Introduction

At first sight, the John Day Basin does not seem to change much. The river, green fields, pastel hills, brown rimrock and gentle mountains alter so slowly they don't seem to change at all. This illusion dispels us when the earth suddenly moves beneath us in an earthquake, a landslide covers the road, or the river rapidly covers the valley in a flood. Other processes are hidden deep in the earth; slowly forming rocks by the inch. These changes are the heart of the John Day Basin landscape.

But the weather changes the landscape, too. Rains soak it in the fall, snow blankets it in the winter, and intense thunderstorms chew it up in the summer.

Context

In January 2003 the Regional Executives for the USDA Forest Service, Forest Service Research, USDI Bureau of Land Management, US Fish and Wildlife Service, the National Marine Fisheries Service and the Environmental Protection Agency signed a Memorandum of Understanding to cooperatively implement The Interior Columbia Basin Strategy and to utilize the scientific findings of the ICBEMP Science, and new information and best available science as they are developed. The agencies developed an Aquatic/Riparian Habitat Framework (July 2004) to clarify the Interior Columbia Basin Strategy relative to the aquatic and riparian habitat components. This science will be used to guide the amendment and revision of this plan, and project implementation. This will help to meet community needs for goods and services in an ecologically sustainable way.

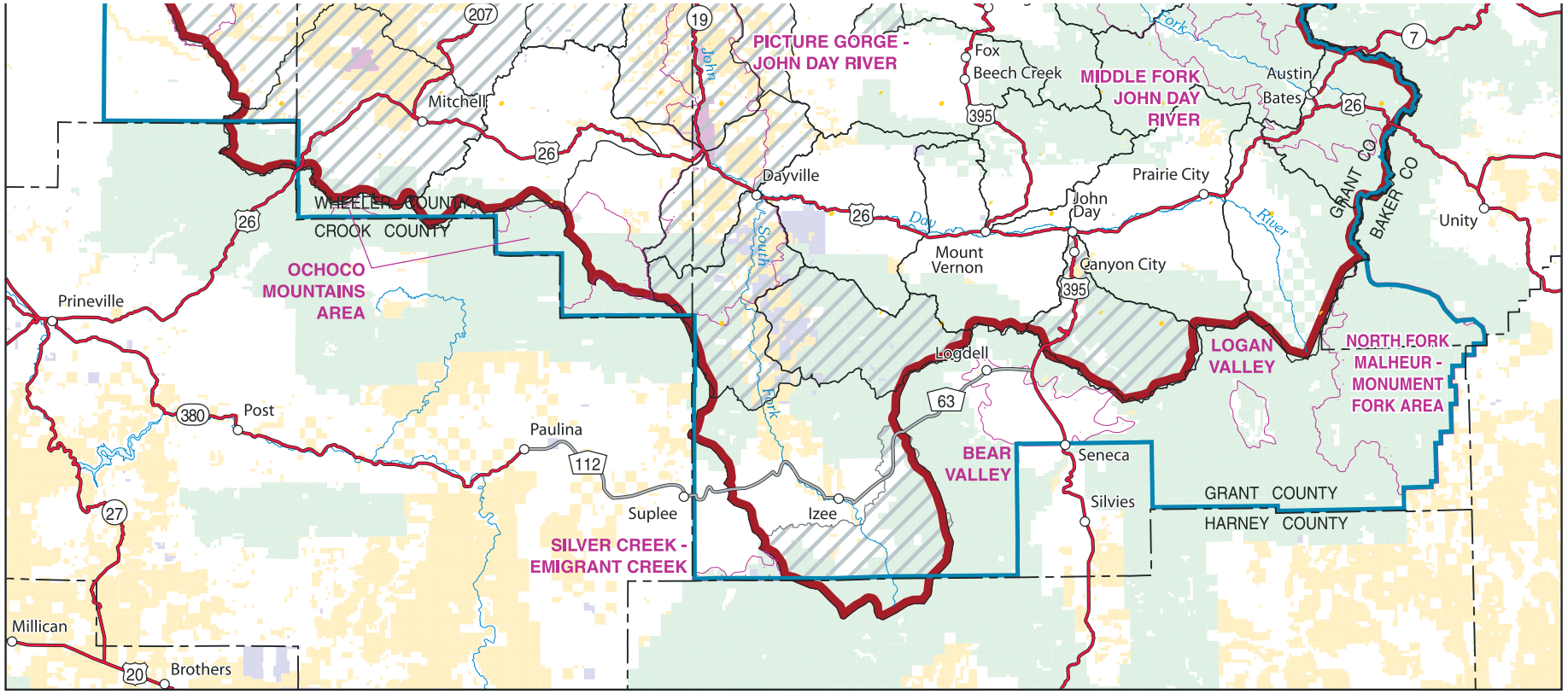
The Aquatic/Riparian Habitat Framework includes the following six components: Riparian Conservation Areas (or appropriate direction accomplishing the same end, Protection of Population Strongholds for Listed or Proposed Species and Narrow Endemics, Multiscale Analysis, Restoration Priorities and Guidance, Management Direction (Desired conditions, objectives, management actions), and Monitoring/Adaptive Management.

The Prineville District BLM has completed the Multiscale Analysis component by conducting a Subbasin assessment and prioritizing watersheds for restoration. This prioritization is presented in Map 3. This map also displays Subbasin ratings and opportunities based on assessments by other agencies.

Ecoregions

Combinations of landscape and climate create different Ecoregions. The John Day Planning Area falls within the Blue Mountains and the Columbia Plateau Ecoregions. To better understand the planning area we will look at these two Ecoregions, as well as "Subecoregions" or Level 4 Ecoregions. . See Map 2 and following Table 1.


N
W
E
S
10 0 10 20 Miles
10 0 10 20 Kilometers
OREGON
PACIFIC OCEAN
John Day Basin Planning Area
Prineville District
Astoria
Portland
Tillamook
Pendleton
The Dalles
Salem
Albany
Newport
Madras
Baker City
Prineville
John Day
Florence
Eugene
Bend
Vale
Coos Bay
Roseburg
Burns
Grants Pass
Medford
Klamath Falls
Lakeview
WASHINGTON
OREGON
Columbia River
Maryhill
Biggs
Rufus
Wasco
Arlington
Boardman
Heppner Junction
BOARDMAN AREA
Cecil
Morgan
Ione
Olex
Lexington
Heppner
Ruggs
Hardman
Condon
Moro
Grass Valley
Kent
Deschutes River
John Day River
SHERMAN COUNTY
GILLIAM COUNTY
LOWER JOHN DAY RIVER
Mayville
Fossil
Shaniko
Antelope
Clarno
WASCO COUNTY
JEFFERSON COUNTY
LOWER JOHN DAY RIVER AREA
Service Creek
Spray
Richmond
Kimberly
Monument
Hamilton
Long Creek
Ukiah
La Grande
Dale
MORROW COUNTY
GRANT COUNTY
UMATILLA CO
UNION CO
NORTH FORK JOHN DAY RIVER
North Fork John Day River
Middle Fork John Day River
Sumpter



LEGEND

Interior Columbia Basin Ecological Management Plan

- Low Ecological Integrity

Prineville District BLM Subbasin Assessment for Priority Restoration

- Bonneville Power Administration Subbasin Assessment for Priority Restoration
- Prineville District BLM Subbasin Assessment for Priority Restoration
- Oregon Department of Fish and Wildlife Conservation Opportunity Areas
- Planning Area Boundary

Administered Land

- Bureau of Land Management
- Forest Service
- John Day Fossil Beds National Monument
- Other Federal
- State
- Private or Other

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Land Management

PRINEVILLE DISTRICT

John Day Basin Resource Management Plan

2006

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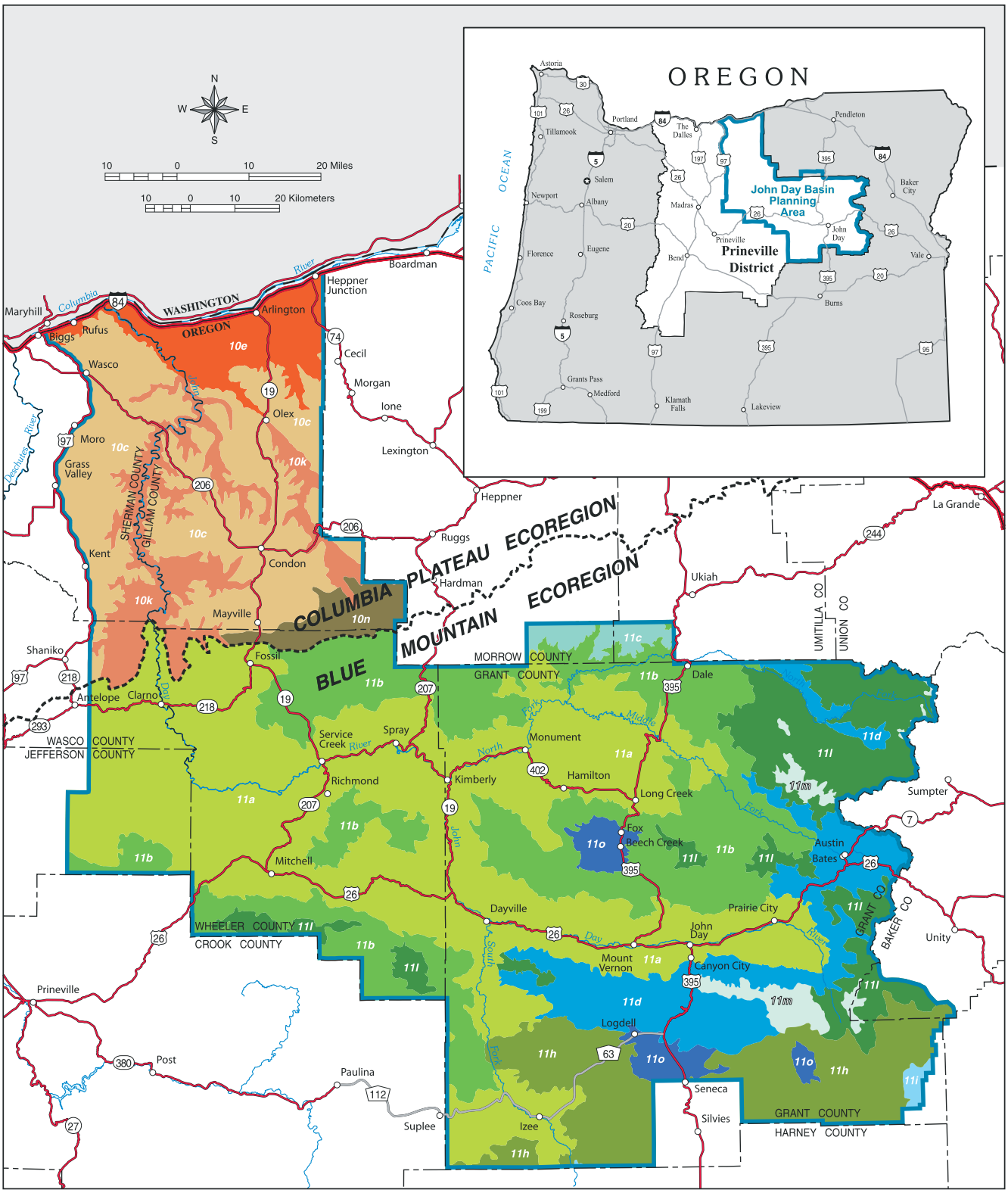
Map 3 : Subbasin Assessment Ratings



LEGEND

- Planning Area Boundary
- Oregon Level Three Ecoregions

Columbia Plateau Ecoregion

- 10c - Umatilla Plateau
- 10e - Pleistocene Lake Basins
- 10k - Deschutes / John Day Canyons
- 10n - Umatilla Dissected Uplands

Blue Mountains Ecoregion

- 11a - John Day / Clarno Uplands
- 11b - John Day / Clarno Highlands
- 11c - Maritime-Influenced Zone
- 11d - Melange
- 11h - Continental Zone Highlands
- 11i - Continental Zone Footlands
- 11l - Mesic Forest Zone
- 11m - Subalpine - Alpine Zone
- 11o - Cold Basins

Map 4: Environmental Protection Agency Ecoregions

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Table 1: Ecoregion Acres		
Ecoregion	**Subecoregion**	**BLM Plan Area Acres**
Columbia Plateau	Pleistocene Lake Basins	12,603
	John Day Canyons	79,319
	Umatilla Plateau	10,351
	Umatilla Dissected Uplands	885
Blue Mountains	John Day/Clarno Uplands	275,983
	John Day/ Clarno Highlands	56,440
	Maritime-Influenced Zone	2,503
	Cold Basins	40
	Melange	8,559
	Subalpine-Alpine Zone	45
	Mesic Forest Zone	561
	Continental Zone Highlands	8,678
	Continental Zone Foothills	184
Plan Area	**TOTAL**	**456,151**

Columbia Plateau Ecoregion

The Columbia Plateau Ecoregion, which covers about 32,100 square miles, occurs in portions of Idaho, Oregon, and Washington. About 20 percent of the planning area (6630 square miles) is within this Ecoregion. The Oregon portion of the Ecoregion extends from the eastern slopes of the Cascades Mountains, south and east from the Columbia River to the Blue Mountains. The centerpiece of the Ecoregion, the Columbia River, has greatly influenced the surrounding area, with cataclysmic floods and large deposits of wind-borne silt and sand. Over time, winds scoured the floodplain, depositing silt and sand across the landscape and creating ideal conditions for agriculture: rolling lands, deep soil, and plentiful flowing rivers including the lower stretch of the John Day River. The Ecoregion is made up entirely of lowlands, with an arid climate, cool winters and hot summers.

The Columbia Plateau produces the vast majority of Oregon's grain, and grain production is the heart of the agricultural economy. The Columbia Plateau produces the second-highest agricultural sales per year for any ecoregion in Oregon. More than 80 percent of the Ecoregion's population and employment is located in the Umatilla County portion of the Ecoregion, which includes Pendleton and Hermiston. Other population centers include The Dalles, Condon, and Heppner. Almost all of the Columbia Plateau Ecoregion is privately owned.

The foundation of the Columbia Plateau Ecoregion is its geology. Beginning 17 million years ago, massive eruptions of basalt flowed out of cracks or "vents" in the earth. These vents were located in northeastern Oregon, central western Idaho and southeastern Washington and produced lava flows over a period of 11 million years. This layering of basalt flows formed the Columbia River Basalt Group (CRBG) (Orr et al., 1992). Erupting from large fissures measuring 10 to 25 miles in length, the molten basalt filled basins in southeastern Washington and northeastern Oregon (Orr et al., 1992). The average volume of each flow was more than 100 cubic miles of basalt with some single flows exceeding 500 cubic miles. In total, approximately 42,000 cubic miles of basalt flowed over an area almost the size of the state of Washington, ranking the CRBG as the second largest flood basalt group in the world (Bishop, 2003; Orr et al., 1992). Southward, the CRBG continues to thin and tapers out in the Blue Mountains. Individual flows can be up to 200 feet thick, but vary substantially.

The flood basalt flows of the CRBG had dramatic effects on the Columbia River. Prior to eruption of the basalt flows, the ancestral Columbia River was situated far south of its present location. Gorge-filling basalt flows periodically plugged and disrupted the flow of the Columbia River, eventually forcing it northward to its modern day location.

Subecoregions of the Columbia Plateau

Within the Planning Area the Columbia Plateau contains 4 Subecoregions: the Pleistocene Lake Basin, Umatilla Plateau, Deschutes/John Day Canyons, and Umatilla Dissected Uplands.

The **Pleistocene Lake Basin** is a nearly level to undulating lake plain with very little surface water runoff. Surface geology consists of ancient lake and flood deposits associated with ice plugged lakes from 2 million years ago. These glacial lakes backed up water then suddenly released catastrophic flood waters that permanently scarred the landscape on its' way to the ocean. Lake Condon in the northeastern portion of the plan area is one of these ancient glacial lakes. Major vegetation is sagebrush steppe includes needleandthread grass, Indian ricegrass, bluebunch wheatgrass, Sandberg bluegrass, and basin big sagebrush. Alien cheatgrass covers broad areas. The sagebrush steppe is used primarily for irrigated cropland; some rangeland; and irrigated poplar tree farms for pulp. Crops include winter wheat, potatoes, alfalfa, and silage corn.

Elevations range from 300 to 1200 ft. There is very little relief to the landscape; only 10-200ft. The climate is very dry. The Pleistocene Lake Basins generally receive the most precipitation from November through February. These winter storms bring rain to lower elevations and snow to higher ridges and peaks. Mean annual precipitation ranges from 7 to 10 inches. Mean annual frost free days range from 140 to 200.

The **Umatilla Plateau** is a nearly level to rolling, loess-mantled plateau. Glacial features such as patterned-ground are common. Most streams are ephemeral. Surface geology was created by the Wapanum and Grande Rhonde flows of the Columbia River Basalts. The basalt occasionally displays erosion or deposition from glacial activity. Vegetative cover of the Umatilla Plateau is primarily bluebunch wheatgrass with scattered sagebrush steppe, Sandberg bluegrass, and Idaho fescue. Stiff sagebrush occupies very shallow soils sites. Introduced cheatgrass covers broad areas of this Subecoregion. Agriculture consists of mostly cropland and some grassland. Non-irrigated winter wheat is grown using the crop–fallow rotation method. Irrigated land grows winter wheat, alfalfa, and barley

Elevations range from 1000 to 3200 feet. Occasionally, valleys cut down several hundred feet from the plateau. The nearly level to rolling relief varies between 200 and 600 feel. Mean annual precipitation ranges from 9 to 15 inches. Most streams are ephemeral. The mean annual frost free days vary from 100 to 170.

The **Deschutes/John Day Canyons** are very steep to precipitous canyonlands containing the Deschutes and John Day rivers. Surface geology is the same as the Umatilla Plateau but the rivers have exposed the depth of these layers. The land is sparsely covered by grasses and shrubs. Land is used for livestock grazing and wildlife habitat. Soils contain a significant amount of fragmented rock. Vegetation across this sagebrush steppe includes bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, Wyoming big sagebrush, and cheatgrass. White alder, mockorange, western clematis, and choke cherry run along narrow canyon riparian areas.

Elevations range from 200 to 3600 feet, with deep valleys cutting down 1000 to 2000 feet. Mean annual precipitation ranges from 9 to 14 inches. The mean annual frost free days vary from 100 to 190.

The **Umatilla Dissected Uplands** are dissected, hilly uplands with a terrace-like appearance. Slopes are rolling to very steep. Surface geology consists of Grand Rhonde Basalts with canyons cutting down through the older John Day and Clarno Formations. These uplands are mostly used as rangeland and wildlife habitat. In higher elevations, north-facing slopes are forested. Vegetation is primarily wheatgrass–bluegrass/ Idaho fescue, bluebunch wheatgrass, and Sandberg bluegrass. Forested, higher elevation, north-facing slopes contain Douglas-fir, ponderosa pine, snowberry, pinegrass, and ninebark.

Elevations range from 1600 to 4400 ft. Hills rise and fall 500 to 1500 ft. Mean annual precipitation ranges from 9 to 14 inches. Mean annual from free days vary from 100- 160.

Blue Mountains Ecoregion

At 27,380 square miles, the Blue Mountains Ecoregion is the largest in Oregon, accounting for about 80 percent of the planning area (6630 square miles). Named for its largest mountain range, the Blue Mountains, this Ecoregion is a diverse complex of mountain ranges, valleys and plateaus containing deep rocky-walled canyons, glacially cut gorges, sagebrush steppe, juniper woodlands, mountain lakes, forests, and meadows. Broad river valleys support ranches surrounded and the surrounding irrigated hay meadows and wheat fields. Elevation influences a varied climate that ranges in temperature and precipitation. Overall, the Ecoregion has short, dry summers and long, cold winters. Much of the precipitation falls as snow and snow melt gives life to the rivers and irrigated fields.

Timber products and cattle production are the economic mainstays of the Ecoregion, but dryland wheat and alfalfa are important in the river valleys. The Ecoregion supports some of the finest big game hunting in Oregon and attracts tourists year-round to the scenic lakes and rivers, geologic features, and alpine areas that characterize the area. The cities of Mitchell, Dayville, Monument and John Day benefit from this thriving tourist industry.

While the Blue Mountain Ecoregion contains some of the largest intact native grasslands in Oregon and several conservation areas, fire suppression, selective timber harvest, and unsustainable grazing management have impacted habitat for wildlife. These changes have resulted in changes in vegetation which has increased vulnerability of forests to insects, disease, and effects of severe wildfire. The result has become a new compliment of invasive species that gain a foothold after sagebrush steppe fires move through the area. .

The foundation of the Blue Mountains Ecoregion is its geology. Approximately 200 million years ago, seas covered the entire state of Oregon. The Pacific Coast shoreline was in Idaho and eastern Washington (Orr et al., 1992). The Blue Mountains were a series of volcanic island chains (similar to present day Hawaii) off the Mainland Coast. These islands were perched on top a slab or plate of oceanic crust in the Pacific Ocean. (See Figure 1)

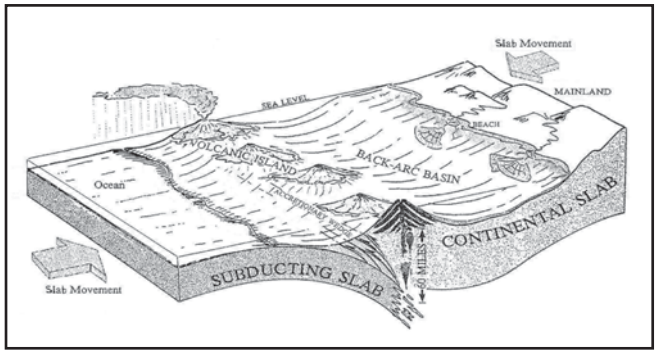

Figure 1: Underlying Geology

Drawing modified from William and Elizabeth Orr, published with permission of the authors.

As the slabs moved toward each other, the Oceanic slab sunk beneath the North American Continental Slab. The Oceanic slab scrapped off the Volcanic Islands onto the Mainland before diving down or "subducting"under the mainland. Across 400 million years, many chains of volcanic islands sprouted and were scrapped or "accreted" onto the North American Continent. Oceanic sediment and ash from the volcanoes were sandwiched onto the mainland in between the volcanic islands. These series of collisions created new landmasses called "terranes." This succession of terranes displaced the coast to its current location.

Three terranes are recognized in the John Day planning area: Baker, Grindstone, and Izee. Each terrane contains unique groups of rocks and fossils. The Grindstone terrane contains some of the oldest rocks in Oregon. Limestone and other layered rocks from about 380 million years old. The Baker terrane is composed of heated and folded rocks from the oceanic crust. Table 2 displays the major rock types and ages of all three terranes.

Between 120 and 160 million years ago, these terranes were intruded by magmas that later cooled to form masses of granodiorite and gabbro (Orr et al., 1992). Along with the magma came hot fluids that mineralized the surrounding rocks with gold-bearing veins (Brooks and Ramp, 1968; Bishop, 2003).

FIGURE 2:
CLARNO FORMATION

Table 2: Accreted terranes in the planning area with rock types and age

Terrane	Major Rock Types	Age
Grindstone	limestone, mudstone, siltstone, sandstone, chert, argillite	about 380 – 235 million years agp
Izee	volcanic and volcaniclasitc sedimenatary rocks	about 220 – 175 million years
Baker	Peridotite, gabbro, basalt, shale, argillite, chromite, and dioroite	about 285 – 175 million years

The oldest rocks that formed on the local surface of the Blue Mountain Ecoregion are of the *Clarno Formation*.(see Figure 2) Placement of these rocks began approximately 50 million years ago during the birth of a the Clarno volcanoes in eastern Oregon (Bishop, 2003). The Cascade Mountains were not present at that time and the Pacific Ocean shoreline was east of the modern day location of the Cascades (Orr, et al., 1992). Moist air from the Pacific Ocean created a wet tropical climate and supported lush woodlands and open grasslands. The Clarno volcanoes erupted large quantities of ash, rhyolite, and andesite. Thick, loose ash was deposited on steep volcano slopes. The ash frequently mixed with water to form large mudflows. These flows moved like molasses over the landscape, entombing both plants and animals, and preserving them as fossils. Plant fossils found in these deposits include petrified wood, leaves, nuts, fruits, and seeds of tropical hardwoods (Retallack et al., 1996). Fossilized remains of prehistoric horses and other mammals are also found in the Clarno Formation.

About 33 million years ago, the climate shifted from tropical to temperate, Clarno volcanism ceased and a short period of erosion ensued (Bishop, 2003). Then, a new episode of volcanic activity commenced, producing the rocks and ash beds of the *John Day formation* (See Figure 3). The volcanoes of the John Day produced explosive ash eruptions and flows that blanketed much of the region. Dense clouds of hot ash swept across the landscape and fused into “tuffs”. Basalt, andesite, and rhyolite lavas also flowed from these volcanoes. Rapidly deposited ash and mud from volcanic activity provided ideal conditions for fossilization of the plants and animals living in the region at the time. Preserved leaves from dawn redwood (metasequoia) and alder are common in these deposits (Retallack et al., 1996). Animal fossils include various prehistoric cats, dogs, horses, camels, rodents, and rhinoceroses.

Approximately 16 million years ago, massive flows of basalt erupted from large cracks holes near Monument and Kimberly. The lava flowed out at speeds up to 30 miles per hour. Layer upon layer of columnar basalt form the Picture Gorge Basalts (Orr et al., 1992). Between the basalt layers are thin bands of silt and limestone, telling us that there was often a lull between successive volcanic flows. The Picture Gorge Basalts cap the John Day and Clarno Formations.

Figure 3: John Day Formation

Figure 4: Picture Gorge Basalts on top of Clarno Formation US Park

Service Photo from 1925

Subecoregions of the Blue Mountains

The Blue Mountains includes nine Subecoregions in the planning area, including: JohnDay/Clarno Uplands, JohnDay/Clarno Highlands, Maritime Influenced Zone, Melange, Continental Zone Highlands, Continental Zone Foothills, Mesic Forest Zone, Subalpine Zone, and Cold Basins.

The **JohnDay/Clarno Uplands** are moderately to highly dissected hills and low mountains. Hills are rolling to steep and mountain slopes are steeply sloping. Scattered buttes occur, throughout the hills and mountains. Major valleys are formed by the John Day River. Surface geology consists of volcanic ash, alluvium, and piedmont gravels from the Clarno and John Day formations. Basalt, tuff, andesite, rhyolite, and breccia from Picture Gorge Basalt and other isolated volcanic activity are also part of the surface geology. Dominant vegetation associations include wheatgrass–bluegrass and juniper steppe woodland. The vegetation includes Bluebunch wheatgrass, Idaho fescue, basin wildrye, Wyoming big sagebrush, and Thurber needlegrass. Western juniper woodland transitions into higher elevation ponderosa pine forest. Riparian areas express white alder, mockorange, chokecherry, clematis, willows, black cottonwood, and water birch.

Elevations range from 1600 to 4400 feet and relief varies from 400 to 2500 feet. Mean annual precipitation ranges from 10 to 16 inches. Mean annual frost free days vary from 70 to 150.

The climate of the John Day/Clarno Uplands has a noteworthy history of intense thunderstorms. Occasional thunderstorms produce intense precipitation that localized flooding (“flash floods”) occurs.

Dr. John Merriam, a University of California paleontologist, experienced just such a flood during a fossil hunt in 1900. On June 23, Merriam and a companion were digging near Bridge Creek, 6 miles downstream from Mitchell in central Oregon. They were working in the shade of a low cliff under a partly cloudy sky. Suddenly,

> *...there began to fall what might best be called balls of water. Thinking the shower would soon pass, we kept at work, but heavy clouds swung across the sky. During the next hour, as we made our way out of the area, we were exposed to one of the hardest rain storms I have ever seen.*

That storm devastated a large area in Wheeler County. Crops were destroyed, mud- and rockslides were common, and farm buildings were destroyed. Eyewitnesses reported hailstones up to 6 inches in diameter. Fortunately, no lives were lost. Not far away from the site of that storm, in a secluded graveyard, are buried Nancy Wilson and three of her children. They died on June 2, 1884, when an intense thunderstorm sent a "wild torrent of muddy boulder-laden water over the flatlands of what is now Painted Hills State Park."

The same area was also the scene of one of the largest flash floods in the United States. On July 13, 1956, intense thunderstorms and heavy rain occurred near Mitchell between 5 and 6 in the evening. During the event Bridge Creek rose from its depth of 1 foot to a torrent, that destroyed upwards of 20 buildings including houses, businesses, a garage, and a post office. A highway was blocked by washouts and mud and rock slides. People who had accidentally left open containers out during the 50-minute storm calculated that the rainfall was 3.5 inches in Mitchell and 4 inches in Girds Creek. This was more than 25% of the area's annual average rainfall!

Intense thunderstorms similar to those in the Mitchell area have been observed near Spray and most recently along the South Fork John Day River. These intense thunderstorms frequently wash across the John Day/Clarno Uplands, taking out roads and creating new river features.

The **John Day/Clarno Highlands** consist of moderately to highly dissected, steeply sloping low mountains and rolling hills. The area includes broad streams fed more by springs than by snow melt. Surface geology is similar to that of the John Day/Clarno Uplands, but also includes colluvium from the eroding Picture Gorge Basalts. Dominant vegetation includes western ponderosa pine forest/ open ponderosa pine, Douglas-fir, and western juniper. Vegetation includes mountain-mahogany, snowberry, mountain big sagebrush, antelope bitterbrush, elk sedge, Idaho fescue, and bluebunch wheatgrass. Riparian areas express grand fir, mountain alder, red-twig dogwood, ninebark, Wood's rose, Rocky Mountain maple, and various willows. These forest and woodland areas are used for woodland grazing, logging, and recreation.

Elevations range from 3000 to 6200 feet. The mountains and hills rise from 200 to 2000 feet. Mean annual precipitation ranges from 16 to 28 inches. Mean annual frost free days vary from 30 to 100.

The **Maritime-Influenced Zone** consists of gently-sloping to hilly volcanic plateaus and mountain valleys. Springs occur throughout this zone. Most of the surface geology consists of the Grande Rhonde Basalt flow which was part of the Columbia River Basalt Flows. Major vegetation associations include Western ponderosa pine forest, and grand fir–Douglas-fir forest. Most of the forest is composed of ponderosa pine with scattered Douglas-fir and grand fir. Dense forest understory and riparian shrub cover consists of snowberry, spirea, ninebark, serviceberry, and red-twig dogwood. Herbaceous ground cover includes heartleaf arnica, pinegrass, elk sedge, Idaho fescue, Sandberg bluegrass, and bluebunch wheatgrass. This forested landscape is primarily used for logging, grazing, wildlife habitat, and recreation.

Elevations range from 3000 to 6000 feet. The plateaus drop down 150 to 1600 feet to valley bottoms. The climate is moderated by moderate maritime weather and oceanic trends. Mean annual precipitation ranges from 20 to 40 inches. Most of this annual precipitation arrives in the late winter and early spring. Compared to other areas in Oregon, the monthly precipitation values are fairly evenly distributed. Mean annual frost free days range from 40 to 80.

The **Melange** consists of mid-elevation mountains with few perennial streams. The surface geology was created by the sandwiched ocean sediments during accretion events and intrusions of magma through those layers. Stiff flows of the Strawberry volcanics cover portions of this Subecoregion. These events combine to create a surface geology consisting of a mix of colluvium, basalt, andesite, rhyolite, granite, partly metamorphosed limestone, marble, chert, argillite, shale, greywacke, serpentine, greenstone, and schist. Major vegetation associations are western ponderosa pine forest, juniper steppe woodland. Vegetation includes ponderosa pine, Douglas-fir, subalpine fir, lodgepole pine, western larch, grand fir, grouse huckleberry, snowberry, prince's pine, sidebells pyrola, twinflower, pinegrass, elk sedge, and heartleaf arnica. Riparian areas are vegetated with mountain alder, red-twig dogwood, prickly currant, black currant, Columbia monk's hood, and bluebells. This forested landscape is used for woodland grazing, wildlife habitat, and mining. Only limited logging occurs due to the difficulty in reforesting the droughty, exposed soils. Historic placer mining for gold has altered the structure of many streams.

Elevations range from 3500 to 7400 ft. The local relief varies from 600 to 3400 ft. Mean annual precipitation ranges from 16 to 35 inches. Mean annual frost free days range from 30 to 90.

The **Continental Zone Highland** consists of moderately dissected, mountainous volcanic plateaus. Mountain slopes are steep and scattered with cinder cones. Surface geology consists of colluvium and volcanic ash from the Strawberry Volcanics. Major vegetation associations are western ponderosa pine forest, grand fir–Douglas-fir forest, and sagebrush steppe/ Ponderosa pine. Vegetation includes Douglas-fir, grand fir, juniper, antelope bitterbrush, snowberry, mountain-mahogany, mountain big sagebrush, stiff sagebrush, elk sedge, pinegrass, bluebunch wheatgrass, and Idaho fescue. This forested area has a xeric shrub or bunchgrass understory. These highlands are used for livestock grazing, logging, and recreation.

Elevations range from 4000 to 6700 feet. Local relief varies from 400 to 2000 feet. Mean annual precipitation ranges from 16 to 30 inches. Mean annual frost free days vary from 50 to 80.

The **Continental Zone Foothills** consist of hills and scattered buttes. A few perennial streams occur and originate in the surrounding mountain ranges. Much of the surface geology is basalt and ashflows from the Strawberry volcanics. Some of the Jurassic and Triassic graywacke, siltstone, and limestone are present across the foothills. Triassic layers consist of gabbro and metamorphic rock. Vegetation associations include sagebrush steppe/ Bluebunch wheatgrass, mountain big sagebrush, Idaho fescue, Wyoming big sagebrush, Sandberg bluegrass, and, on schist, Nevada greasebush. The shrub- and grass-covered land is utilized for livestock grazing and wildlife habitat

Elevations range from 1800 to 6000 feet. Local relief varies from 200 to 2500 feet. Mean annual precipitation ranges from 9 to 18 inches. Mean annual frost free days vary from 50 to 140.

The **Mesic Forest Zone** is a dissected, volcanic plateau with some mid-elevation mountains. Intermittent headwater streams or perennial streams that are fed by snow melt from adjacent mountains. Surface geology and bedrock includes basalt flows, volcanic ash and colluvium, associated with Picture Gorge Basalts. The Mesic Forest Zone geology also includes some older areas of granite, sedimentary rock, volcanic and partly metamorphosed sedimentary and volcanic rocks. Major Vegetation associations include grand fir–Douglas-fir forest. Cold slopes contain Sub alpine fir, Engelmann spruce, mountain hemlock, lodgepole pine, big huckleberry, grouse huckleberry, Utah

honeysuckle, side bells pyrola, round leaved violet, and northwestern sedge. Cool moist slopes exhibit grand fir, western larch, queen's cup beadlily, and prince's pine. The vegetation on drier slopes includes Douglas-fir, ponderosa pine, mountain maple, ninebark, pinegrass, elk sedge, and bigleaf sandwort. This forested landscape is used for logging, woodland livestock grazing, wildlife habitat, and recreation.

Elevations range from 4000 to 7000 feet. Local relief varies from 400 to 2500 feet. These areas are influenced by marine air coming through the Columbia River Gorge to the west. Mean annual precipitation ranges from 30 to 60 inches. This comes mostly in the form of snow and persists into late spring. Mean annual frost free days vary from 15 to 70.

The **Subalpine-Alpine Zone** includes high elevation, glaciated mountains with arêtes, cirques, mountain slopes, tarns, permanent snowfields, and a remnant glacier. The high gradient streams have boulder and cobble substrates. Surface geology includes volcanic ash and colluvial deposits from the Strawberry Volcanics and Picture Gorge Basalts. Intrusive formations of basalt and andesite are the result of magma pushing up through layers of older rocks that changed the rocks as they cooled. The area is dotted with rock. Surface geology includes remnant glacial deposits associated with glaciers from glacial Lake Missoula, e.g., about 2 million years ago. The dominant vegetation associations are western spruce–fir forest and alpine meadows–barren. Common species include subalpine fir, whitebark pine, Engelmann spruce, and lodgepole pine. Dry south-facing slopes have mountain big sagebrush and Idaho fescue. Wet meadows contain heather and Parry's rush. The treeline is vegetated by krummholz. Alpine meadows are marked by green fescue and Hood's sedge. The highest elevations consist of rock outcrops, rubble land, and snowfields. This expanse of forest, meadowland, and bare rock is used for recreation, and wildlife habitat. The land is used for summer livestock grazing. The Subalpine-Alpine Zone is an important water source for lower elevation areas.

Elevations range from 6500 to 9900 feet. Local relief varies from 600 to 3000 feet. Mean annual precipitation ranges from 35 to 80 inches and is mostly snow. Mean annual frost free days vary from 10 to 30.

The **Cold Basins** are cold, wet valleys and basins. Most streams have been channelized, but undisturbed reaches are meandering, with well developed floodplains. Surface geology consists of recent alluvium and lacustrine deposits. Older layers are formed from ash and sediment. The dominant vegetation associations are sagebrush steppe and wetlands. Common vegetation includes sedges, mountain big sagebrush, low sagebrush, and Idaho fescue. Wetlands and wet meadows are covered with tufted hairgrass, Baltic rush, and alien Kentucky bluegrass. The pastureland, shrubland, grassland, and wetlands are heavily grazed by cattle and elk. Meadow hay is harvested for winter livestock feed.

Elevations range from 3600 to 6000 feet. Local relief is mostly level. Mean annual precipitation ranges from 12 to 25 inches and is mostly snow. Mean annual frost free days vary from 20 to 50.

Mineral Resources

Much of the early history of the North, Middle and Upper John Day basins involves the search for the "motherlode." For a few the search continues even today. More common material, such as sand, gravel, and aggregate literally form the foundation of community and regional infrastructure. Modern roads and building foundations would not be possible without these common materials.