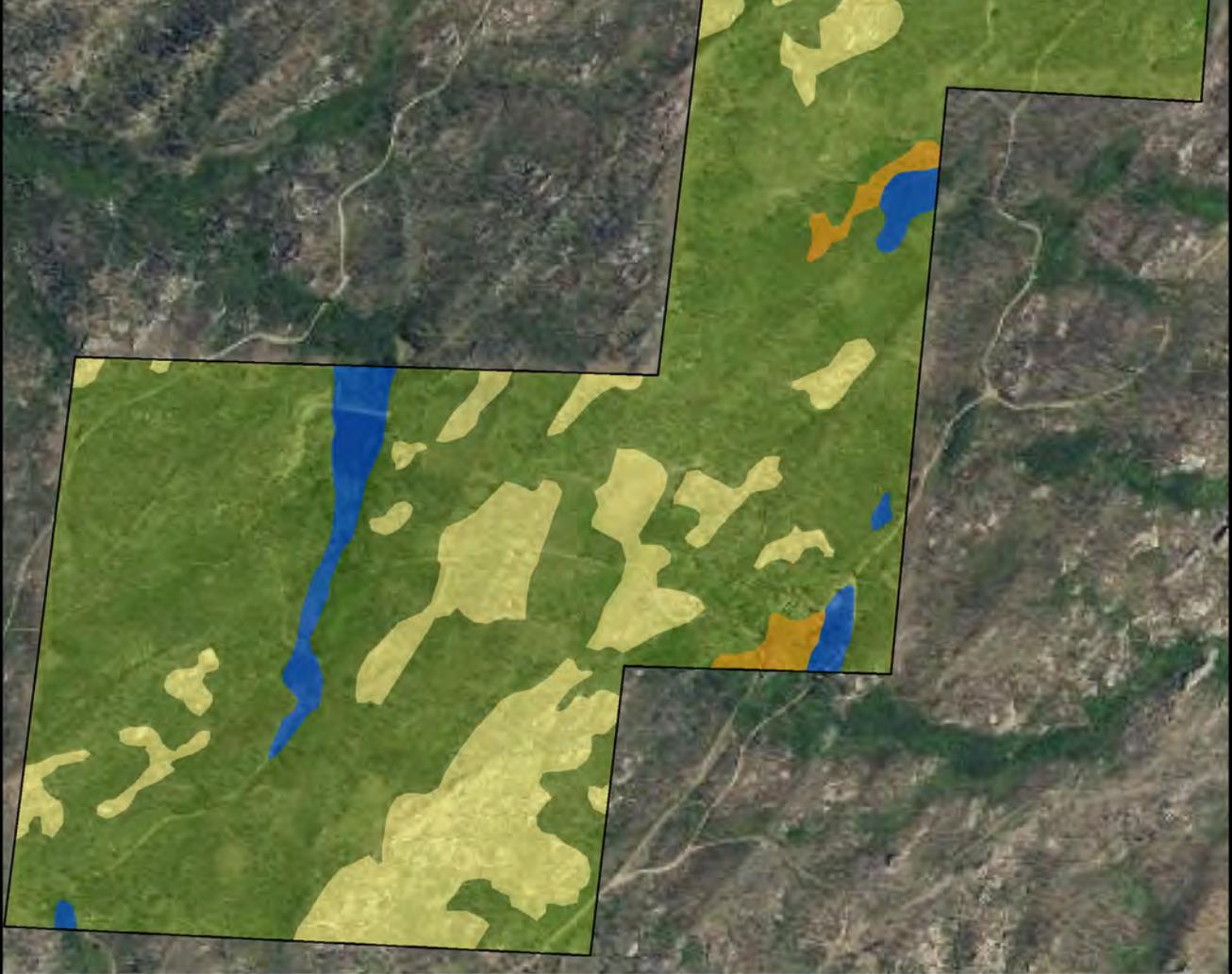
Cathedral Series (RRS-02)

The Cathedral soil is shallow to bedrock, less than 50 cm thick (<20 in). It occurs

intermixed among the bedrock outcrops and the deeper Alderon soils, usually on the upper portions of ridges having slopes of 20 to 40% (Figs. 13, 15–16, 19–20). The thinness of the soil is related to low weathering ability of the granite and erosiveness of the landscape after fire. These soils may not directly support trees because of their low water-holding capacity, instead supporting scattered herbaceous plants; and they are not as leached as the Alderon Series since they do not have the thick carpet of conifer needles that provide acidity to those soils. Because of lower acid loading and more persistent erosion, these soils do not have the clay accumulation in the subsoil that Alderon soils do and are generally coarser textured and rockier. The landscape positions where the NRCS mapped the **Cathedral Series (a Mollisol)** on large expanses of more open landscapes, under grassland vegetation, are occupied on the RRS by the



Soils Map (Post-Fire Imagery 2015)
 Rogers Research Site
 North Laramie Mountains
 Wyoming

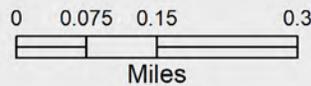


Soils Legend¹

-  RRS-01 Alderon
-  RRS-02 Cathedral
-  RRS-03 Dalecreek
-  RRS-04 Kovich



Scale 1: 11,000



DESCRIPTION:

- RRS-01 - Alderon-rock outcrop, 25 to 50% slopes**
- RRS-02 - Rock outcrop-Cathedral taxajunct, 20 to 40% slopes**
- RRS-03 - Dalecreek, 4 to 10% slopes**
- RRS-04 - Kovich, 0 to 5% slopes**

¹The soils in this legend are described in the text under the heading "Soils of the Rogers Research Site"

Figure 19. General soils map of the Rogers Research Site, showing the boundaries of the Alderon, Dalecreek, and Kovich soils, and the Cathedral taxajunct. The backdrop aerial image was taken in 2015, three years after the Arapaho Fire. (Soils mapping by L. Munn; digital GIS and cartography work by S. Lanning/WyGIS; aerial base image from the National Agriculture Imagery Program; RRS boundary mapping by Z. Dushdurova, courtesy J. Decker, UW Real Estate Operations)

Figure 20. The Cathedral taxajunct (RRS-02/Entisol) is shallow to bedrock, occurring intermixed among the bedrock outcrops (foreground) and the deeper Alderon soil (RRS-01/ Alfisol) at RRS, usually on the upper portions of ridges occupied by ponderosa pine (in this case, dead trees from the Arapaho Fire). The Dalecreek soil (RRS-03/Mollisol) occurs below the lower tree line, and the Kovich soil (RRS-04/Mollisol) occurs along the wettest areas in the drainage. This photo was taken in August 2017, five years after the Arapaho Fire. Pictured is undergraduate student Kristina Kline, who is among the many UW students who have assisted faculty and student researchers at RRS. (Photo by Linda van Diepen)



Figure 21. This photo shows Cathedral taxajunct (RRS-02/Entisol) in the foreground and Alderon (RRS-01/Alfisol) on the slope below. The image (from Williams and Waggener, 2017a) was taken in July 2015, three years after the high-intensity Arapaho Fire. In the background is the prominent Laramie Peak (10,272 ft [3,131 m]). (Photo by M. Curran)





Figure 22. This photo shows Alderon (RRS-01/ Alfisol) on the hillside, Dalecreek (RRS-03/Mollisol) as a strip at the base of the hill below the pine trees, and Kovich (RRS-04/ Mollisol) in the foreground. The image (from Herget et al., 2018) was taken on June 5, 2015, at a site near RRS. Among the plants in the photo is the moisture-loving Rocky Mountain iris (*Iris missouriensis*). (Photo by Mollie Herget)



Figure 23. The Dalecreek soil (RRS-03/Mollisol) occurs at RRS below the lower tree line of the coniferous forest on the concave slopes leading down to stream channels. The soil has a high water table within the profile, which drops during the growing season as the herbaceous vegetation transpires groundwater. Quaking aspen often occur in these moist habitats. This photo (from Williams and Waggner, 2017a) was taken in 2013, one year after the Arapaho Fire, and it shows good aspen regeneration. (Photo by S. Williams)

Figure 24. The Kovich soil (RRS-04/Mollisol) is dominated by a high water table, organic matter buildup, and accumulation of fine particles (silt and clay) due to its position low in the landscape near springs and along streams. This soil supports a variety of vegetation, including grasses, forbs, shrubs, and deciduous trees. Also visible in this photo, taken three years after the Arapaho Fire, is a dense patch of Canada thistle (*Cirsium arvense*), left center. (Photo by M. Herget)



Figure 25. This photo shows Kovich (RRS-04/Mollisol) in the drainage leading to the pond. Also present are Dalecreek (foreground), Alderon (the hillside with living and dead pine trees), and Cathedral-rock outcrop. The image (from Williams and Waggener, 2017a) was taken in July 2015, three years following the Arapaho Fire. In the background is Laramie Peak. (Photo by M. Curran)



Cathedral taxajunct (an Entisol) (Fig. 21).

The Cathedral taxajunct at RRS is an Entisol because of the lower organic matter content typical of coniferous forest soils.

Dalecreek Series (RRS-03)

The Dalecreek soil occurs below the lower tree line of the coniferous forest on the concave slopes (4 to 10%) leading down to the stream channels (Figs. 13, 15, 19, 22). The soil is very deep (greater than 1.5 m [4.9 ft]), and it has a high water table within the profile. The water table drops during the growing season as the herbaceous vegetation transpires groundwater. Depth to this saturated zone typically varies from 0.8 to 1.2 m (2.5–4 ft) over the summer. The Dalecreek Series has thick surface accumulation of mineral soil enriched in organic matter through both additions by plant roots and through erosion onto the site of surface soil materials from higher landscape positions. Aspen usually occur in these moist habitats (Figs. 4, 23).

Kovich Series (RRS-04)

The Kovich soil is dominated by a high water table, organic matter accumulation, and accumulation of fine particles (silt and clay) due to its position low in the landscape along streams and near springs (Figs. 13, 15, 19, 24–25). Slopes range from 0 to 5%. The water table persists at or near the surface throughout the growing season. This soil is thick, greater than 125 cm (>49 in), and it contains significant accumulation of organic matter, as evidenced by the plant material in Figures 24–25. The soil shows stratification with different layers varying in both color (due to organic matter content) and texture as material is added to the surface by water erosion from the surrounding uplands.

RRS SOILS COMPARED TO ADJACENT SOILS

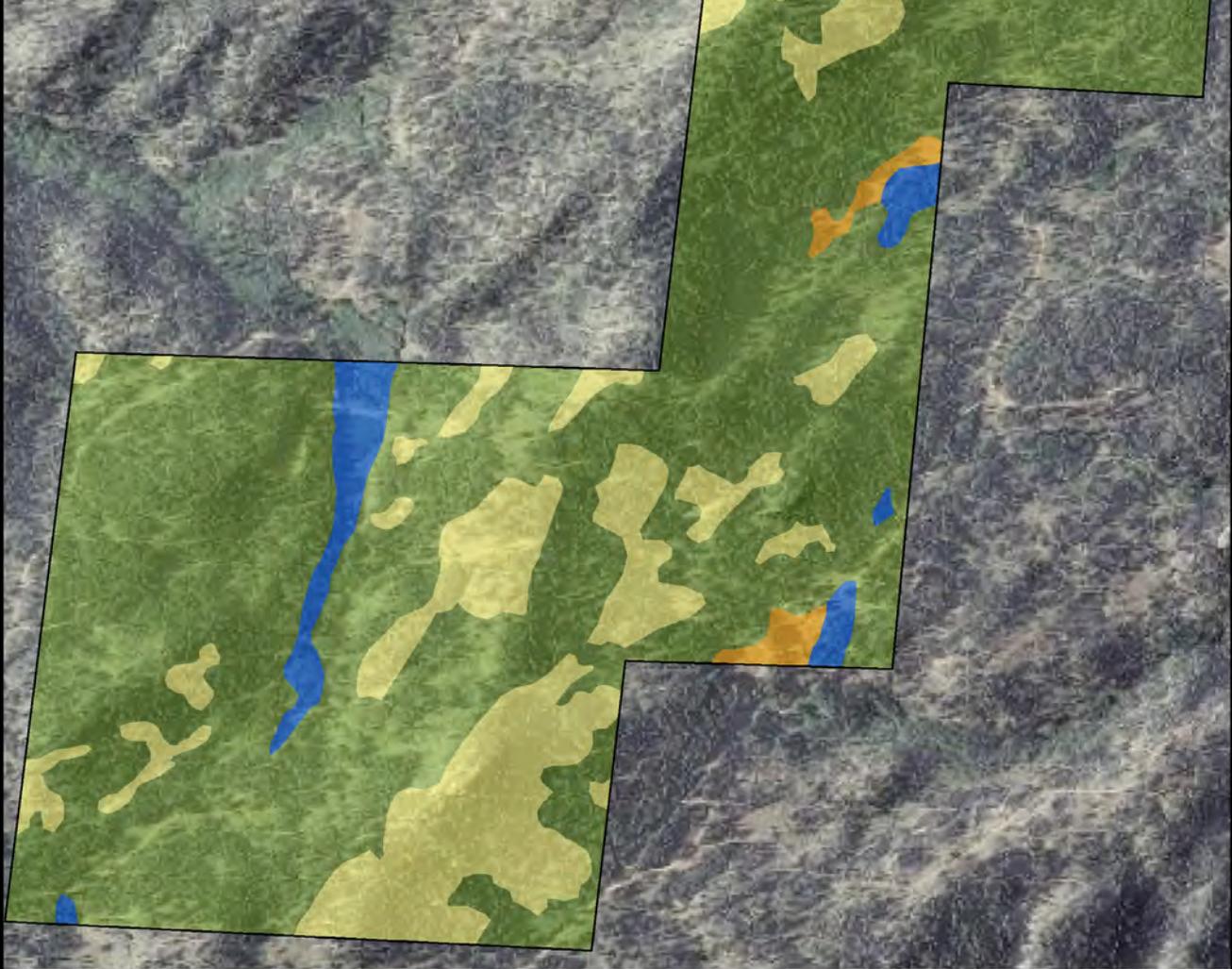
Areas adjacent to the RRS were mapped by the NRCS (Reckner, 1998) as SMUs 149 and 213. The more detailed mapping of the RRS resulted in replacement of the

Cathedral soil (a Mollisol) with the Cathedral taxajunct (an Entisol [Fig. 21]), which has low organic matter content as is characteristic of coniferous forest soils. Physical properties of the Cathedral Series (Reckner, 1998) and the Cathedral taxajunct (Fig. 21; this study) are essentially identical.

DISCUSSION AND CONCLUSIONS

A question that may occur to people viewing the pattern of vegetation at RRS is: Why are the trees confined to the drier, rocky slopes (Figs. 1, 12, 16–18, 20–22, 25–26) while the herbaceous vegetation occurs on the thicker, organic-matter-rich soils along the streams (Figs. 4, 22–26)? Trees, particularly conifers, have to maintain transpiration all year. So, why are they on the thinner, rocky soils with low water-holding capacity? The answer is that fractured bedrock and coarse-textured soils are conducive to woody plant survival because water infiltrates deeply during spring snowmelt and rains, and this water is available to the deep tree roots. The same amount of precipitation water does not penetrate nearly as deeply in the fine-textured, organic-matter-rich soils that support herbaceous vegetation along the springs and streams at RRS. The fibrous roots of the grasses compete with tree roots for the water, and the grasses and forbs can go dormant under late-season drought conditions and survive. After a fire (Figs. 27–28), the herbaceous vegetation will re-grow and provide intense competition to any tree seedlings that sprout from blown-in seed. On the hillsides, which were forested before the Arapaho Fire, the conifer seedlings land on bare mineral soil, and those that become established face no competition for water from the root systems of the herbaceous plant community. The net effect is that the trees typically come back where they were before the fire, and the herbaceous community re-establishes itself almost immediately. (The

Soils Map (Pre-Fire Imagery 2009)
 Rogers Research Site
 North Laramie Mountains
 Wyoming

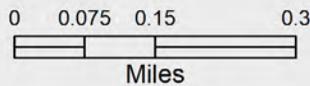


Soils Legend¹

-  RRS-01 Alderon
-  RRS-02 Cathedral
-  RRS-03 Dalecreek
-  RRS-04 Kovich



Scale 1: 11,000



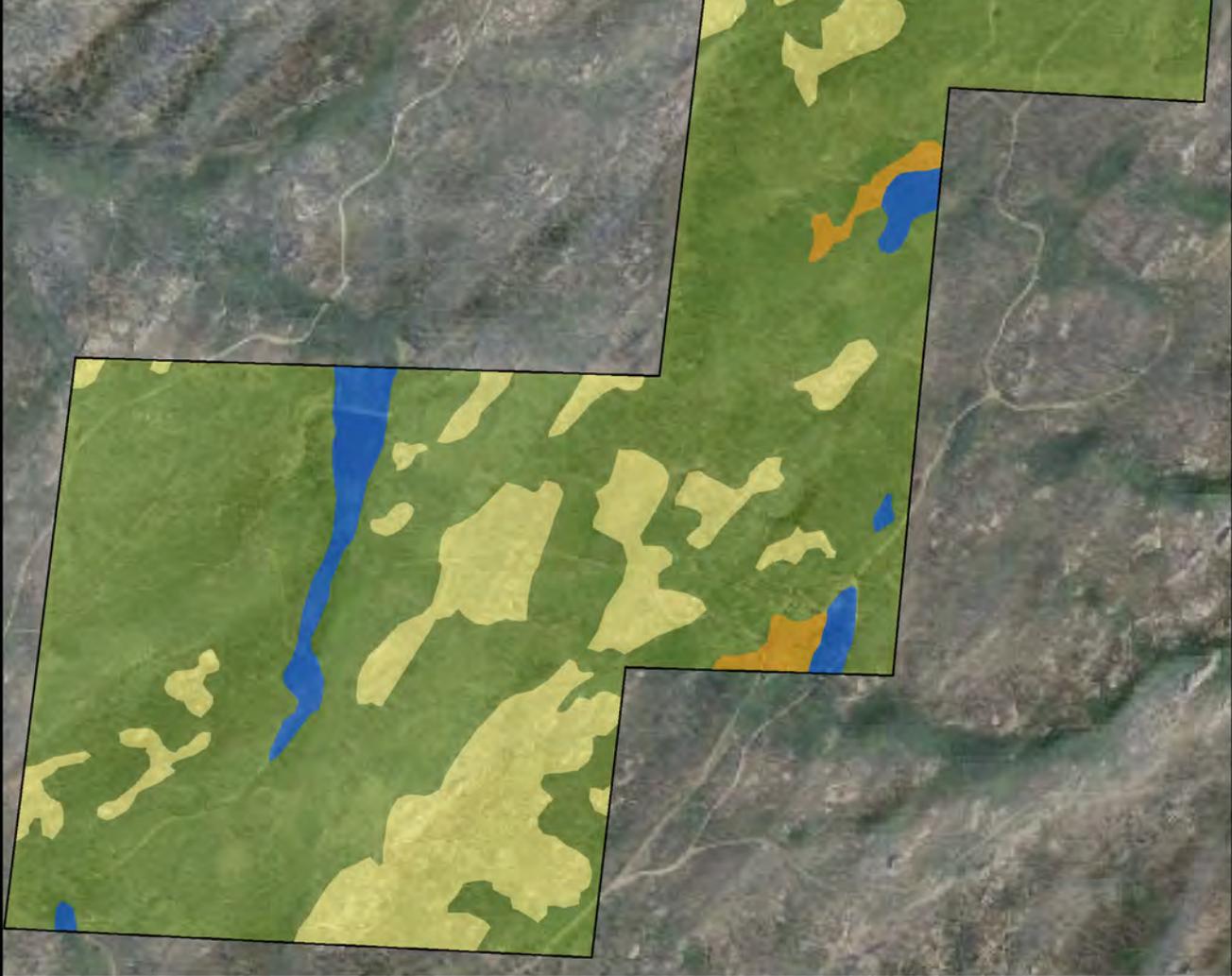
DESCRIPTION:

- RRS-01 - Alderon-rock outcrop, 25 to 50% slopes**
- RRS-02 - Rock outcrop-Cathedral taxajunct, 20 to 40% slopes**
- RRS-03 - Dalecreek, 4 to 10% slopes**
- RRS-04 - Kovich, 0 to 5% slopes**

¹The soils in this legend are described in the text under the heading "Soils of the Rogers Research Site"

Figure 26. General soils map of the Rogers Research Site in 3-D, showing the boundaries of the Alderon, Dalecreek, and Kovich soils, and the Cathedral taxajunct. The backdrop aerial image was taken in 2009, three years before the Arapaho Fire. (Soils mapping by L. Munn; digital GIS and cartography work by S. Lanning/WyGIS; aerial base image from the National Agriculture Imagery Program; RRS boundary mapping by Z. Dushdurova, courtesy J. Decker, UW Real Estate Operations)

Soils Map (Post-Fire Imagery 2015)
 Rogers Research Site
 North Laramie Mountains
 Wyoming

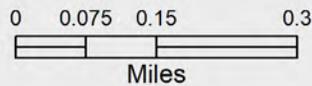


Soils Legend¹

-  RRS-01 Alderon
-  RRS-02 Cathedral
-  RRS-03 Dalecreek
-  RRS-04 Kovich



Scale 1: 11,000



DESCRIPTION:

- RRS-01 - Alderon-rock outcrop, 25 to 50% slopes**
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Figure 27. General soils map of the Rogers Research Site in 3-D, showing the boundaries of the Alderon, Dalecreek, and Kovich soils, and the Cathedral taxajunct. The backdrop aerial image was taken in 2015, three years after the Arapaho Fire. (Soils mapping by L. Munn; digital GIS and cartography work by S. Lanning/WyGISC; aerial base image from the National Agriculture Imagery Program; RRS boundary mapping by Z. Dushdurova, courtesy J. Decker, UW Real Estate Operations)

Figure 28. This photo (from Williams and Waggener, 2017a) shows fire response of lupine (*Lupinus* spp., plant with blue blossoms in foreground) and other forbs and grasses growing in an area at RRS dominated by Alderon soil. It was taken in 2015, three years after the high-intensity Arapaho Fire. (Photo by S. Williams)

former [ponderosa pine restoration] is part of a long-term study at RRS, which was introduced in RRS Bulletin 5 [Herget et al., 2018].) The boundary between the coniferous forest and herbaceous community is thus surprisingly stable over time. Aspen largely regenerate by

root sprouting after the fire, and so they also tend to occupy suitable growing sites over long time spans. The continuous high water table in the Kovich soil would itself be a barrier to upland conifer species.



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One of the fringe benefits of conducting research in areas like the Rogers Research Site is being able to observe Mother Nature's beauty, whether towering peaks miles away or wildflowers at one's feet. Among the numerous forbs at RRS and surrounding lands in the Laramie Mountains is blanketflower (*Gaillardia aristata*). This photo was taken in July 2015, three years after the Arapaho Fire. (Photo by M. Curran)



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APPENDIX A. CLASSIFICATION OF SOILS AT THE ROGERS RESEARCH SITE.

SOIL CLASSIFICATION TERMS EXPLAINED

Soil classification can seem complicated to those who do not use the system regularly. There is, however, a lot of information conveyed by the taxonomic system. The following is an explanation of soils in the soil mapping units delineated at the Rogers Research Site (RRS), north Laramie Mountains, Wyoming. The references for classification are from Soil Survey Staff, 1999, 2014.

ALDERON (RRS-01): FINE-LOAMY, MIXED, SUPERACTIVE, FRIGID TYPIC HAPLUSTALFS MODERATELY DEEP

- “fine-loamy” indicates that the texture of the subsoil contains between 18 and 35% clay, less than 50% silt, and less than 35% rock fragments.
- “mixed, superactive” indicates that the mineralogy of the clay present (particles <0.002 mm in diameter) is a variety of clay minerals and has cation exchange >60 millimoles⁽⁴⁾ per 100 g (3.5 oz) clay. Clay particles are a very active component in some soils because their small size (less than .002 millimeters in diameter) results in particles having a very high surface area per unit weight. The surface commonly is electrostatically charged, hence the ⁽⁴⁾ behind millimoles. In temperate regions, including Wyoming, soil clays usually have a net negative charge, signified by ⁽⁻⁾. This negative charge helps retain positively charged nutrient ions like calcium (Ca), potassium (K), and magnesium (Mg) on the clay particle surface and

so they are not readily leached by water flowing through the soil.

- “frigid” indicates that the mean annual soil temperature at 50.0 cm (19.7 in) depth is between 32°F (0°C) and 47°F (8°C), and the mean summer soil temperature at that depth is not greater than 47°F (8°C).
- “Typic” indicates that this soil fits the central concept of the “Haplustalfs,” with no important special features such as shallow bedrock (see “lithic” below).
- “-----alfs” indicates that the soil is classified as an Alfisol at the soil order level of soil taxonomy. The Alfisols are conceptually stable, mature forest soils with subsurface clay accumulation and at least moderately high base status (greater than 35% Ca, Mg, K, and sodium [Na] on the exchange complex).
- “----ustalfs” indicates that the soil has an ustic moisture regime. This indicates that the soil will experience a pronounced summer dry period, but does have soil water available for plant growth for at least half the time the soil is warm enough to support plant growth. “Haplustalfs” indicates a common soil horizon sequence (haplos means ‘simple’ in Greek) without a high exchangeable Na-containing layer or without such layers as a fragipan (altered subsurface layers that restrict water flow and root penetration).
- “moderately deep” indicates that there is a root restrictive layer between 50 and 100 cm (20–40 in).

CATHEDRAL (RRS-02): LOAMY-SKELETAL, MIXED, MICACEOUS, FRIGID LITHIC HAPLUSTOLLS SHALLOW

- “loamy-skeletal” indicates that the soil contains less than 35% clay, less than 50% silt, and more than 35% rock fragments.
- “mixed, micaceous” indicates that the clay present is of mixed type, but with a significant component of mica.
- “frigid” indicates the soil temperature regime as defined for Alderon.
- “Lithic” indicates that the soil is shallow and that the restrictive layer is hard bedrock.
- “-----olls” indicates that the soil is a Mollisol at the soil order level of taxonomy. Mollisols are conceptually the grassland soils of the world—extensive on prairies, but also found under herbaceous vegetation in mountains and along riparian channels. They are characterized by a dark-colored surface layer enriched in soil organic matter and have high base saturation (greater than 50%).
- “Haplustolls” has the same connotation as for Alderon.
- “Shallow” indicates a root restricting layer within 50 cm (20 in) of the soil bedrock.

CATHEDRAL TAXAJUNCT: LOAMY-SKELETAL, MIXED, MICACEOUS, FRIGID LITHIC USTORTHENTS SHALLOW

“Taxajunct” means that this soil is, in many characteristics, similar to Cathedral, but with at least one major difference. In this case, the soil is an Entisol rather than a Mollisol because it lacks the thick, dark surface mineral layer characteristic of the grassland soils, which is required for a soil to classify as a Mollisol. The mineral features of the soil are otherwise similar to the Cathedral series, and interpretations in the *Soil survey of Albany County area, Wyoming* (Reckner, 1998) can be used with confidence.

DALECREEK (RRS-03): FINE-LOAMY, MIXED, SUPERACTIVE, FRIGID AQUIC CUMULIC HAPLUSTOLLS VERY DEEP

- “fine-loamy, mixed, superactive, frigid” as defined for Alderon.
- “Aquic” used as a subgroup modifier indicates that the soil has a high water table within one meter (3.3 ft) of the surface for part of the summer, but it is not present throughout the growing season.
- “Cumulic” indicates that the thick surface layer enriched in soil organic matter is greater than 50 cm (20 in) thick and has built up, in part, through addition of mineral material to the surface through erosion from soils higher in the landscape.
- “Haplustolls” indicates a Mollisol with a simple (but thick in this case) soil profile, and an ustic moisture regime.
- “very deep” indicates that the soil is more than 150 cm (60 in) thick.

KOVICH (RRS-04): FINE-LOAMY, MIXED, SUPERACTIVE, FRIGID CUMULIC ENDOAQUOLLS VERY DEEP

- “fine-loamy, mixed, superactive, frigid Cumulic” is the same as for Dalecreek.
- “---aquolls” indicates that the soil has an aquic soil moisture regime. It is saturated with water within 50 cm (20 in) of the surface throughout the growing season; oxygen in the soil is depleted, and the soil undergoes a reducing environment evidenced by dull, low chroma colors and iron mottles.
- “Endoaquolls” indicates that the soil is subject to a local water table and not just seasonal surface flooding.
- “very deep” means a profile greater than 150 cm (60 in) thick.

OTHER SOILS PRESENT: INCEPTISOLS

In addition to the soil series used in the four soil mapping units for RRS, there are soils on the hillsides that would classify as the Order Inceptisols. These soils were observed both during vegetation and soil microbial investigations (S. E. Williams) and during the soil inventory (L. C. Munn). They were not mapped in the area surrounding RRS during the Albany County soil survey (Reckner, 1998) and were not delineated in this mapping project because of their small areal extent. They occur as a thin transition zone between the Cathedral taxajunct and the Alderon soils adjacent to rock outcrops. The full taxonomy

is: loamy-skeletal, mixed, micaceous, frigid Typic Haplustepts, moderately deep. They lack sufficient clay accumulation to meet the requirements for the Alderon soil and contain too many rock fragments. The Natural Resources Conservation Service did not map any Inceptisols in the Laramie Mountains during the Albany County soil survey (Reckner, 1998); however, they are extensive in the Medicine Bow Mountains (Snowy Range) on glacial deposits of Late Pleistocene age (McCahon and Munn, 1991a) with Alfisols occurring there on older landscapes (McCahon and Munn, 1991b.)



Co-author Steve Williams, left, and University of Wyoming Assistant Professor John Derek Scasta survey the Rogers Research Site on July 23, 2015, approximately three years after the Arapaho Fire burned through the area. (Photo by M. Curran)



A diversity of habitats (from wet to dry), soils (at least four series), and elevations (~2,000–2,200 m) contribute to a wide range of plant species at the Rogers Research Site in southeast Wyoming's north Laramie Mountains. Among the species is dogbane (*Apocynum cannabinum*), a perennial herb adapted to mildly acidic to alkaline soil containing loam, clay-gravel, or clay-loam. 'Dogbane' refers to the plant's toxic nature, which can be poisonous to dogs. 'Apocymum' is Greek for "away dog." This photo was taken in July 2015, three years after the high-intensity Arapaho Fire, which burned approximately 98,000 ac (~39,700 ha). (Photo by M. Curran)