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Benjamin Research Natural Area: Guidebook Supplement 36

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The Pacific Northwest Research Station is publishing this guidebook as part of a continuing series of guidebooks on federal research natural areas begun in 1972.

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Cover

Benjamin Research Natural Area. Open stand of western juniper woodland with low sagebrush and Idaho fescue predominant in the understory. The abundance of perennial bunchgrass in the foreground characterizes the site and distinguishes it from the majority of juniper woodlands in the High Lava Plains and foothills of the Blue Mountains. Flat and gently sloping terrain typically supports a much higher percentage of annuals, especially the nonnative cheatgrass. Bare soil surface alternates with patches of (barely visible) microbiotic crust in foreground.

Photo credits

JoAnne Armson, Bureau of Land Management

Abstract

Schuller, Reid; Halvorson, Ron. 2009. Benjamin Research Natural Area: guidebook supplement 36. Gen. Tech. Rep. PNW-GTR-786. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

This guidebook describes Benjamin Research Natural Area, a 258-ha (637-ac) tract originally established to represent an example of the western juniper/Idaho fescue (*Juniperus occidentalis/Festuca idahoensis*) plant association. Subsequent field surveys indicate the predominant vegetation is best characterized as the western juniper/low sagebrush/Idaho fescue plant association. Current vegetation is dominated by western juniper woodland with an understory vegetation mosaic that varies with soil depth. Low sagebrush (*Artemisia arbuscula* Nutt.) occurs as the major shrub in shallow or rocky soils, and Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle and Young) predominates in areas with deeper or more finely textured soil.

Keywords: Research natural area, *Juniperus occidentalis*, western juniper, *Artemisia arbuscula*, low sagebrush, *Artemisia tridentata* ssp. *wyomingensis*, Wyoming big sagebrush, *Festuca idahoensis*, Idaho fescue, relict vegetation, juniper invasion, juniper woodland, sagebrush steppe, Northern Great Basin, Oregon High Desert.

Preface

The research natural area (RNA) described in this supplement[1] is administered by the Prineville District, Bureau of Land Management (BLM), U.S. Department of the Interior.

Scientists and educators wishing to visit or use the RNA for scientific or educational purposes should contact the Prineville BLM field office manager in advance and provide information about research or educational objectives, sampling procedures, and other prospective activities. Research projects, educational visits, and collection of specimens from the RNA all require prior approval. There may be limitations on research or educational activities.

Benjamin RNA is part of a federal system of such tracts established for research and educational purposes. Each RNA is a site where natural features are protected or managed for scientific purposes and natural processes are allowed to dominate. Their main purposes are to provide:

- Baseline areas against which effects of human activities can be measured or compared.
- Sites for study of natural processes in undisturbed ecosystems.
- Gene pool preserves for all types of organisms, especially rare and endangered types.

Of the 183 federal RNAs established in Oregon and Washington, 45 are described in *Federal Research Natural Areas in Oregon and Washington: A Guidebook for Scientists and* Educators.[2] Supplements to the guidebook such as this publication constitute additions to the system or comprehensive revisions of previously published guidebooks.

The guiding principle in management of RNAs is to prevent unnatural encroachments or activities that directly or indirectly modify ecological processes or conditions. Logging and uncontrolled grazing are not allowed, for example, nor is public use that might impair scientific or educational values. Management practices necessary to maintain or restore ecosystems may be allowed.

Federal RNAs provide a unique system of publicly owned and protected examples of undisturbed ecosystems where scientists can conduct research with

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[1] Supplement No. 36 to Franklin, J.F.; Hall, F.C.; Dyrness, C.T.; Maser, C. 1972. Federal research natural areas in Oregon and Washington: a guidebook for scientists and educators. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 498 p.

[2] Federal Committee on Ecological Reserves. 1977. A directory of the research natural areas on federal lands of the United States of America. Washington, DC: U.S. Department of Agriculture, Forest Service. [Irregular pagination].

minimal interference and reasonable assurance that investments in long-term studies will not be lost to logging, land development, or similar activities. In return, a scientist wishing to use an RNA is obligated to:

- Obtain permission from the appropriate administering agency before using the area.[3]
- Abide by the administering agency's regulations governing use, including specific limitations on the type of research, sampling methods, and other procedures.
- Inform the administering agency on progress of the research, published results, and disposition of collected materials.

The purpose of these limitations is to:

- Ensure that the scientific and educational values of the tract are not impaired.
- Accumulate a documented body of knowledge and information about the tract.
- Avoid conflict between studies and activities.

Research must be essentially nondestructive; destructive analysis of vegetation is generally not allowed, nor are studies requiring extensive modification of the forest floor or extensive excavation of soil. Collection of plant and animal specimens should be restricted to the minimum necessary to provide voucher specimens and other research needs. Under no circumstances may collecting significantly reduce populations of species. Collecting also must be carried out in accordance with agency regulations. Within these broad guidelines, appropriate uses of RNAs are determined by the administering agency.

Prineville BLM management direction is to preserve, protect, or restore native species composition and ecological processes of biological communities including terrestrial and aquatic cells[4] listed in the *Oregon Natural Heritage Plan*. The RNAs are available for short- or long-term scientific study, research, and education and will serve as a baseline against which human impacts on natural ecosystems can be measured.

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[3] Six federal agencies cooperate in this program in the Pacific Northwest: U.S. Department of the Interior Bureau of Land Management, Fish and Wildlife Service, and National Park Service; U.S. Department of Agriculture Forest Service; U.S. Department of Energy; and U.S. Department of Defense.

[4] Cells are the basic units that must be represented in a natural area system. A cell can be an ecosystem, community, habitat, or organism. Taken from: Dyrness, C.T.; Franklin, J.F.; Maser, C.; Cook, S.A.; Hall, J.D.; Faxon, G. 1975. Research natural area needs in the Pacific Northwest: a contribution to land-use planning. Gen. Tech. Rep. PNW-38. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Forest and Range Experiment Station. 231 p.

Contents

Introduction

Benjamin Research Natural Area (RNA) is a 258-ha (637-ac)[1] tract of western juniper (*Juniperus occidentalis*) woodland (see app. 1 for plant names and authorities) located in northern Lake County, Oregon. Benjamin RNA was established as a research natural area and as an area of critical environmental concern (ACEC) in 1989 with publication of the *Brothers/LaPine Resource Management Plan Record of Decision and Program Summary* (USDI BLM 1989), and reaffirmed in the *Upper Deschutes Resource Management Plan Record of Decision and Rangeland Program Summary* (USDI BLM 2005).

The tract supports a late-seral example of the western juniper/low sagebrush/Idaho fescue (*Juniperus occidentalis/Artemisia arbuscula/Festuca idahoensis*) plant association (Johnson and Swanson 2005), and limited examples of the western juniper/big sagebrush/Idaho fescue (*Juniperus occidentalis/Artemisia tridentata/Festuca idahoensis*) plant association. The RNA is located in the extreme southern portion of the Blue Mountains Ecological Province in central Oregon (Oregon Natural Heritage Plan 2003.

Access and Accommodations

To reach the Benjamin RNA, proceed east from Bend, Oregon, on U.S. Highway 20. Turn right (south) off Highway 20 11.3 km (7 mi) east of Brothers, Oregon, onto Frederick Butte Road (marked on highway). Proceed south on the gravel road for 19 km (11.8 mi). Cross a cattle guard on the east side of Frederick Butte and continue for 0.65 km (0.4 mi) to a four-wheel-drive track marked as Bureau of Land Management (BLM) road 6181. Turn left onto road 6181 and proceed for 4.5 km (2.8 mi) to a "Y" intersection. Take the left fork at the "Y" and proceed 4.5 km (2.8 mi) to a dry lake bed. Continue on the track through the lake bed, turn right, and proceed for 1.1 km (0.7 mi) in a south-southeasterly direction to the northeast corner of the RNA in Section 7 (fig. 1).

Permission for public access must be obtained prior to entering the site. Inquiries should be directed to the Prineville District Office, Bureau of Land Management in Prineville, Oregon. Road conditions and access can vary greatly with rain

[1] These data are on file at the Prineville District Office of the Bureau of Land Management, and at the U.S. Forest Service, Pacific Northwest Research Station, Corvallis, Oregon.

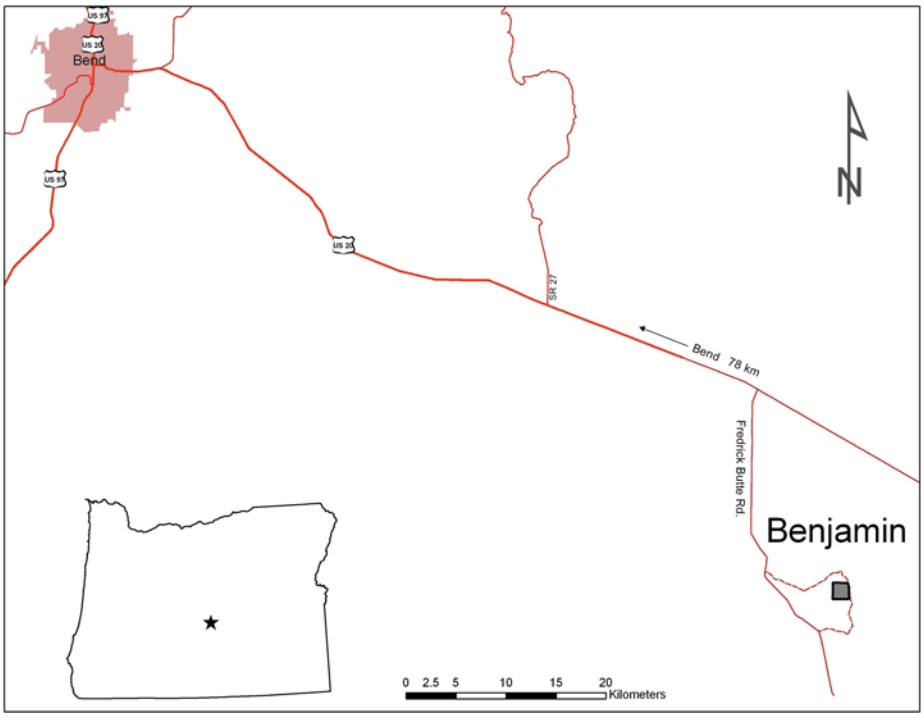

Figure 1—Benjamin Research Natural Area location and access.

and snow conditions. Check with the Prineville District Office prior to attempting access into the area. Lodging is available in Bend, Prineville, and Burns, Oregon.

Environment

Elevations range from 1500 m (4,921 ft) near the east-central boundary of the RNA to 1536 m (5,040 ft) along the west-central boundary within Mahogany Flat. The entire RNA is enclosed by a barbed-wire fence. Terrain is gently sloping to the east, and three intermittent channels flow in an eastward direction (fig. 2). The area is roughly square and extends 1.6 km (1 mi) in north-south and east-west directions.

The geologic setting consists of lava plains and tablelands. Parent material is aeolian deposits and residuum weathered from basalt and tuff. Soils within the RNA are primarily mapped as Moonbeam very gravelly ashy loam. Four percent of the soil surface is covered with stones and pebbles. Soils are well drained and depth to a duripan layer is 33 to 51 cm (13 to 20 in) and 51 to 102 cm (20 to 40

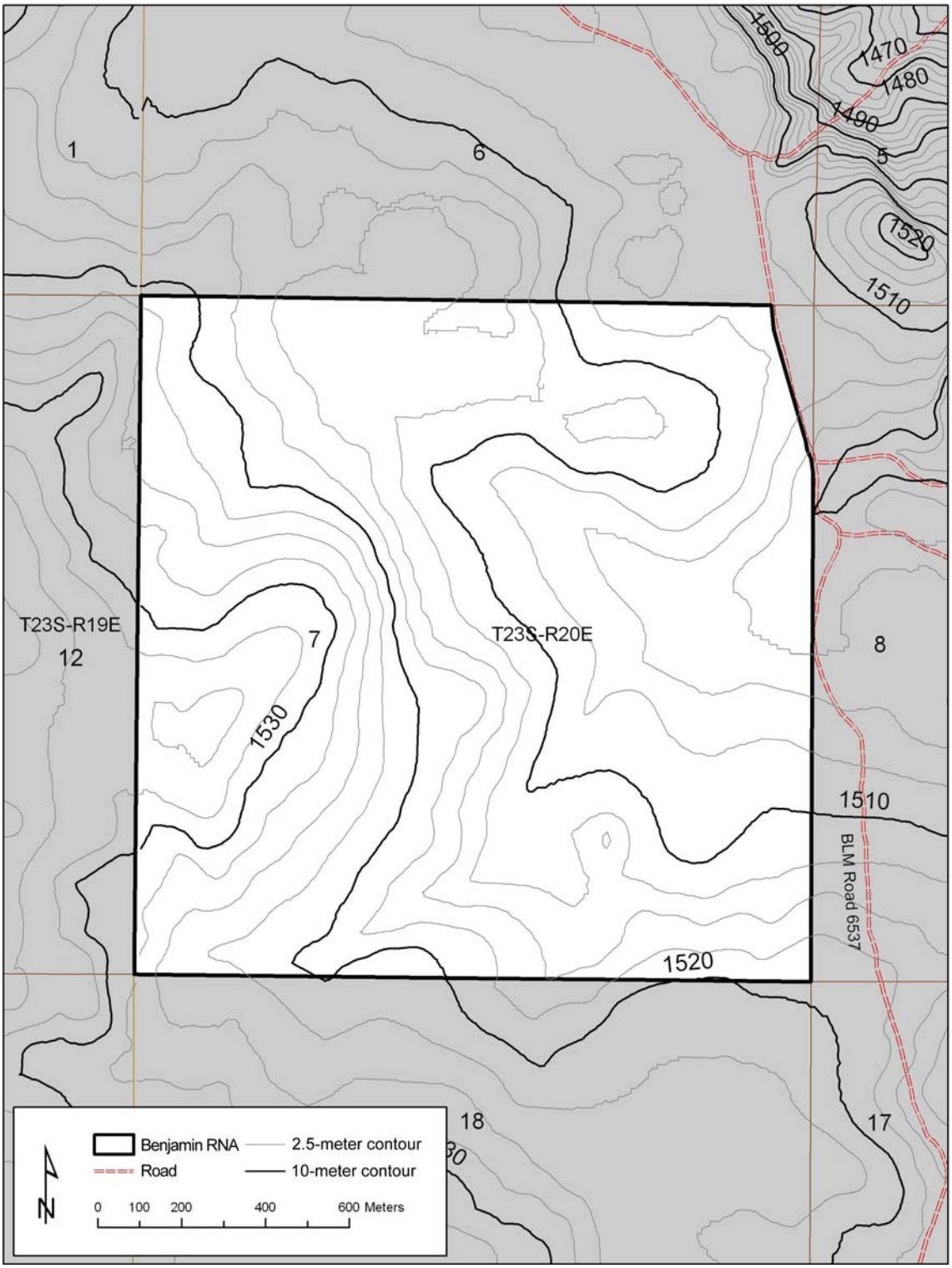

Figure 2—Benjamin Research Natural Area topography and boundary.

in) to lithic bedrock. A generalized soil profile for the Moonbeam very gravelly ashy loam, which occupies 93 percent of the RNA follows (USDA NRCS 2008):

0 to 8 cm	(0 to 3 in)	Very gravelly ashy loam
8 to 20 cm	(3 to 8 in)	Gravelly ashy sandy clay loam
20 to 46 cm	(8 to 18 in)	Clay
46 to 69 cm	(18 to 27 in)	Cemented material
69 to 79 cm	(27 to 31 in)	Bedrock

Climate

The desert climate is characterized by cool winters and warm, dry summers. The weather station nearest to the Benjamin RNA is the Brothers, Oregon (351067) station. Data collected from 1959 to 2007 are reported in table 1.

Annual precipitation of 230 mm (9.04 in) is typical of this desert steppe environment. Summers are dry with warm days and cool nights. Frost occurs rarely during the summer but may occur anytime between October and June. Twenty-seven percent of annual precipitation occurs during the 3-month growing period from May through July. Snowfall may occur from October through April and taper off into May. Average total snowfall from October through May is 630 mm (24.8 in). Average snow depth accumulations of 25 mm (1 in) occur from December through February. Fifty-four percent of the average annual snowfall occurs in December and January (343 mm [13.5 in]) (Western Regional Climate Center 2008).

Vegetation

The RNA is situated along the boundary of two major ecological provinces (Franklin and Dyrness 1988). Although the site has geologic affinities with the High Lava Plains physiographic province, it bears close vegetative similarities to the adjacent Blue Mountains province. Western juniper woodlands are common in the vicinity of the province boundary (Driscoll 1964, Johnson and Swanson 2005).

The designation of Benjamin RNA was originally based on the presence of a representative example of the western juniper/Idaho fescue (*Juniperus occidentalis/Festuca idahoensis*) plant association (Oregon Natural Heritage Program 2003). Subsequent field surveys indicate that the western juniper/low sagebrush/Idaho fescue plant association (*Juniperus occidentalis/Artemisia arbuscula/Festuca idahoensis*) more accurately characterizes the existing and potential vegetation within the RNA.

Table 1—Temperature and Precipitation summary

Measure	Average
Average minimum January temperature	-8.2 °C (17.2 °F)
Average maximum January temperature	3.1 °C (37.6 °F)
Average minimum July temperature	5.9 °C (42.7 °F)
Average maximum July temperature	27.9 °C (82.2 °F)
Average annual precipitation	230 mm (9.04 in)
Average July-September precipitation	49 mm (1.61 in)
Average annual snowfall	630 mm (24.8 in)

Note: Period of record: 5/30/1959 to 5/31/2007, Brothers, Oregon (351067).

Subsequent vegetation surveys in the Blue Mountains ecoregion has led to reclassification of some former vegetation types into new categories (Driscoll 1964, Johnson and Swanson 2005). The majority of Benjamin RNA is dominated by western juniper woodland with an understory of low sagebrush and lesser amounts of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) along with an herbaceous ground cover of Idaho fescue. Typical herbaceous species include spiny phlox (*Phlox hoodii*), low pussytoes (*Antennaria dimorpha*), Nevada biscuitroot (*Lomatium nevadense*), and sulphur-flower buckwheat (*Eriogonum umbellatum*). Numerous other herbaceous species occur in low abundances within the RNA.

In June 2008, four 0.1-ha circular plots were established to monitor structural and compositional change over time within the western juniper/low sagebrush/ Idaho fescue, plant association. Table 2 provides a summary of the physical characteristics of the plots. Table 3 shows soil, gravel, rock, litter, and microbiotic crust[2] cover and frequency within four permanent plots. Table 4 summarizes shrub cover, herb foliar cover, and herb frequency.

Low sagebrush ranged from 6 to 20 percent cover in three of the four plots. In plot 752, low sagebrush was absent and Wyoming big sagebrush occurred at 3 percent cover. Plot 752 was surrounded by stands having low sagebrush as the dominant shrub but with no observable difference in soils or topography from the other plots. Idaho fescue cover ranged between 9 and 15 percent, and Idaho fescue frequency ranged between 64 and 75 percent in all four plots. Other conspicuous grasses included Sandberg bluegrass (*Poa secunda*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Grasses such as prairie junegrass (*Koeleria macrantha*), and Thurber's needlegrass (*Achnatherum thurberianum*) were infrequently observed

[2] Microbiotic crust is composed of ground-surface-dwelling mosses and lichens.

Table 2—Physical features of four permanent plots within Benjamin Research Natural Area

	Plot			
Feature	**751**	**752**	**753**	**754**
Elevation (m)	1509	1511	1512	1522
Aspect (°)	330	220	45	102
Slope grade (°)	2	4	2	9
Slope position	Mid	Mid	Mid	Mid

Table 3—Soil, gravel, rock, litter, and microbiotic crust[a] cover and frequency within four permanent plots, Benjamin Research Natural Area

	Plot 751		Plot 752		Plot 753		Plot 754	
Feature	**Cover[b]**	**Frequency**	**Cover**	**Frequency**	**Cover**	**Frequency**	**Cover**	**Frequency**
				Percent				
Rock[c]	0	0	4	36	1	14	6	29
Gravel	+	7	1	21	1	29	1	32
Bare soil	35	68	24	39	62	96	43	93
Litter	32	89	51	79	12	61	31	86
Moss	33	71	23	54	16	64	18	71
Lichen	2	43	3	43	3	39	2	39

[a] Ground-surface-dwelling mosses and lichens.

[b] Cover is expressed as percentage of aerial cover; frequency is expressed as percentage of occurrence within 28, 20- by 50-cm microplots.

[c] Rock = particles >8 cm diameter, gravel = 2 mm to 8 cm, bare soil = <2 mm.

Table 4—Understory species coverage, and frequency of four permanent plots in Benjamin Research Natural Area with JUOC/ARAR/FEID plant association[a]

	Plot							
	751		752		753		754	
Species	Cover[b]	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
				Percent				
Shrub cover:								
Artemisia arbuscula[c]	10	—		—	6	—	20	—
Artemisia tridentata ssp. *wyomingensis*		—	3	—		—	+	—
Ericameria humilis	+	—		—	1	—		—
Grass cover and frequency:								
Festuca idahoensis	15	75	9	64	10	64	9	64
Poa secunda	1	18	1	29	6	75	2	71
Koeleria macrantha	+	4	+	4	+	4		
Achnatherum thurberianum			1	7			2	11
Pseudoroegneria spicata					+	4	2	7
Bromus tectorum							+	4
Herb cover and frequency:								
Phlox hoodii	2	11	1	11	7	32	1	14
Collinsia parviflora	+	25	+	7	+	32	1	43
Nothocalais troximoides	+	14			+	29	+	7
Eriogonum strictum ssp. *proliferum*	+	7			+	4		
Antennaria dimorpha			1	14	1	11		
Lomatium nevadense			+	7	+	4		
Eriogonum umbellatum			+	4			1	4
Astragalus agrestis					+	4	+	4
Linanthus pungens					+	4	+	14
Phlox speciosa	+	7						
Cryptantha circumscissa	+	11						
Trifolium gymnocarpon			1	21				
Astragalus lentiginosus					+	4		
Gayophytum humile							+	4
Lomatium triternatum							+	4
Castilleja longispica							+	4
Trifolium macrocephalum							2	61
Descurainia incana ssp. *incisa*							1	4

Note: JUOC = *Juniperus occidentalis,* ARAR = *Artemisia arbuscula,* FEID = *Festuca idahoensis*, + = trace (<0.5 percent foliar cover), — = not recorded.

[a] Plant association names and acronyms follow Johnson and Swanson (2005). Some species nomenclature has been updated to reflect accepted names used in the Flora of North America (various volumes 1993 thru 2008).

[b] Cover is expressed as percentage of foliar cover; frequency is expressed as percentage of occurrence within 28, 20- by 50-cm microplots. Zero values are not included.

[c] See appendix 1 for a listing of scientific and common names.

(fig. 3). The very low abundance of the highly invasive cheatgrass (*Bromus tectorum*) was evidence of the relatively unmodified condition of the site (see "Disturbance History" section) (table 3).

Western juniper sapling[3] and live tree density data recorded in the four 0.1-ha plots in 2008 are shown in table 5. Small sapling densities averaged 60 per ha (148 per ac), with a range from 0 to 100 per ha (0 to 247 per ac). Large sapling densities averaged 22.5 per ha (56 per ac), with a range from 0 to 40 per ha (0 to 99 per ac). Western juniper live tree density averaged 82.5 per ha (204 per ac), with a range from 30 to 140 per ha (74 to 346 per ac). Western junipers that branched below 1.47 m averaged 10 per ha (25 per ac), with a range from 0 to 20 per ha (0 to 49 per ac). Three of the four plots had no standing dead trees. One downed and dead western juniper constituted the only coarse woody debris.

Appendix 1 lists scientific and common names of plant species known to occur within the RNA. A list of scientific names of mosses and lichens is provided in appendix 2.

Fauna

Reptiles, amphibians, birds, and mammals known or expected to occur within the RNA are listed in appendix 3. These lists were compiled from a combination of field observations and published literature. They approximate the species that are expected to occur within or use the RNA for portions of their life cycles (Csuti et al. 1997).

Disturbance History

Lightning-ignited fire has played a role at Benjamin RNA as is evident by the presence of scattered, large fire-scarred or burned-out, western juniper, and by small areas where woody vegetation is either absent or is represented by small individuals of western juniper, low sagebrush, or Truckee rabbitbrush (*Ericameria humilis*). One such fire burned a small patch in the northwest portion of the RNA in 2001. The burn site has been mapped with a global positioning system, and this information is on file at the Prineville District office of the BLM (USDI BLM 2002).

[3] "Saplings" refers to two groups of small trees: (a) those > 10 cm (4 in to 4.8 ft) in height but < 5 cm (2 in) diameter at breast height (1.47 m) and (b) those slightly taller small trees > 4.8 ft (1.47 m) but < 5 cm (2 in) diameter at breast height.

Prineville District, Bureau of Land Management

Figure 3—Example of typical stand of the western juniper/low sagebrush/Idaho fescue plant association in plot 754. Exposed surface soil is sandy loam with high stone content. Native bunchgrasses predominate in the understory. Grasses include Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, and Thurber's needlegrass mixed with herbs such as spiny phlox and blue-eyed Mary.

Table 5—Western juniper density of stand structure attributes, Benjamin Research Natural Area, 2008

	Plot				
Attribute	**751**	**752**	**753**	**754**	**Mean**
	Number per hectare				
Small sapling	100	90	50	0	60.0
Large sapling	30	20	0	40	22.5
Live trees	100	140	30	60	82.5
Standing dead trees	0	10	0	0	2.5
Multibranched trees	10	20	0	10	10.0

The role of anthropogenic disturbance owing to grazing by domestic livestock appears to have played only a minor role at Benjamin RNA (see "Site History" section). The dominance and vigor of the grazing-sensitive Idaho fescue lends support to the relatively undisturbed nature of the RNA. This is further supported by the very sparse abundance of invasive species such as cheatgrass.

Research History

Research focusing on microbiotic crusts:

- *Biotic soil crusts of Oregon's shrub steppe* (Ponzetti 2000)

Research on *Juniperus occidentalis* (western juniper) growth and expansion:

- *Occurrence of sustained droughts in the interior Pacific Northwest (A.D. 1733–1980) inferred from tree-ring data* (Knapp et al. 2004)
- *Human agency, environmental drivers, and western juniper establishment during the late Holocene* (Soulé et al. 2004)
- *Climatic regionalization and the spatio-temporal occurrence of extreme single-year drought events (1500-1998) in the interior Pacific Northwest, USA* (Knapp et al. 2002)
- *Detecting potential regional effects of increased atmospheric CO_2 on growth rates of western juniper* (Knapp et al. 2001a)
- *Post-drought growth responses of western juniper (*Juniperus occidentalis *var.* occidentalis*) in central Oregon* (Knapp et al. 2001b)

In addition to the research and monitoring described above, four permanent vegetation plots were established in 2008 to characterize and monitor change in forest/shrub steppe composition and structure (tables 1 through 4.) Data are on file at the Prineville District office, BLM, and the Pacific Northwest Research Station, USDA Forest Service, Corvallis, Oregon.

Site History

The Yreka Trail was established in 1862 to get miners to the Canyon City gold rush from northern California. This trail extended through the Benjamin RNA and was used until about 1864. The trail was generally one-way as miners who traveled to Canyon City generally stayed. The Yreka Trail bears the unique distinction of being the only pioneer road where rocks were not thrown to the side in significant numbers–the miners were in too much of a hurry. The vicinity of Benjamin RNA is where the trail turned east, departing from the general north/south direction (Nielsen et al. 1985).

The RNA was part of a larger grazing allotment until about 1980 when it was designated as an RNA and fenced off from adjacent lands. The RNA site was in a corner of a large pasture and had no natural or supplemented water. This resulted in light use of the area by livestock, and may partially explain its relatively pristine condition today.

Maps

Maps applicable to Benjamin RNA: Topographic—Benjamin Lake, Oregon, 7.5 minute, 1:24,000 scale, 1962; Brothers/LaPine Planning Area—East Half, 1:100,000, 1998.

Acknowledgments

We thank BLM specialists Rick Demmer and Bill Dean for assistance in creating appendix 3, animals occurring or likely to occur within the RNA. We thank Todd Wilson, Rex Crawford, Geoff Babb, Sarah Greene, and JoAnne Armson for reviewing the manuscript. We also thank the BLM Prineville District for funding this project and the USDA Forest Service Research Station for publishing this guidebook supplement.

English Equivalents

1 hectare (ha) = 2.47 acres (ac)
1 kilometer (km) = 0.62 mile (mi)
1 meter (m) = 3.28 feet (ft)
1 centimeter (cm) = 0.394 inch (in)
1 millimeter (mm) = 0.0394 inch
Degrees Celsius (°C) = 0.56(degrees Fahrenheit – 32)

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Appendix 1: Vascular Plants and Ferns[1,2]

Scientific name	Common name
Coniferous trees	
Juniperus occidentalis Hook.	Western juniper
Medium shrubs 0.5 to 2 m (1.6 to 6.6 ft) tall	
Artemisia arbuscula Nutt.	Low sagebrush
Artemisia tridentata Nutt. ssp. *tridentata*	Big sagebrush
Artemisia tridentata Nutt. ssp. *wyomingensis* Beetle & Young	Wyoming big sagebrush
Ericameria humilis (Greene) L.C. Anderson	Truckee rabbitbrush
Ericameria nauseosa (Pallas ex Pursh) Nesom & Baird	Gray rabbitbrush
Linanthus pungens (Torr.) J.M. Porter & L.A. Johnson	Granite prickly phlox
Purshia tridentata (Pursh) DC.	Bitterbrush
Ribes cereum Dougl.	Wax currant
Tetradymia canescens DC.	Spineless horsebrush
Herbs	
Achillea millefolium L.	Common yarrow
Agoseris glauca (Pursh) Raf. var. *glauca*	Pale agoseris
Allium tolmiei (Hook.) Baker ex S. Wats.	Tolmie's onion
Antennaria dimorpha (Nutt.) T. & G.	Low pussytoes
Antennaria microphylla Rydb.	Littleleaf pussytoes
Arabis holboellii Hornem.	Holboell's rockcress
Arabis sparsiflora Nutt.	Sicklepod rockcress
Astragalus agrestis Dougl. ex G. Don	Purple milkvetch
Astragalus filipes Torr. ex Gray	Basalt milkvetch
Astragalus lentiginosus Dougl. ex Hook. var. *chartaceus* M.E. Jones	Broadleaf milkvetch
Astragalus salmonis M.E. Jones	Trout Creek milkvetch
Calochortus macrocarpus Dougl.	Sagebrush mariposa lily
Castilleja campestris (Benth.) Chuang & Heckard ssp. *campestris*	Vernal pool Indian paintbrush
Castilleja longispica A. Nels.	Longspike Indian paintbrush
Castilleja sp.	Indian paintbrush
Chenopodium fremontii S. Wats.	Fremont's goosefoot
Collinsia parviflora Dougl. ex Lindl.	Maiden blue-eyed Mary
Collomia grandiflora Dougl. ex Lindl.	Grand collomia
Collomia linearis Nutt.	Tiny trumpet
Cordylanthus ramosus Nutt. ex Benth.	Bushy bird's beak
Crepis sp.	Hawksbeard
Cryptantha circumscissa (Hook. & Arn.) I.M. Johnston	Cushion cryptantha
Delphinium andersonii Gray	Anderson's larkspur
*Descurainia incana (*Bernh. ex Fisch. & C.A. Mey.) Dorn ssp. *incisa* (Engelm.) Kartesz & Gandhi	Mountain tansymustard
Dieteria canescens (Pursh) Nutt.	Hoary tansyaster

Dodecatheon conjugens Greene	Bonneville shootingstar
Draba verna L.	Spring draba
Epilobium minutum Lindl. ex Lehm.	Chaparral willowherb
Eremogone kingii (S. Wats.) S. Ikon. ssp. compacta (Coville) Maguire	King's compact sandwort
Eriastrum sparsiflorum (Eastw.) Mason ssp. *sparsiflorum*	Great Basin woollystar
Erigeron elegantulus Greene	Blue dwarf fleabane
Erigeron filifolius (Hook.) Nutt.	Threadleaf fleabane
Erigeron poliospermus Gray	Cushion fleabane
Eriogonum microthecum Nutt. var. *laxiflorum* Hook.	Slender buckwheat
Eriogonum strictum Benth. ssp. *proliferum* (Torr. & Gray) Stokes var. *anserinum* (Greene) R.J. Davis	Blue Mountain buckwheat
Eriogonum umbellatum Torr. var. *umbellatum*	Sulphur-flower buckwheat
Eriophyllum lanatum (Pursh) J. Forbes	Common woolly sunflower
Erodium cicutarium (L.) L'Her. ex Ait.	Redstem storksbill
Erysimum sp.	Wallflower
Frasera albicaulis Dougl. ex Griseb.	Whitestem frasera
Fritillaria atropurpurea Nutt.	Spotted fritillary
Fritillaria pudica (Pursh) Spreng.	Yellow fritillary
Gayophytum humile Juss.	Dwarf groundsmoke
Gayophytum ramosissimum Torr. & Gray	Pinyon groundsmoke
Geum triflorum Pursh var. *ciliatum* (Pursh) Fassett	Old man's whiskers
Gilia sinuata Dougl. ex Benth.	Rosy gilia
Hesperolinon micranthum (Gray) Sm.	Tidytips
Holosteum umbellatum L.	Jagged chickweed
Ionactis alpina (Nutt.) Greene	Lava aster
Iva axillaris Pursh	Povertyweed
Layia glandulosa (Hook.) Hook. & Arn.	Whitedaisy tidytips
Leptosiphon liniflorus (Benth.) J.M. Porter & L.A. Johnson	Narrowleaf flaxflower
Leucocrinum montanum Nutt. ex Gray	Common starlily
Lewisia rediviva Pursh	Bitter root
Linanthus pungens (Torr.) J.M. Porter & L.A. Johnson	Prickly phlox
Lithophragma glabrum Nutt.	Bulbous woodland-star
Lithophragma tenellum Nutt.	Slender woodland-star
Lomatium nevadense (S. Wats.) Coult. & Rose	Nevada biscuitroot
Lomatium triternatum (Pursh) Coult. & Rose	Nineleaf biscuitroot
Lupinus argenteus Pursh	Silvery lupine
Lupinus lepidus Dougl. ex Lindl.	Pacific lupine
Melilotus alba Medik.	White sweet clover
Mentzelia albicaulis (Hook.) Torr. & A. Gray	Whitestem blazingstar
Mimulus cusickii (Greene) Rattan	Cusick's monkeyflower
Mimulus suksdorfii Gray	Suksdorf's monkeyflower
Navarretia breweri (Gray) Greene	Brewer's navarretia
Nothocalais troximoides (Gray) Greene	Sagebrush false dandelion
Orobanche fasciculata Nutt.	Clustered broomrape

Packera cana (Hook.) W.A. Weber & A. Löve	Woolly groundsel
Penstemon seorsus (A. Nels.) Keck	Shortlobe penstemon
Phlox gracilis (Hook.) Greene	Slender phlox
Phlox hoodii Rich	Spiny phlox
Phlox longifolia Nutt.	Longleaf phlox
Phlox speciosa Pursh	Showy phlox
Plagiobothrys leptocladus (Greene) I.M. Johnst.	Finebranched popcornflower
Polemonium micranthum Benth.	Annual polemonium
Polyctenium fremontii (S. Wats.) Greene	Desert combleaf
Ranunculus glaberrimus Hook. var. *glaberrimus*	Sagebrush buttercup
Senecio integerrimus Nutt.	Lambstongue ragwort
Silene scaposa B.L. Robins var. *lobata* C.L. Hitchc. & Maguire	Lost River silene
Taraxacum officinale G.H. Weber ex Wiggers	Common dandelion
Trifolium gymnocarpon Nutt.	Hollyleaf clover
Trifolium macrocephalum (Pursh) Poir.	Largehead clover
Viola nuttallii Pursh	Nuttall's violet
Zigadenus venenosus S. Wats.	Meadow deathcamas
Grasses and Sedges	
Achnatherum thurberianum (Piper) Barkw.	Thurber's needlegrass
Bromus tectorum L.	Cheatgrass
Carex douglasii Boott	Douglas' sedge
Elymus elymoides (Raf.) Swezey	Bottlebrush squirreltail
Festuca idahoensis Elmer	Idaho fescue
Koeleria macrantha (Ledeb.) Schult.	Prairie junegrass
Leymus cinereus (Scribn. & Merr.) A. Love	Basin wildrye
Muhlenbergia richardsonis (Trin) Rydb.	Mat muhly
Poa cusickii Vasey ssp. *cusickii*	Cusick's bluegrass
Poa secunda J. Presl ssp. *secunda*	Sandberg bluegrass
Pseudoroegneria spicata (Pursh) A. Love	Bluebunch wheatgrass

[1] Compiled from numerous sources.

[2] Nomenclature for vascular plants, ferns, and fern-allies follows the Flora of North America (1993+) and the Oregon Flora Project Web site (2008).

Appendix 2: Bryophytes and Lichens[1 2]

Scientific name and authority	Substrate
Lichens	
Arthonia glebosa Tuck.	—
Aspicilia hispida Mereschk	Soil
Aspicilia spp.	Rock
Caloplaca saxicola (Hoffm.) Nordin	Rock
Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr.	—
Caloplaca tominii (Savicz) Ahlner	Soil
Candelariella rosulans (Müll. Arg.) Zahlbr.	Rock
Candelariella efflorescens R.C. Harris & W.R. Buck	Wood
Candelariella terrigena Räsänen	Soil
Catapyrenium squamellum (Nyl.) J.W. Thomson	Soil
Cladonia pocillum (Ach.) Grognot	Soil
Collema cf. *tenax* (Sw.) Ach.	Soil
Lecanora phaedrophthalma Poelt	Rock
Lecidea atrobrunnea (Lam. & DC.) Schaerer	Rock
Letharia columbiana (Nutt.) J.W. Thomson	Wood
Melanelia elegantula (Zahlbr.) Essl.	Wood
Nodobryoria abbreviata (Mull. Arg.) Common & Brodo	Wood
Rhizoplaca melanophthalma (DC.) Leuckert & Poelt	Rock
Thelomma ocellatum (Körber) Tibell	Wood
Umbilicaria hyperborean (Ach.) Hoffm.	Rock
Usnea sp.	Wood
Xanthoria fallax (Hepp.) Arnold	Wood
Xanthoria polycarpa (Hoffm.) Rieber	Wood
Mosses	
Bryum argenteum Hedw.	
Bryum spp.	
Ceratodon purpureus (Hedw.) Brid.	
Encalypta rhaptocarpa Schwägr.	
Tortula caninervis (Mitt.) Broth.	
Tortula ruralis (Hedw.) P. Gaertn.	

[1] Taken from Ponzetti 2000.

[2] Nomenclature follows Missouri Botanical Garden W[3]MOST database (2008) for mosses and Esslinger (2006) for lichens.

Appendix 3: Amphibians, reptiles, birds, and mammals[1]

Family	Scientific name	Common name
Amphibians		
Ambystomatidae	*Ambystoma macrodactylum*	Long-toed salamander
Bufonidae	*Bufo boreas*	Western toad
Hylidae	*Pseudacris regilla*	Pacific chorus frog
Pelobatidae	*Scaphiopus intermontanus*	Great Basin spadefoot
Reptiles		
Boidae	*Charina bottae*	Rubber boa
Colubridae	*Coluber constrictor*	Racer
	Hypsiglena torquata	Night snake
	Masticophis taeniatus	Striped whipsnake
	Pituophis melanoleucus	Gopher snake
	Thamnophis elegans	Western terrestrial garter snake
Iguanidae	*Phrynosoma douglasii*	Short-horned lizard
	Sceloporus graciosus	Sagebrush lizard
	Sceloporus occidentalis	Western fence lizard
	Uta stansburiana	Side-blotched lizard
Scincidae	*Eumeces skiltonianus*	Western skink
Viperidae	*Crotalus viridis*	Western rattlesnake
Birds		
Accipitridae	*Accipiter cooperii*	Cooper's hawk
	Accipiter striatus	Sharp-shinned hawk
	Aquila chrysaetos	Golden eagle
	Buteo regalis	Ferruginous hawk
	Buteo jamaicensis	Red-tailed hawk
	Buteo swainsonii	Swainson's hawk
	Circus cyaneus	Northern harrier
Cathartidae	*Cathartes aura*	Turkey vulture
Falconidae	*Falco mexicanus*	Prairie falcon
	Falco peregrinus	Peregrine falcon
	Falco sparverius	American kestrel
Phasianidae	*Alectoris chukar*	Chukar
	Callipepla californica	California quail
	Centrocercus urophasianus	Sage grouse
	Perdix perdix	Gray partridge
Scolopacidae	*Numenius americanus*	Long-billed curlew
Columbidae	*Columbia livia*	Rock dove
	Zenaida macroura	Mourning dove
Tytonidae	*Tyto alba*	Barn owl
Strigidae	*Asio otus*	Long-eared owl
	Athene cunicularia	Burrowing owl
	Bubo virginianus	Great-horned owl
	Otus kennicottii	Western screech-owl
Caprimulgidae	*Chordeiles minor*	Common nighthawk
	Phalaenoptilus nuttallii	Common poorwill

Apodidae	*Aeronautes saxatalis*	White-throated swift
	Selasphorus rufus	Rufous hummingbird
Picidae	*Colaptes auratus*	Northern flicker
	Picoides villosus	Hairy woodpecker
	Sphyrapicus nuchalis	Red-naped sapsucker
Tyrannidae	*Contopus sordidulus*	Western wood-pewee
	Empidonax oberholseri	Dusky flycatcher
	Empidonax wrightii	Gray flycatcher
	Sayornis saya	Say's phoebe
	Myiarchus cinerascens	Ash-throated flycatcher
	Tyrannus verticalis	Western kingbird
Alaudidae	*Eremophila alpestris*	Horned lark
Corvidae	*Corvus brachyrhynchos*	American crow
	Corvus corax	Common raven
	Gymnorhinus cyanocephalus	Pinyon jay
	Nucifraga columbiana	Clark's nutcracker
	Pica pica	Black-billed magpie
Paridae	*Parus gambeli*	Mountain chickadee
Aegithalidae	*Psaltriparus minimus*	Bushtit
Troglodytidae	*Salpinctes obsoletus*	Rock wren
	Troglodytes aedon	House wren
Muscicapidae	*Myadestes townsendi*	Townsend's solitaire
	Sialia mexicana	Western bluebird
	Sialia currucoides	Mountain bluebird
	Turdus migratorius	American robin
Mimidae	*Oreoscoptes montanus*	Sage thrasher
Bombycillidae	*Bombycilla cedrorum*	Cedar waxwing
Laniidae	*Lanius ludovicianus*	Loggerhead shrike
Sturnidae	*Sturnus vulgaris*	European starling
Vireonidae	*Vireo solitarius*	Solitary vireo
Emberizidae	*Chondestes grammacus*	Lark sparrow
	Amphispiza belli	Sage sparrow
	Dendroica coronata	Yellow-rumped warbler
	Dendroica nigrescens	Black-throated gray warbler
	Euphagus cyanocephalus	Brewer's blackbird
	Junco hyemalis	Dark-eyed junco
	Molothrus ater	Brown-headed cowbird
	Passerella iliaca	Fox sparrow
	Pipilo chlorurus	Green-tailed towhee
	Pipilo maculatus	Spotted towhee
	Pooecetes gramineus	Vesper sparrow
	Spizella breweri	Brewer's sparrow
	Spizella passerina	Chipping sparrow
	Sturnella neglecta	Western meadowlark
	Zonotrichia leucophrys	White-crowned sparrow
Fringillidae	*Carduelis psaltria*	Lesser goldfinch
	Carduelis tristis	American goldfinch
	Carpodacus cassinii	Cassin's finch
	Carpodacus mexicanus	House finch

Mammals

Soricidae	*Sorex merriami*	Merriam's shrew
	Sorex preblei	Preble's shrew
	Sorex vagrans	Vagrant shrew
Vespertilionidae	*Antrozous pallidus*	Pallid bat
	Eptesicus fuscus	Big brown bat
	Myotis ciliolabrum	Western small-footed myotis
	Myotis evotis	Long-eared myotis
	Myotis volans	Long-legged myotis
Leporidae	*Brachylagus idahoensis*	Pygmy rabbit
	Lepus californicus	Black-tailed jackrabbit
	Sylvilagus nuttallii	Mountain cottontail
Sciuridae	*Spermophilus beldingi*	Belding's ground squirrel
	Spermophilus townsendii	Townsend's ground squirrel
	Tamias minimus	Least chipmunk
Geomyidae	*Thomomys talpoides*	Northern pocket gopher
Heteromyidae	*Dipodomys ordii*	Ord's kangaroo rat
	Dipodomys microps	Chisel-toothed kangaroo rat
	Perognathus parvus	Great Basin pocket mouse
	Microdipodops megacephalus	Dark kangaroo mouse
Muridae	*Lemmiscus curtatus*	Sagebrush vole
	Neotoma cinerea	Bushy-tailed woodrat
	Neotoma lepida	Desert woodrat
	Onychomys leucogaster	Northern grasshopper mouse
	Peromyscus maniculatus	Deer mouse
	Peromyscus truei	Pinyon mouse
Erethizontidae	*Erethizon dorsatum*	Common porcupine
Canidae	*Canis latrans*	Coyote
Procyonidae	*Procyon lotor*	Common raccoon
Mustelidae	*Mustela frenata*	Long-tailed weasel
	Taxidea taxus	American badger
Felidae	*Felis concolor*	Mountain lion
	Lynx rufus	Bobcat
Cervidae	*Cervus elaphus*	Elk
	Odocoileus hemionus ssp. *hemionus*	Mule deer
Bovidae	*Antilocapra americana*	Pronghorn

[1] Nomenclature, distribution and habitat characteristics taken from Csuti et al. 1997.

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