introduced or hatchery supported sport fisheries). In general, however, these watersheds are strongly fragmented by extensive habitat loss or disruption throughout the component watersheds, and most notably through disruption of the mainstem corridor. Although important and unique aquatic resources exist, they usually are localized.

Terrestrial Community Types

We aggregated 165 cover type and structural stage combinations into 24 terrestrial community types (*Component Assessment*—Landscape). Terrestrial communities have changed from historic to current time periods. Late-seral forested communities, herbland, and shrubland have declined (table 17). Terrestrial community types were simulated across the Basin for a 400-year period using pre-European conditions as the initial point. These broad-scale estimates provided a range of conditions that may have existed in presettlement times. Departures from this range of conditions were developed to estimate the magnitude of broad habitat changes in forestlands and rangelands within subbasins. Estimating broad habitat departures from estimated historical ranges of conditions enabled us to infer potential effects on current and future species habitat. Habitat departure estimates can be useful in setting priorities for terrestrial ecosystem restoration activities, and understanding important trade-offs and risks associated with vegetation management. Examples of species associated with terrestrial community types are provided in table 18. If substantial shifts in a specific terrestrial community are projected, reference to this table provides insight into some species that may be affected.

We further collapsed the forest terrestrial community types having late-seral/single-layered, and late-seral/multi-layered structures into a "late" class. We then estimated departure[17] from historical ranges of conditions by subbasin for nine resulting Forestland terrestrial community types (table 19)

[17]Terrestrial community type departures were determined by comparing the current areal extent of each type to 75 percent of the historical ranges (simulated) of each type.

and three rangeland terrestrial community types (table 20). We estimated departures for those terrestrial community types that account for at least 1 percent of the subbasin area for any output period of the historical simulation run, or for the current condition.

Forest and Rangeland Cluster Descriptions

Each of the 164 subbasins in the Basin is unique. The challenge is to identify meaningful similarities among subbasins, while preserving these unique characteristics. We organized subbasins within clusters based on common ecological themes that highlight the similarities of subbasins grouped within clusters, while acknowledging substantive differences among the subbasins. These clusters reflect recurring patterns that emerged from the analyses. Clusters represent a simplified synthesis of common management history, resultant conditions, management needs, opportunities, and potential conflicts across large and complex landscapes.

Two sets of clusters emerged: six forestland and six rangeland groupings or clusters (figs. 38 and 39). The primary characteristics for the clusters are shown in tables 21 and 22. These clusters or groupings are a representation of the current ecological conditions for the Basin. As change occurs, the groupings would be expected to also change. The clusters can be useful to land managers as they make decisions about priorities, emphases, and where management activities might occur across the landscape in order to achieve specific goals and attain desired future conditions.

A brief description of each cluster in terms of its current characteristics and conditions is presented in the following paragraphs. Table 23 provides a quick highlight of the primary characteristics of each cluster, the primary risks to current ecological integrity, and primary opportunities to address ecological integrity. When a decline in occurrence of a terrestrial community is noted for a particular

Table 17—Changes of broadscale terrestrial communities between historical and current periods within the Basin assessment area.

Terrestrial community[1]	Historical area	Current area	Class change[2]	Basin change [3]
	------------------------------- percentage ---			
Agricultural	0.0	16.1	N.A.[4]	16.1[5]
Alpine	0.2	0.2	-0.2	0.0
Early-seral Montane Forest	8.7	7.9	-8.4	-0.7
Early-seral Lower Montane Forest	1.1	0.3	-76.8[5]	-0.9
Early-seral Subalpine Forest	1.2	1.8	48.2[5]	0.6
Exotics	0.0	2.1	N.A.[4]	2.1[5]
Late-seral Montane Multi-layer Forest	3.8	3.4	-11.2	-0.4
Late-seral Montane Single-layer Forest	0.8	0.9	8.4	0.1
Late-seral Lower Montane Multi-layer Forest	2.2	1.4	-34.6[5]	-0.8
Late-seral Lower Montane Single-layer Forest	5.6	1.1	-80.6[5]	-4.5[5]
Late-seral Subalpine Multi-layer Forest	1.2	0.5	-63.8[5]	-0.8
Late-seral Subalpine Single-layer Forest	0.6	0.8	36.3[5]	0.2
Mid-seral Montane Forest	10.5	16.6	58.6[5]	6.1[5]
Mid-seral Lower Montane Forest	4.9	7.5	53.0[5]	2.6[5]
Mid-seral Subalpine Forest	2.7	2.7	-1.0	0.0
Rock/Barren	0.2	0.2	0.0	0.0
Upland Herbland	14.9	4.9	-66.8[5]	-9.9[5]
Upland Shrubland	36.7	25.5	-30.5[5]	-11.2[5]
Upland Woodland	1.9	2.9	49.5[5]	0.9
Urban	0.0	0.2	N.A.[4]	0.2
Water	0.9	0.9	0.0	0.0

Note: numbers have been rounded.

[1]The terrestrial community types riparian herbland, riparian shrubland and riparian woodland comprised less than 1.0 percent historically and are not shown in the table.

[2]Class change = percent change historical to current for the terrestrial community.

[3]Basin change = percent change historical to current as a proportion of the Basin.

[4]Not applicable since the terrestrial community did not exist during the historical period.

[5]Ecologically significant changes.

Table 18—Examples of species associated with specific community types.

Terrestrial community type	Examples of associated species
Lower Montane:	
Forest generalist	Least chipmunk, dusky-footed woodrat, Nashville warbler
Late-seral	Olive-sided flycatcher, white-headed woodpecker, pygmy nuthatch
Mid/Upper Montane:	
Forest generalist	California myotis, creeping vole, blue grouse
Late-seral	American marten, northern spotted owl, northern saw-whet owl
Subalpine:	
Forest generalist	Wolverine
Late-seral	Boreal owl, heather vole, chestnut-backed chickadee
Herblands:	Idaho ground squirrel, savannah sparrow, bobolink, Say's phoebe, greater sandhill crane
Shrublands:	Mojave black-collared lizard, pygmy rabbit, black-throated sparrow, loggerhead shrike
Mixed conifer woodlands:	Uinta ground squirrel, fringed myotis, mountain quail
Juniper woodlands:	plain titmouse, pinyon jay

Table 19—Percent of subbasins within each Forest Cluster having a net departure [reduction (-) or increase (+)] in terrestrial community type from 75 percent range of the historic 400 year simulation run.

Terrestrial community type	Forest Cluster					
	1	2	3	4	5	6
	---------------------------- percent ----------------------------					
Lower Montane Early-seral	-36	-73	-85	-82	-91	-77
Mid-seral	+18	+42	+54	-18	+37	+27
Late-seral	-54	-95	-85	-96	-33	-82
Middle and Upper Montane Early-seral	+18	-6	-62	-65	-54	-41
Mid-seral	+9	+21	+62	+78	+13	+32
Late-seral	-64	-27	-23	-87	+42	-55
SubAlpine Early-seral	+36	+58	+39	-4	+4	+18
Mid-seral	+9	-26	-16	+8	-29	-5
Late-seral	-73	-42	-38	-91	+4	-41

Source: Hann and others (1996).

Table 20—Percent of subbasins with range clusters having a net departure, reduction (-) and increase (+), in 400 year simulation run.

Terrestrial community type	Range Cluster					
	percent					
	1	2	3	4	5	6
Herblands	-100	-15	-68	-100	-62	-84
Shrublands	-67	-46	-46	-71	-4	-39
Mixed Conifer Woodlands	+100	-23	-32	+29	0	-24

Source: Hann and others (1996).

cluster, reference to table 18 provides examples of the species that are likely to be affected by a decline. More details on the terrestrial communities and hydrologic parameters are in the *Component Assessment*—Biophysical and Landscape Dynamics chapters.

Forest Cluster 1

High integrity cold- and moist-forest—These subbasins contain the greatest proportion of high forest, aquatic, and hydrologic integrity of all clusters. Subbasins in this cluster are dominated by wilderness and roadless areas and contain cold and moist/cold forests that are the least altered by management. Subbasins in this cluster are predominantly high elevation subbasins where forest structure and composition have been simplified by fire exclusion, and there has been little alteration from timber harvest. Late-seral structure has declined in all three (montane, lower montane, and subalpine) elevation settings. Early-seral and mid-seral structure has increased. Mean changes in fire severity and frequency are the lowest for this cluster. Where important changes have occurred, mixed-severity fire regimes have tended toward lethal regimes and fire frequency has generally declined as a result of effective fire suppression. Relatively limited road access in cold and moist forests of this cluster suggests that forest habitats provide a relatively high degree of security for a variety of species vulnerable to human exploitation

and/or disturbance (such as, the Rocky Mountain gray wolf, grizzly bear, wolverine, lynx, moose, and elk). Hydrologic integrity of these subbasins is the highest of any forestland in the Basin. Connectivity among subwatersheds supporting native fish strongholds is good and strongholds for multiple species often exist in subwatersheds throughout these subbasins. Fish populations and communities associated with these subbasins are likely the most resilient in the Basin, are able to withstand large-scale disturbance events, and will likely persist without any human intervention.

Forest Cluster 2

Moderate and high-integrity forest—Subbasins in this cluster represent a mix of moderate to high forest, hydrologic, and aquatic integrity. In general the forestland contains semi-wild and moderately-roaded areas. Landscape vegetation patterns and disturbances are more highly altered in lower- and mid-montane settings, which coincide with higher road densities. Late- and early-seral structure has declined in most elevation settings with compensating increases in mid-seral, resulting in more homogeneous forest structure. Subbasins in this cluster provide relatively secure habitats for vertebrates vulnerable to human disturbance. The tendency in dry forests has been to move from non-lethal, to mixed and lethal fire severities with declining fire frequencies. The tendency in moist forest groups has been to move from mixed to lethal fire severity with

Table 21—Summary of Characteristics of Forest Clusters.

Variable	Forest Cluster					
	1	2	3	4	5	6
	------------------------------ percent of area ------------------------------					
Ownership						
BLM/FS	80	86	40	58	50	35
Other	20	14	60	42	50	65
Potential Vegetation Groups						
Dry Forest	13	26	22	14	43	23
Moist Forest	23	25	33	67	6	16
Cold Forest	47	30	15	7	4	9
Dry Grass/Shrub	7	11	6	3	24	15
Cool Shrub	3	3	1	1	8	11
Other	8	5	24	8	15	26
Forested Vegetation Groups (% of forested area in each)						
Dry Forest	16	37	55	18	81	51
Moist Forest	27	27	52	73	11	21
Cold Forest	57	36	13	9	8	28
Road Density Classes						
Low or none	85	62	32	20	22	36
Moderate or higher	15	38	68	80	78	64
Cropland/pasture	0	3	20	2	11	21
<12" annual precipitation	1	4	2	3	14	14
Fire frequency change	37	60	66	51	60	60
Fire severity increase	36	50	57	47	35	36
High wildland/urban fire interface risk	0	17	6	1	29	10
Moderate wildland/urban fire interface risk	29	61	36	13	30	23
Change in juniper woodland	0	0	0	0	0	0
Forest Integrity						
Low	0	10	67	86	79	59
Moderate	0	43	33	10	21	17
High	100	47	0	4	0	24
Range Integrity						
Low	0	29	100	57	100	66
Moderate	61	48	0	43	0	35
High	40	23	0	0	0	0
Aquatic Integrity						
Low	5	0	8	54	52	87
Moderate	38	59	85	46	44	13
High	58	41	7	0	4	0
Hydrologic Integrity						
Low	0	4	47	12	39	76
Moderate	4	30	49	54	41	17
High	96	66	4	34	20	7
Composite Ecological Integrity						
Low	0	0	4	83	96	100
Moderate	0	3	96	17	4	0
High	100	97	0	0	0	0

Source: ICBEMP GIS data (converted to 1 km² raster data).

Table 22— Summary of characteristics of Range Clusters.

Variable	Range Cluster					
	1	2	3	4	5	6
	----------------------------- percent of area -----------------------------					
Ownership						
BLM/FS	36	81	44	5	75	55
Other	64	19	56	95	25	45
Potential Vegetation Groups						
Dry Forest	29	21	34	8	10	12
Moist Forest	5	33	28	4	5	2
Cold Forest	1	34	14	30	11	4
Dry Grass/Shrub	32	4	4	26	45	50
Cool Shrub	22	1	2	3	20	9
Other	11	7	18	59	9	23
Rangeland Vegetation Groups						
Dry Rangeland	49	34	17	30	61	61
Cool Rangeland	34	8	8	3	27	11
Other	17	58	75	67	12	28
Road Density Classes						
Low or none	20	71	30	62	64	30
Moderate or higher	80	29	70	38	36	70
Cropland/pasture	9	3	14	56	5	17
<12" annual precipitation	23	1	2	51	33	38
Fire frequency change	37	51	67	17	24	17
Fire severity increase	18	47	49	13	16	9
High wildland/urban fire risk interface	32	7	12	0	6	8
Moderate wildland/urban fire risk interface	10	59	33	4	58	39
Change in juniper woodland	+ 12	0	0	0	0	0
Forest Integrity						
Low	100	6	76	79	12	37
Moderate	0	37	15	21	27	43
High	0	57	9	0	61	20
Range Integrity						
Low	100	6	76	100	26	79
Moderate	0	37	15	0	50	21
High	0	57	9	0	24	0
Aquatic Integrity						
Low	39	4	43	84	37	79
Moderate	61	24	50	16	57	18
High	0	72	7	0	6	3
Hydrologic Integrity						
Low	34	6	49	100	7	44
Moderate	66	16	35	0	35	34
High	0	78	16	0	58	22
Composite Ecological Integrity						
Low	100	0	58	97	8	80
Moderate	0	3	32	3	63	20
High	0	97	10	0	29	0

Source: ICBEMP GIS data (converted to 1 km² raster data).

Figure 38—Subbasins grouped into six Forest Clusters.

Figure 39—Subbasins grouped into six Range Clusters.

Table 23—Forest and Rangeland Clusters - primary characteristics, risks to ecological integrity, and opportunities to address risks to integrity.

Forest or Range Clusters	Primary characteristics	Primary risks to ecological integrity	Primary opportunities to address risks to integrity
Forest 1	1. Moist and Cold Forest types 2. Minimally roaded 3. High aquatic, forest, hydrologic, and composite integrity	1. Severe fire potential in lower elevations 2. Higher elevations sensitive to soil disturbances (i.e., roading)	1. Prescription of natural or prescribed fire to reduce risks of severe fire 2. Reduction of stocking levels in lower elevations - reductions of fire severity. Maintenance of integrity in higher elevations
Forest 2	1. Minimally roaded 2. Mix of high and moderate forest, hydrologic, and aquatic integrity 3. High composite integrity 4. Mix of cold, moist, and dry forest types (nearly equal)	1. Cold forest types sensitive to soil disturbance (i.e., roading) 2. Fire severity in lower elevations and dry forest types 3. Aquatic integrity induced by low forest integrity in dry and moist forest types	1. Reduction of fire threat in lower elevations and manage road densities 2. Improvement of aquatic integrity through improving connectivity 3. Reduction of fire severity through restoration practices
Forest 3	1. Moderately roaded 2. Moderate aquatic and composite integrity 3. Low and moderate forest and hydrologic integrity 4. Dry and moist forest types	1. Fire severity in dry/moist forest types 2. Aquatic integrity at risk in areas of high fire potential 3. Old/late forest structures in managed areas	1. Restoration of forest integrity 2. Maintenance of aquatic and hydrologic integrity 3. Management of road densities
Forest 4	1. Moist forest types 2. Highly roaded 3. Low forest, aquatic, and composite integrity 4. Moderate to high hydrologic integrity	1. Hydrologic and aquatic systems from fire potentials 2. Late and old forest structures in managed areas 3. Forest compositions - susceptibility to insect, disease, and fire	1. Restoratoion of late and old forest structure in managed areas 2. Connection of aquatic strongholds through restoration 3. Treatment of forested areas to reduce fire, insect, and disease susceptibility
Forest 5	1. Dry forest types 2. Low to moderate aquatic integrity and low forest integrity and low composite integrity 3. Sensitive watersheds to disturbance 4. Highly roaded	1. Fish strongholds from sediment/erosion potential 2. Forest composition and structure, especially old/late 3. Hydrologic integrity due to fire severity and frequency	1. Restoration of forest integrity through vegetation management 2. Restoration of old/late forest structure 3. Restoration of aquatic and hydrologic integrity by reducing risk of fire, insect, and disease and road management
Forest 6	1. Dry forest types 2. Low hydrologic, forest, aquatic, and composite integrity 3. Moderately roaded	1. Forest composition and structures especially old/late 2. Primarily present at finer resolutions	1. Restoration of forest structures 2. Maintenance of the scattered aquatic strongholds that exist 3. Reduction of risk of fire, insect, and disease

Forest or Range Clusters	Primary characteristics	Primary risks to ecological integrity	Primary opportunities to address risks to integrity
Range 1	1. Highest level of juniper woodlands 2. High road densities 3. Low forest, range, and composite integrity 4. Moderate aquatic and hydrologic integrity 5. Fire regimes are more severe	1. Juniper encroachment into shrubland 2. Forage for ungulates (wild/domestic) reduced through woodland encroachment 3. Noxious weed expansion	1. Reduction of forest stocking could improve forage/cover relationships for livestock and big game 2. Curtailment of juniper expansion 3. Curtailment of noxious weed expansion 4. Management of riparian areas to enhance stream bank stability and riparian vegetation
Range 2	1. Forested rangelands in moderate to high integrity 2. High aquatic, hydrologic, and composite integrity 3. Minimally roaded	1. Fish and aquatic systems from dry vegetation types with fire severity/frequency changes 2. Dry forest types - especially late/old structures 3. Aquatic system sensitivity to disturbance	1. Restoration of vegetation and fuels treatments in dry forest types 2. Maintenance of aquatic and hydrologic integrity - emphasize connectivity 3. Restoration of maintenance sagebrush ecotone 4. Restoration of forage production in winter range
Range 3	1. Low forest and range integrity 2. Low and moderate hydrologic, aquatic, and composite integrity 3. Highly roaded	1. Conflicts with big game management from conifer invasion reducing forage 2. Elevated fuel and fire from conifer invasion 3. Riparian conditions from disturbances 4. Increased susceptibility to insect, disease, and fire in forested areas	1. Management of to restore/ maintain riparian conditions 2. Prescription of fire to reduce risks from fire, insect, and disease in forested areas 3. Containment of noxious weeds 4. Maintenance of water quality for native and desired non-native fish
Range 4	1. Very low levels of FS/BLM lands 2. Lowest integrity in all components 3. Low levels of residual rangeland	1. Reduced fish habitat and populations from agricultural conversions	1. Reduction of threats to local populations of fish and their habitat
Range 5	1. Minimally roaded 2. Low croplands and other disturbances 3. High hydrologic and forest integrity 4. Moderate and low range and aquatic integrity 5. Moderate and high composite integrity	1. Continued declines in herb-land and shrubland habitats 2. Risks to local populations and habitats for fish	1. Maintenance restoration of riparian condition 2. Restoration of productive aquatic areas 3. Conservation of fish strongholds and unique aquatic areas
Range 6	1. Highly roaded 2. Highly altered from grazing and fire exclusion 3. High exotic species 4. Low composite integrity	1. Continued declines in herb-land and shrubland 2. Dry shrubland highly sensitive to overgrazing and exotic grass and forb invasion	1. Containment of exotic weed expansion 2. Maintenance restoration of riparian conditions 3. Management of grazing intensity, duration, and timing 4. Conservation of fish strongholds and unique aquatic areas

reduced fire frequency. Aquatic population strong-holds are generally associated with headwaters and unroaded portions of the subbasins. These subbasins have good connectivity via unimpeded river corri-dors. Subbasins within this cluster are ideal for restoration because relatively small investments could secure relatively large, diverse and functional systems.

Forest Cluster 3

Moderate and low-integrity forest—Forests in these subbasins are generally rated as low in integrity with the highest mean departures in fire frequency and severity. The subbasins have moderate road densi-ties. Areas of late- and early-seral structures have declined most significantly with compensating increases in mid-seral structures with the net result being more homogeneous forest structure. Verte-brates vulnerable to human disturbance have limited secure habitat. Risks are highest for those species relying on late- or early-seral forest structure and those species using small non-forest openings or canopy gaps. The aquatic ecosystems may be highly productive and resilient in the face of disturbance, or the cumulative effects of disturbance in streams may simply lag behind changes in watersheds. Consider-ing current knowledge and uncertainty of outcomes for existing fish strongholds, management to restore forest structure and composition may well represent some of the most important risks and potential conflicts for maintaining productive aquatic ecosys-tems. Watershed analysis could be an important tool for increasing the certainty of outcomes from terres-trial ecosystem restoration activities in these subbasins. Hydrologic integrity of these subbasins is low to moderate. Disturbance of hydrologic func-tion from past management activities is moderate to high, due in large part to roads, mines, and cropland conversion of lower-elevation valleys. Most subbasins in this theme are classified as having mod-erate aquatic integrity. Subwatersheds may be vul-nerable to future degradation owing to existing development or dramatic changes in watershed processes from large fires that could produce exten-sive, synchronous changes in watershed condition.

Forest Cluster 4

Low integrity, moist forests—Forests in these subbasins exhibit low integrity and are likely to be dominated by moist, productive forest types and be heavily roaded. Forest structure has likely been altered by past management and forests generally show moderate to strong shifts in fire severity, but less change in fire frequency. Forest structure shows: decreases in late-seral structures in all elevation settings; large increases in mid-seral; decreases in early-seral; and a more homogeneous structure overall (see photo 7). Risks to terrestrial vertebrates that rely on late or early forest structure in the moist forest have increased significantly. Those species that are vulnerable to human distur-

Photo by R. Graham

Photo 7—This young mixed forest stand of western redcedar, western hemlock, and western white pine in northern Idaho illustrates characteristics of a moist forest cluster.

bance or exploitation have relatively low amounts of secure habitat as a result of extensive roading. Forest homogeneity has resulted in fewer canopy gaps and non-forest openings. Although the aquatic systems often have the connectivity to sustain multiple fish life histories, the distribution of important watersheds is often fragmented, perhaps through habitat disruption associated with intensive forest management. Hydrologic integrity of these subbasins is moderate. The moist landscapes are often associated with relatively high-frequency rain on snow events. Where timber harvest and roading are extensive, as in the Coeur d'Alene and St. Joe subbasins, peak flow events may be exaggerated resulting in aggravated channel scour and aggradation that may negatively influence some salmonids and their habitats (Rieman and McIntyre 1993). Fuel management is a priority for maintenance of hydrologic function in these subbasins. Aquatic integrity in these subbasins is judged low or moderate. Recovery of both aquatic and terrestrial ecosystems requires active and intensive restoration efforts. These subbasins have high restoration potential with much to gain and relatively little to lose.

Forest Cluster 5

Low-integrity, dry forests—Forests in these subbasins are dominated by dry-forest with approximately 60 percent of the area showing changes in fire frequency. They are extensively roaded and have little wilderness. Late-seral structure increased significantly in montane forests resulting from conversion of a variety of forest structures dominated by shade-intolerant conifers (such as, pine) to forests dominated by shade-tolerant species (such as, fir). Mid-seral structure increased in lower montane and montane settings. Increases in late-seral montane have benefited species preferring densely-stocked forests composed of shade-intolerant species (for example, American marten, northern spotted owl, and red-backed vole). Habitat for species preferring more open, park-like structures (for example, white-headed woodpecker, silver-haired bat, and flammulated owl) has declined. Nearly 80 percent

of the area in this cluster is classified as low forest and rangeland integrity. Hydrologic integrity of these subbasins is low to moderate. The subbasins associated within the Grande Ronde and John Day river basins are in better condition than average, supporting from 15 to 30 percent of the potential salmonid subwatersheds in a strong condition. Several of the subbasins in this cluster (that is, Lower Deschutes, Upper and Lower Grande Ronde, Umatilla, and the Upper, Middle, and North forks of the John Day) support sensitive populations of anadromous salmonids (the latter three subbasins also support endangered chinook salmon). Forests are less productive than those associated with Forest Cluster 4, and historical disturbance regimes imply the need for more frequent silvicultural and prescribed fire treatments. These subbasins show moderate opportunities for restoration.

Forest Cluster 6

Mixed-integrity dry and moist forests with low aquatic integrity—Half the forested area in this cluster is composed of dry forest types, the other half is split between dry and cold forest types. This cluster has the smallest amount of FS- and BLM-administered lands of all the forest clusters, yet still has over one-third of its area in low road-density classes. This cluster has the largest proportion of its area rated as low hydrologic integrity and aquatic integrity. Late- and early-seral structures have declined in most elevation settings; an increase in mid-seral was the most compensating change. Species vulnerable to human exploitation and disturbance have a relatively low amount of secure habitat. The aquatic systems tend to be especially fragmented and remaining populations of native species are often isolated. The subbasins seem to support few and widely scattered strongholds and the poorest measures of condition for fish communities. There will be little chance for recreating fully connected aquatic systems either because habitats are seriously degraded or because remaining populations are strongly isolated. Disturbance of hydrologic function from manage-

ment activities is high primarily because of roads, dams, and cropland conversion of lower elevation valleys. Because remaining intact aquatic ecosystems are found primarily on Federal land, and because these lands represent a small area of these subbasins, flexibility in management may be limited.

Rangeland Cluster 1

Juniper woodlands—juniper woodlands are more common in this cluster than any other cluster within the Basin; additionally woodland area has substantially increased in each subbasin. Herblands and shrublands have significantly decreased. Forest rangelands included in this cluster are found in the lower montane settings. Forested rangeland changes have resulted in declines in ungulate forage and displacement of native ungulates from historic winter ranges to less productive montane forests. Climate associated with juniper woodlands is dry. Large areas receive an average of 12 or fewer inches of annual precipitation, especially in the Lower Deschutes, Trout, Lower Crooked, Upper Crooked, and Beaver South Fork subbasins in central Oregon. Juniper woodlands are frequently subjected to hot, droughty summers, and cold winters.

Western juniper communities in the subbasins of this theme typically exist as (1) inclusions in the forest zone, (2) old juniper woodlands, and (3) young woodlands that in the recent past have expanded into the sagebrush zone. Old western juniper woodlands contain an old tree component, one that contains trees that generally exceed 150 years. These old woodlands typically persisted on mesa edges, ridges, and knolls characterized by fractured bedrock near the surface, and well-drained, shallow soils that produced relatively little understory herbaceous vegetation. These sites were not relatively disposed to fire.

Fire, typically occurring at intervals ranging from 5 to 50 years, tended to restrict western juniper woodland extent in the sagebrush-bunchgrass zone. Fire frequency has declined substantially in the western juniper woodland areas between historic and current time periods. This is because of a decline in fires set by American Indians, concurrently with a reduction in fire fuel availability caused by domestic livestock grazing. Climate and fire combined were likely causal in western juniper expansion and retraction before 1800.

The combined effects of extensive livestock grazing in the late 1800s and early 1900s, fire exclusion over large areas, and possibly climate changes probably are responsible for expansion of western juniper woodlands during the last 100 years (see photos 8a and 8b). Concomitant reduction in the area of historical herblands and shrubland cover generally has not proceeded at a rate that equals or exceeds the rate of western juniper woodland expansion.

Diffuse knapweed, yellow starthistle, medusahead, whitetop, and Canada thistle are examples of problematic exotic weed species in this cluster on rangelands. Subbasins in this cluster support the highest average road densities, and roads are causal in the past and current spread of several exotic weed species in this cluster, for example diffuse knapweed. Diffuse knapweed, medusahead, and whitetop are extensive in some locations along the Deschutes and John Day rivers and tributaries.

Average area in cropland and pasture is low. The hydrologic integrity of these subbasins ranges from low to moderate and the riparian environment integrity is commonly low. Rangeland and forest integrity are low while aquatic and hydrologic integrity are mixed low and moderate; the composite integrity rating is low. The Lower Deschutes and the Upper John Day subbasins are strongholds for native rainbow and redband trout. The Lower Deschutes and Upper John Day subbasins currently contain important native steelhead and chinook salmon stocks and habitats, and dams do not preclude connecting these existing habitats with larger functional networks. These subbasins and their resident populations are key to any strategy to restore conditions for anadromous fish. The Trout subbasin (Trout Creek primarily) also contains native steelhead stocks but habitats are in poor condition.

Photo 8a by M.K. Kennedy

Photo 8b by W.K. Farrell

Photo 8a and 8b. The expansion of western juniper into sagebrush-grass is evident in this photo pair showing 1920 to 1956 change resulting form grazing and fire exclusion. The photo pair typifies changes commonly found in the juniper woodland rangeland cluster. Source: (Skovlin and Thomas 1995.)

Rangeland Cluster 2

High-integrity dry-forest rangelands—dry forested rangelands of these subbasins have been altered by livestock grazing, timber harvest, and exclusion of fire, but are rated as the cluster with the highest proportion in high forest, range, aquatic, and hydrologic integrity. The resulting composite integrity rating was high. Subbasins are largely blocks of wilderness and minimally roaded areas with more than 70 percent in low or minimal roading classes. Herblands, shrublands, and woodlands have significantly declined. In this century, conifers have invaded meadows, grassland and shrubland areas, and savannah woodlands reducing both livestock and big game forage, as well as creating elevated fuel and increasing fire. The loss of woodlands is most likely the result of conifer woodland progression to dry forest. Terrestrial vertebrates most associated with ecotones between shrubland and herbland and dry forests would be most affected. Lower elevations of forested rangelands support domestic livestock and big game, and are generally where conflicts arise between livestock production and big game management.

Diffuse knapweed, yellow starthistle, leafy spurge, and spotted knapweed are examples of problematic exotic weed species in this cluster on rangelands. Diffuse knapweed is especially prevalent in the Methow subbasin in north-central Washington; yellow starthistle is prevalent in the Hells Canyon subbasin. For the cluster as a whole, exotic weed acreage is not extensive on rangeland.

Hydrologic and riparian environment integrity of these subbasins is high. These subbasins support riparian environments that are some of the most resilient to livestock grazing. The best conditions in the aquatic ecosystems within rangelands are associated with the subbasins in this cluster. The subwatersheds and aquatic systems that are most degraded, however, may be associated with the lower gradient and lower elevation rangeland portions of these subbasins. Connectivity of subwatersheds that function as native fish strongholds is good, and strongholds for more than one species are often present in subwatersheds

throughout the subbasins. Fish populations and communities associated with these subbasins are among the most resilient in the Basin and represent core distributions for many of the sensitive salmonids. Because these lands tend to be productive and more resilient to disturbance than others, there could be some opportunities to maintain commodity production with little risk to other components of the system provided they are focused in the areas least important to the aquatic system. These subbasins can likely withstand the consequences of some large-scale fires in the higher elevation cold and moist forest areas, and fish populations will likely persist in the absence of management intervention. The occurrence of large fires in the lower-elevation dry forests poses a somewhat different threat.

Rangeland Cluster 3

Moderate integrity dry-forest rangelands—These subbasins are among the most altered by livestock grazing, timber harvest practices, and exclusion of fire compared to presettlement condition. These subbasins are dominated by moderate or high road densities and have the highest level of fire frequency among the rangeland clusters. Substantial declines in the amount of herblands, shrublands, and mixed conifer woodlands have occurred. Effects of fire exclusion and grazing have been compounded by harvest practices in dry-forest types promoting dense, multi-layered forests with increasing amounts of shade-tolerant, insect and pathogen-susceptible conifers, and reduced understory shrub and herbaceous cover. Shrub and herbaceous understories are also typically less productive and diverse than they were historically. Subbasins of this cluster were severely affected by extensive, heavy cattle and sheep grazing in the late 1800s and early 1900s, both at low and high elevations. Many areas are recovering as a result of decreased grazing pressure (Skovlin and Thomas 1995), prescribed fire, and cultural treatments.

Curbing the expansion of introduced exotic weeds continues to be a substantial management chal-

lenge in these subbasins. Whitetop, diffuse knapweed, spotted knapweed, yellow starthistle, leafy spurge, sulfur cinquefoil, and medusahead are examples of problematic exotic weed species in this cluster on rangeland. Examples of subbasins that support extensive infestations of these exotic weeds include the Powder in north-east Oregon (whitetop and medusahead), Kettle, Sanpoil, Franklin D. Roosevelt Lake, Colville, and Lower Spokane in northeast Washington (diffuse knapweed), the Little Spokane, Upper Spokane, and Hangman in eastern Washington (spotted knapweed), and the lower Flathead, Blackfoot, Bitterroot, and Upper Clark Fork in Western Montana (spotted knapweed, leafy spurge, sulfur cinquefoil).

In this century, conifers have invaded meadows, grassland and shrubland areas, and savannah woodlands reducing both livestock and big game forage, as well as increasing fuel loadings and fire intensity and severity. Hydrologic and riparian integrity is low.

Aquatic integrity is rated as moderate or low, while forest and range integrity are mostly low. For the most part, remaining native fish populations are fragmented, represented by remnant and isolated populations scattered throughout the subbasins. Some subwatersheds within these subbasins support remnant strongholds, isolated populations of listed or sensitive species, or narrowly endemic species that will be priorities for conservation. More than 50 percent of the area of these subbasins is on public lands.

Rangeland Cluster 4

Columbia croplands—These subbasins are primarily composed of croplands and pasture. Rangelands in these subbasins have the lowest overall integrity of all rangelands in the Basin. Extensive irrigation systems are present. Herbland and shrubland have significantly decreased compared to presettlement. The climate of these subbasins is typically dry; area of subbasins experiencing less than 12 inches of average annual precipitation is

51 percent. Although the climate of the area is relatively dry, protracted droughts do not occur as commonly in subbasins of this cluster as in those of other clusters, and growing seasons are fairly long. Soils of the Columbia croplands are deep, wind-deposited loessial soils that developed with the retreat of the glaciers. Topography is gentle and much of the area was dominated by dry shrubland and dry grasslands. Narrow to wide, gentle valley bottoms were once dominated by riparian woodland, riparian shrub, or riparian herb types. Most of these areas have been converted to herbaceous pasture, hay, or croplands. Small areas of native herbland and shrubland amongst cropland still exist where steep slopes and relatively shallow soils predominate, or in military reservations, nuclear reservations, parks, reserves, cemeteries, or railroad rights-of-way. Of the grassland and shrubland areas that have not been converted to cropland or pasture, many have been heavily grazed and are now undergoing invasion by exotic weeds.

Whitetop, diffuse knapweed, yellow starthistle, Russian knapweed, Canada thistle, Scotch thistle, and cheatgrass are examples of problematic exotic weed species in this cluster on rangeland. Of these species, Canada thistle and cheatgrass are widespread in the cluster. For the remaining weeds listed, examples of subbasins that support extensive infestations include the Okanogan, Lower Yakima, Banks Lake, and Lower Crab (diffuse knapweed and/or Russian knapweed), and the Walla Walla, Lower Snake-Tucannon, Lower Snake-Asotin, and Umatilla (yellow starthistle and/or Scotch thistle). Conversion of native herblands and shrublands to agricultural types has diminished habitat for a large number of species.

Hydrologic and riparian environment integrity of these subbasins is low. The potential for streams to recover following disturbance is the lowest of any rangeland setting within the Basin. The subbasins in this cluster are strongly degraded from an aquatic perspective. Most native fishes currently exist as very isolated populations. There is little opportunity for restoration to more functional aquatic ecosystems.

Rangeland Cluster 5

Moderate integrity upland shrublands—These subbasins represent the bulk of high elevation ranges. Shrublands in this cluster, although influenced by grazing (see photo 9), fire exclusion, and exotic weed invasion, are least affected by humans. They have low levels of road densities and cropland, but have high levels of wildland/urban fire risk interface. Declines in herbland and shrubland habitats observed within Rangeland Cluster 5 have contributed to observed declines in populations of species associated with these habitats (table 18). An average of nearly 4 percent of the area of each subbasin has been invaded by exotic plants in this cluster.

Diffuse knapweed, yellow starthistle, spotted knapweed, leafy spurge, rush skeletonweed, medusahead, cheatgrass, and Canada thistle are examples of problematic exotic weed species in this cluster on rangeland. Examples of subbasins that support extensive infestations of these exotic weeds include the Upper Columbia-Entiat and Upper Yakima in Washington (diffuse knapweed), the Imnaha in Oregon (yellow starthistle), and the Upper Owyhee, Bruneau, and Salmon Falls in Idaho (cheatgrass and/or medusahead). Hydrologic and riparian environment integrity of these subbasins is high and moderate, respectively. These subbasins commonly provide the fewest limitations to rangeland management from a hydrologic integrity perspective (that is, they are resilient and have not been overly affected in the past). Areal extent of upland shrubland in the cool shrub PVG is larger relative to other clusters. Rangelands in these subbasins tend to be more resilient to grazing pressure and can be more likely maintained and/or restored to proper functioning condition. Because of the relatively good or improving condition of many of the rangeland communities and the remaining integrity in aquatic ecosystems, there is opportunity for management to benefit both.

Photo 9—This photo illustrates characteristics of a moderate integrity, dry forest rangeland cluster. Livestock use on FS- and BLM-administered lands is common within the Basin.

Figure 40—Composite ecological integrity ratings synthesized the forest, rangeland, forest and rangeland hydrologic, and aquatic component integrity ratings.

Rangeland Cluster 6

Low integrity upland shrublands—These subbasins are primarily located on the Snake River Plain and in south-central Oregon and have been significantly altered by grazing and fire exclusion. They are dominated by dry shrubland vegetation, which is the most extensive rangeland PVG in this cluster. It is highly sensitive to overgrazing and susceptible to invasion by exotic grasses and forbs. Agriculture, dry forest, and cool shrub, in that order, follow in sensitivity the dry shrub PVG. Shrublands and herblands have declined owing to conversion to agriculture, change in fire regimes, increases in conifer woodlands, and encroachment by exotics, including the conversion to crested wheatgrass and other desirable exotic grasses. Similar to Rangeland Cluster 5, an average of nearly 4 percent of the area of each subbasin has been invaded by exotic plants in this cluster.

Dyers wood, diffuse knapweed, yellow starthistle, leafy spurge, medusahead, cheatgrass, Mediterranean sage, and whitetop are examples of problematic exotic weed species in this cluster on rangeland. Examples of subbasins that support extensive infestations of these exotic weeds include the Warner Lakes, Guano, and Upper Malheur in Oregon (medusahead and/or Mediterranean sage), the Lake Wolcott and American Falls in Idaho, (cheatgrass), and the Middle Snake-Payette (yellow starthistle). The increase in mixed conifer woodlands is most likely the result of conifer invasion of herbland and shrubland areas.

Hydrologic integrity of these subbasins ranges from low to moderate, whereas the integrity of the riparian environments they contain is commonly low. The subbasins in this cluster represent some of the most strongly altered conditions for aquatic systems in the assessment area. Where redband trout now persist, they generally occur in highly fragmented habitat and in isolated populations. Steelhead historically inhabited tributary basins of the middle Snake River (such as the Malheur and Owyhee Rivers), but are now blocked by the Hells Canyon complex of hydroelectric dams. The lower Grande Ronde and Middle Fork John Day River subbasins are exceptions within this cluster

as they both support native chinook salmon and steelhead trout. In addition to the Federally listed chinook salmon, the Lower Grande Ronde River contains numerous continuous strongholds of native rainbow and bull trout. Aquatic integrity of the lower Grande Ronde River is among the highest because of the presence of native fish strongholds, even though it has low forest and hydrologic integrity. Consequently, these strongholds may be short lived. The Middle Fork John Day River subbasin has numerous strongholds of native rainbow and steelhead trout and has high fish community integrity; few exotic fishes have been introduced into this subbasin. Subbasins along the middle Snake River above Hell's Canyon historically supported anadromous fish, but do so no longer. In many of these subbasins, there is little hope of restoring any resemblance of historical structure and composition of aquatic communities.

Composite Ecological Integrity

We used five component integrity ratings (forestland, rangeland, forestland and rangeland hydrologic, and aquatic systems) to estimate the current composite ecological integrity of each subbasin (see fig. 40). Component integrity ratings were based on information brought forward through the *Component Assessment*, the *Evaluation of Alternatives* (Quigley and others 1996b, hereafter called the *Evaluation*) which includes a discussion of landscape integrity, terrestrial integrity (Marcot 1996), and our understandings of conditions and trends. Composite integrity was estimated by comparing the component integrity ratings and our knowledge of actual on-the-ground conditions, with how each subbasin met the definitions described above for systems with high ecological integrity. We found that at present 16 percent of the area is in high (of which 84 percent is FS- and BLM-administered lands), 24 percent is in moderate, and 60 percent is in low ecological integrity (fig. 41a). Much of this last category includes lands used for agricultural and grazing uses, and a low rating does not imply low productivity or
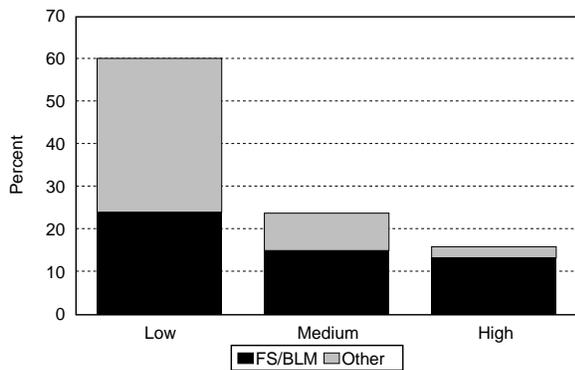
Figure 41a—Percent of the Basin by composite ecological integrity.

Figure 41b—Percent of FS- and BLM-administered land by composite ecological integrity rating.

other similar implications. The rating system emphasizes ecological processes and functions and thus, has a tendency to rate human-altered systems lower than systems dominated by more natural processes. Finally, 26 percent of the FS- and BLM-administered lands are rated as high integrity, 29 percent are rated as medium, and 45 percent as low (fig. 41b).

Social and Economic Resiliency

Both social and economic resiliency measure the adaptability of human systems (*Component Assessment*—Economics). Social resiliency was measured using four factors: (1) civic infrastructure (that is, leadership, preparedness for change); (2) economic diversity; (3) social/cultural diversity (population size, mix of skills); and (4) amenity infrastructure (that is, attractiveness of the community and surrounding area). Economic resiliency was measured by the diversity among employment sectors. The assumption is that people in high resiliency counties have ready access to a range of employment opportunities if specific firms or business sectors experience downturns. Much like the biophysical components of the ecosystem, social and economic resiliency are affected by the size of the area measured (such as community, county, and trade regions) but they also reflect human notions of the landscape rather than hydrologic subbasins. In general, larger units display greater economic diversity (and by extension, economic and social resiliency) than smaller
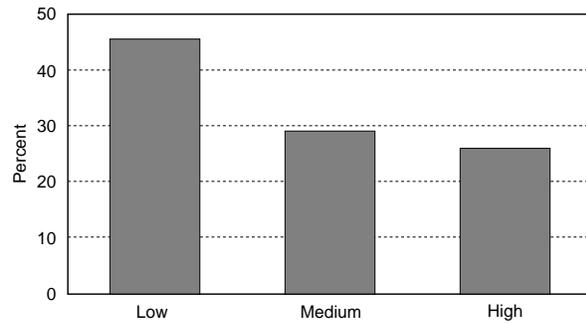
areas. Further, since resiliency attempts to measure a capacity for human response, classifications of either social or economic resiliency serve as relative estimates of adaptability, rather than absolute descriptors.

When we look at the Basin from the social and economic perspective our basic frame of reference is how humans organize themselves both in a community sense and how they relate to their biophysical environment. One overarching feature of this perspective is the speed at which human communities, interests, values, and economies change. Given this characteristic, one useful and relatively permanent administrative feature is the county. We observe that counties and available county data can be used to describe broad trends in social and economic resiliency. There is another powerful argument for considering counties. That is, their role as entities in a political system that simultaneously relates federal, state, and local interactions.

Economic Resiliency

The ratings for economic resiliency indicate that the economies within the Basin are diverse, and consequently have high economic resiliency. The average economic resiliency index for the nine BEA regions is 0.80 and there is little variation among BEA regions. These findings make sense as per capita income is rising rapidly and there are few pockets of poverty in the Basin. Furthermore, the economy of the Basin has shown resistance to

national recessions except when they greatly affect the agricultural sector.

The highest resiliency ratings are for BEA regions containing metropolitan counties (Boise, Spokane, and Tri-Cities). The BEA economies in which employment associated with recreation is substantial have high resiliency suggesting they have high potential resilience to fluctuations in recreation activity (Idaho Falls, Idaho; Missoula, Montana; and Redmond-Bend, Oregon). The two BEA regions in which timber plays a major role (Redmond-Bend and Pendleton) also have fairly diverse economies, suggesting they are resistant to fluctuations in that industry. The lowest resiliency rating is for Butte, Montana but is misleading because diversity is calculated for only that portion of the BEA region lying in the Basin.

Estimating resiliency at the county level based on employment diversity provides a different picture requiring some care to interpret. The average resiliency index for the 100 counties in the Basin is 0.70, much lower than the statistics calculated for the Basin BEA areas. This difference suggests that employment options, and thus employment diversity, is less at the county level than the larger BEA areas. This is generally true; the smaller the area the fewer options exist for employment as compared to larger areas. Seventeen percent of the counties within the Basin have high economic resiliency (fig. 42).

Social Resiliency

Like economic resiliency social resiliency could be addressed at many scales, and yet because of abiding local interest in the future of their communities, the examination of social resiliency is generally focused on the community level. Although communities are highly individualistic, a general distribution of levels of community resiliency was described by Harris in 1996.[18] Key

---

[18]Harris, Chuck. 1996. Rural Communities in the Inland Northwest, characteristics of small towns in the interior and upper Columbia River basins: an assessment of the past and present (final report: parts 1 and 2). On file with: U.S. Department of Agriculture, Forest Service, U.S. Department of Interior, Bureau of Land Management, Interior Columbia Basin Ecosystem Management Project, 112 E. Poplar, Walla Walla, WA 99362. 348 p.

differences were found among communities based on population size, local attractiveness, and economic diversity. These descriptions revealed a pattern across the Basin that is closely associated with annual levels of precipitation. In general, communities that are of smaller size and lower resiliency in the Basin follow the arid crescent that reaches south from the Columbia Plateau in eastern Washington, around the western and southern boundaries of the Blue Mountains in Oregon, and continues east along the Snake River plains in Idaho. This area includes the Columbia Plateau, the Owyhee Uplands, and the Upper Snake ERUs. This is the zone that receives less than 12 inches (30 cm) of precipitation each year, and although it contains prosperous, large, irrigated agricultural operations, the dry, climate has resulted in few towns of over 1,000 people and limited economic diversity.

Communities that exhibit higher levels of resiliency are located along the Cascade crest, the central mountains of Idaho, and in the vicinity of Missoula, Montana (in terms of ERUs, the Northern and Southern Cascades, the Central Idaho Mountains, and the Upper Clark Fork). These communities have high levels of scenic attractiveness and more diverse economies than those that are located in the arid crescent. These are the areas that contain the highest concentrations of Forest Service administered lands, have higher levels of rainfall, and are generally montane environments. These settings receive the greatest amount of recreational use in the Basin in terms of recreation activity days, and they are the location of the region's fastest rates of human population growth. When compared to other communities across the Basin, those exhibiting high levels of community resiliency did not show any differences in levels of perceived community cohesion, services, local government effectiveness, and civic leadership.

In examining community-level changes, Harris discovered that those communities that have been confronted with and survived challenges—such as sawmill closures—are among the most resilient because they have successfully learned how to deal