



## Terrestrial and Marine Management Activities: Links to Habitat Elements and Ecological Processes

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### Introduction

Much has been published on the effects of human activities on the environment,<sup>5,9,16</sup> and recent efforts have attempted to synthesize the literature into comprehensive, easily accessible, digital formats. For example, several state wildlife agencies have produced Web pages that include information on the effects of human activities on individual wildlife species. We believe that a weakness in this approach is its inability to capture the complexity of impacts beyond the individual species level. Ecosystem management suggests that scientists and managers should also determine the effects of management activities on ecological processes and functions, and on the long-term sustainability, diversity, and productivity of resources and environments. This chapter discusses a Washington-Oregon "Management Activities Matrix" (located on the CD-ROM) and illustrates how it can be used with the other data matrices described in this volume to ask more advanced questions than suggested by existing information bases. For example, the Management Activities Matrix allows the manager not only to determine which species may be affected by a particular land use, but also to assess what ecological functions are involved, and which Habitat Elements (HEs).<sup>14</sup> In this chapter we present and illustrate this unique perspective and methodology. Our approach is similar to the concept of the food web: effects of management actions are not only direct and linear but also can have surprisingly indirect and nonlinear implications. To gauge the full extent of an activity's impact, it becomes necessary to examine the entire web of influences.

### Development of the Management Activities Matrix

Producing the Management Activities Matrix presented many challenges. Environmental impacts are complex and defy simple categorization. Therefore we have limited the Management Activities Matrix only to those relationships that were identified either in the literature or by an expert panel, and for the most part, we have reported only direct impacts. We did not attempt to describe in detail the exact nature of every possible influence, because they depend heavily on many factors including local site characteristics and the specific nature of the proposed activity. Any potentially affected HE, regardless of the scale or intensity

of the activity that would be necessary to produce an effect, is linked in the Matrix. For example, one could ask: overall, do road management activities have the potential to affect soil structure and soil organic matter? The Management Activities Matrix can be used as a guide to depict or predict influences on HEs and ecological processes, and to pose concepts, frameworks, and hypotheses regarding the effects of management activities. It is necessarily not a definitive model that precisely predicts site-specific impacts resulting from the described activities.

### The Land Use and Management Activities

We wanted to include activities that we thought were most relevant to Oregon and Washington, and were most useful to characterize across all land ownerships. We limited the activities addressed to those that affect inland and nearshore-marine HEs only. Our activity list was refined and edited several times with the assistance of many resource scientists and managers expert in particular areas (see Acknowledgements). Thirteen broad categories of management activities were identified, ranging from nearshore marine resource management to urban development, and encompassing activities occurring on all land ownerships, locations, and jurisdictions in both Oregon and Washington. These broad categories contain 152 specific activities (see Table 1).

### Information on CD-ROM

Under the Data Query section on the CD-ROM, there are two submenus under Management Activities; one to query for related habitat elements, the other to query the citations that support the Management Activity Matrix. The user can query these to either obtain very specific information on individual HEs or to obtain general information from the literature about the potential effects of an activity. These two queries are described below.

**Querying for Related Habitat Elements.** Also based on the published literature, this table identifies which specific HEs are potentially affected by each management activity (either positively or negatively). In addition, under the heading "Query for Related Habitat Elements," users can query each management activity to obtain a comprehensive list of all HE-management activity links. This list was developed using the literature cited in the

table and expert panels (discussed below under Data Sources).

**Querying for Citations.** Based on the published literature, this table describes the effects of a specific activity, e.g. “thinning” or “impounding water,” on various ecological processes such as biological diversity or ecosystem function.

Linking HEs to management activities allows the manager to query the various data matrixes in this volume, asking such questions as: What species are associated with the HEs linked to this specific management activity, and, furthermore, what are their Key Ecological Functions (KEFs)?<sup>11</sup> We illustrate this approach in detail in the section “How to Use the Matrix: Example Queries.”

### Data Sources

We used two sources of data to populate the Management Activities Matrix: the published literature and an expert panel. During the literature review, we used several reference databases to search titles, keywords, and full abstracts for information, using the management activities as key words. We searched literature on wildlife, ornithology, fisheries, mammalogy, and zoology. The wildlife database search included all papers published during 1937-97 in the *Journal of Wildlife Management*, *Wildlife Monographs*, and the *Wildlife Society Bulletin* (>8,400 records). The ornithology database search included all papers published during 1955-97 in the *Auk*, *Ornithological Monographs*, *Condor*, *Studies in Avian Biology*, *Wilson Bulletin*, and the *Journal of Field Ornithology* (>18,000 records). The mammalogy database search included all papers published during 1950-97 in the *Journal of Mammalogy*, *Mammalian Species*, and *American Society of Mammalogists Special Publications* (>10,900 records). The ecological database search included papers published during 1945-97 in *Ecology*, *Ecological Applications*, and *Ecological Monographs*, plus some additional papers published in the *Journal of Vegetation Science* (1900-97), for a total of >12,000 records. We also obtained references from our personal reference databases, project library, and the Cambridge Scientific Review.

Whenever a link was found in the published literature that associated a particular management activity with an ecological process or a HE, we coded the information in our database. If the information was from research, we briefly described the results, where the study took place, at what time of year, and in what habitat. When the referenced links were not the results of research, the above information was filled out to the extent possible. We listed habitats as they were described, and did not attempt to “crosswalk” the habitat classes to those used in this volume (see *Wildlife Habitats*).<sup>3</sup>

To ensure that all potentially affected HEs were properly identified for each activity, we convened an expert panel consisting of scientists and managers with backgrounds in the various activity areas (see Acknowledgements). The panelists reviewed each activity and indicated which HEs were potentially linked to it. Links obtained from the panels were incorporated into

the database along with links identified from the literature to form a comprehensive list of all HEs potentially associated with each activity. Individual activities may be queried to obtain this information (see Query for Related Habitat Elements on the CD-ROM).

### Major Influences of Activities on Wildlife

Throughout Washington and Oregon, management activities affecting the most wildlife species (>500) pertain to conversion of habitat for development of human habitation, recreation, mineral extraction, forestry, water supply development, controlling and prescribing fire, and livestock grazing (Table 1). The management activities affecting the least wildlife species (<100) include mushroom harvesting, snow-related recreation, creation of artificial nest sites, and providing dead and down wood (Table 1). If the dead and down wood category is a surprise,<sup>15</sup> note that this activity still influences some 96 wildlife species and 9 HEs.

The ranked order of management activities having the most and least influence on number of wildlife species and HEs varies somewhat among specific wildlife habitats. However, the general pattern of land-development activities having the greatest effect remains mostly the same across most terrestrial habitats, including coastal environments. In addition, not surprisingly, other management activities related to aquatic resource management (Management Activity 2; see Table 1) and marine activities (Management Activity 10) show up as potentially influencing a large number of species and HEs in coastal environments. For example, in Bays and Estuaries (Wildlife Habitat 28), the most influential management activity is recreational development (potentially influencing 173 wildlife species in that habitat); other activities of major influence (potentially influencing >150 wildlife species) pertain to conversion of native habitats; road and building construction; controlling water pollution; dredging; harbor, marina, and ferry terminal development; wastewater treatment; and water level management.

### How to Use the Matrix: Example Queries

Using a relational database such as Access or Paradox, the following is an example of a query on fire management that illustrates specifically how the Matrix may be used. Let’s say we’re interested in the influence of the management activity “low- to moderate-intensity burns” (Management Activity 1B), as may be used during prescribed burning to help restore some grasslands and forests east of the crest of the Cascade Mountains in Washington and Oregon, and how such influences may differ between grassland and forest environments.

We first linked the Management Activities Matrix to the Habitat Elements (HEs) Matrix and counted 83 HEs potentially influenced by this activity (the HE tally here refers to HE category headings and subheadings, so there is some redundancy in these figures). Next, we narrowed this by linking the number of HEs affected by this activity to those only associated with wildlife species that occur

**Table 1. Management activities potentially affecting the greatest, and least, number of wildlife species, and the associated number of potentially affected Habitat Elements (HEs) across all wildlife habitats in Washington and Oregon.\***

Management activity	No. wildlife species affected	No. habitat elements affected
<b>Greatest influence (&gt;500 species)</b>		
Conversion of native habitats	577	74
Recreational developments	570	128
Road construction and obliteration	555	70
Mineral exploration	553	123
Building houses and businesses	552	149
Surface/strip mining and processing	544	141
Forest management (in general)	532	64
Conversion of shrubland to native or non-native grassland (for livestock management)	528	51
Conversion of shrubland to native or non-native grassland (for shrubland or grassland management)	528	51
Clearcutting	525	88
Establishing/maintaining greenways and greenbelts	517	105
Suppressing wildfire	514	83
Prescribed/controlled high intensity burns	503	91
Increasing water supply	503	66
Decreasing water supply	503	66
Livestock grazing	500	70
<b>Least influence (&lt;100 species)</b>		
Retaining/providing dead/down wood	96	9
Creating/maintaining islands or rafts within impoundments	61	3
Providing artificial nest sites (for agricultural activities)	59	2
Providing artificial nest sites (for forest habitat management activities)	59	2
Snowshoeing/snow skiing/sledding	42	2
Snowmobiling	42	2
Harvesting wild mushrooms	26	1

\* See Appendix for management activity codes and definitions.

in Habitat 15, Eastside (Interior) Grasslands. This asks the question, what array of HEs for wildlife are potentially influenced by low- to moderate-intensity burns, specifically in Eastside Grasslands? The result was a list of 73 HE categories. We next compared this with use of low- to moderate-intensity burns in Wildlife Habitat 7, Ponderosa Pine Forests and Woodlands, and this produced a list of 78 HE categories.

However, even though the number of HEs is similar between these two habitats, the actual HE categories and the associated array of wildlife species may differ. We tested this by listing wildlife species rather than HEs in each query, saving those results, and comparing the results between the two habitats. It turns out that the HEs potentially affected by low- to moderate-intensity burns are virtually identical in these two habitats (72 of the potentially affected HE categories are shared by these two habitats). However, of the 163 wildlife species in Eastside Grasslands and 218 species in Ponderosa Pine Forests and Woodlands that have HEs potentially influenced by this activity, only 99 of these species occur in common between these two habitats. That is, 39% of the potentially fire-affected wildlife species in the Grasslands habitat and 55% of those in the Forest habitat occur uniquely in these

habitats. Thus, as should be expected, the potential influence of this kind of burn on wildlife species is different in eastside grasslands and forests, and a greater proportion of affected species in the forest habitat would be uniquely influenced.

## Discussion

**Stressors and Indicators.** Why should the manager be concerned about evaluating influences of management activities on Habitat Elements and wildlife? Beyond the obvious reasons—that is, environmental and biological assessments to meet legal and regulatory mandates—the Management Activities Matrix provides a basis for explicitly and repeatably describing the potential influences of stressors on wildlife communities. The model of identifying such stressors (e.g., see the species influence diagram <sup>11</sup>) can be central to identifying the most influential management activities for mitigation, and prioritizing potential wildlife responses for monitoring.<sup>10, 16, 18</sup> What needs empirical work is validating, refining, and quantifying the linkages between management activities and habitat elements and associated wildlife populations.

Although we have purposely avoided the problematic concept of management indicator species, wildlife species

most susceptible to particular stressors and management activities might be good candidates for use as bioindicators and “early warning” signals of impending changes to other aspects of their ecosystem.<sup>13</sup> One example is stream amphibians that indicate levels of aquatic ecosystem stress.<sup>20</sup> However, cryptogams, plants, and invertebrates often serve as more sensitive indicators,<sup>1, 12, 19</sup> or, in many cases, it may be simpler to more directly monitor specific biochemical responses to management activities.

### **Considerations and Caveats for Using the Matrix**

The management activities listed in the Management Activities Matrix are necessarily described in general ways, that is, at broad geographical scales. However, because the effects of management activities act as “stressors” to native systems, they vary by degree of perturbation based on duration, frequency, intensity (amplitude), and combination of activities. Furthermore, the specific influence of a management activity on ecological processes and HEs will vary according to the scale, intensity, and the action of the effect (direct or indirect). Referring to the management activity, scale issues include the level of spatial resolution (the pervasiveness of the activity), overall geographic extent and context (over how large an area does the activity occur, and in what type of environment), and duration of the activity.

Specifically, spatial resolution refers to the geographic extent over which the activities and associated effects occur. For example, some activities affect entire watersheds, whereas others affect only the stream environment. Identifying the level of spatial resolution of the activity determines how finely the Management Activities Matrix can be applied. The Matrix should not be used to predict effects at the scale of individual vegetation stands or point locations, but it can be used to predict overall, general effects averaged at the scale provinces, habitats, and habitat structures.

Geographic extent and context influence an effect’s intensity. The geographic extent of agricultural conversions in eastern Washington and Oregon, for example, is quite widespread; agricultural activities in that region may have different effects on wildlife community composition, structure, and function than will small inclusions of the same activities in a matrix of native grassland or forest. Likewise, agricultural activities adjacent to a wetland will impact wildlife communities differently than agricultural development in an upland context.<sup>2</sup>

Time duration or temporal scale refers to the influence or persistence of effects over time, in terms of how long a management activity has persisted in an area and how long wildlife communities and populations have had to respond. It also refers to the immediacy of an influence; some effects might be time-delayed. Two contrasting examples are faunal relaxation (time-delayed loss of species from isolated native habitats), and recolonization of restored native environments.

Obviously, activities vary in their effects, depending on which HEs are involved. Some HEs will be directly affected and others indirectly. Both direct and indirect effects can result from a single management activity, and can influence wildlife populations through the HEs.

Although all of the above-mentioned factors will determine the ultimate impact of an activity, they are not explicitly depicted in the Matrix because of the difficulties of addressing these complex factors in a simple, qualitative matrix format. Managers need to consider the issues described above and apply the findings of the Matrix to their own geographic area and project scope. Because the influence of a management activity depends largely on local conditions and circumstances, variations in specific effects should be expected.

When evaluating effects of activities, managers might wish to consider the following:

1. The influence of management activities on HEs can vary from those depicted in this simple Management Activities Matrix in several ways: some depicted effects may not occur, some may occur more saliently than others, and there may be some effects not depicted in the Matrix;
2. Effects can vary over space and time, including time lags and off-site influences; and
3. Not all effects are negative; identifying the positive ones could be most useful for some conservation objectives such as habitat restoration.

### **Conclusions and Suggestions for Further Developments**

The Management Activities Matrix provides a rigorous, repeatable basis for considering the influence of land and resource management activities on wildlife habitats and species. By querying the Matrix in conjunction with the other habitat- and species-based databases offered in this volume, the manager can be prompted to consider effects across a full range of environmental conditions and wildlife species groups. Certainly, some activities and wildlife species warrant far more detailed attention than can be provided here.

Spatially, the Matrix might prove most useful when applied to broad geographic areas such as National Forest Ranger Districts, or to general land use allocations. At finer spatial scales, such as individual vegetation stands or point locations, the Matrix might overestimate the number of HEs and wildlife species affected by given management activities.

Temporally, the Matrix does not specify how quickly or for how long an effect can be expected. Stressors to ecosystems operate in different ways depending on their initial intensity as well as duration. Also, effects of some management activities may be indirect or incur time lags. The manager could query the Management Activities Matrix and determine likely HEs and species affected (positive and negative), and then sort those according to expected levels of intensity, duration, and time lag.

Local conditions, site history, and the range of specific activities greatly influence how any given management

activity will affect habitats and wildlife. Thus, use of the Management Activities Matrix may best be seen as helping the manager to develop working hypotheses of effects warranting expert review and, where needed, empirical validation through local testing. At best, the Matrix can be used as a basis for devising and prioritizing adaptive management monitoring studies to better discern and refine the initial, crude estimates of effects.

The next level of development of the Management Activities Matrix could then entail refining the activity categories for greater detail, and quantifying the specific influence of activities on HEs and wildlife species. Several tools may be useful for quantifying the influence of management activities into the “causal web” of wildlife communities, including use of Bayesian belief networks<sup>8</sup> and sequential Bayes statistics,<sup>7</sup> decision-aiding programming,<sup>6</sup> and dynamic, stochastic simulation models.<sup>4</sup> The influence diagram approach presented in Chapter 6 can provide an overall framework for such further modeling exploits.<sup>17</sup> In the end, the challenge to the manager is to consider the influence of management activities in the full web of ecological interactions within the ecosystem.

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## Appendix

## Land use and management activities depicted in the Management Activities Matrix.

Code	Activity	Definition	Code	Activity	Definition
<b>1</b>	<b>Fire Management</b>		2G	Burning wetlands to maintain successional stages	Periodic, low intensity burning of wetlands that occurs in association with rivers, lakes, and streams. The extent, intensity, and timing are either planned or controlled.
1A	Suppressing wildfire	Actively extinguishing or preventing wildfires.	2H	Restoration of wetlands	Revegetation with native wetland species, and the maintenance of water levels for the majority of the year.
1B	Low- to moderate-intensity burns	Fires that are usually intentionally lit (or natural fires that are allowed to burn) for a specific management objective. The extent, intensity, and timing are either planned or controlled. Low-intensity burns usually are repeated at regular time intervals.	2I	Wetland management techniques	Describes a variety of methods by which wetland ecosystem function is maintained.
1C	High-intensity burns	Usually natural fires that are allowed to burn for a specific management objective. The extent, intensity, and timing are either planned or controlled. High-intensity burns are usually a one-time event or occur very infrequently.	2J	Flooding fields and wetlands	Flooding that would, without human intervention, occur normally in agricultural habitats and other nonforest environments due to site conditions and the water table.
<b>2</b>	<b>Freshwater Wetland, Riparian, and Aquatic Resource Management</b>		2K	Removing riparian vegetation	Removal of trees and shrubs within 30 m of a waterway.
2A	Creating and maintaining impoundments	Activities include the construction of main and retention dams that create impoundments >4 ha.	2L	Livestock grazing of riparian areas	The effects of primary grazers (cattle, horses, and sheep) within 366 m of a waterway.
2B	Controlling water levels	The effects of raising and lowering water levels within an impoundment, assuming the high and low water marks are already well established, and considering only those effects that occur within the variable zone.	2M	Adding coarse woody debris and boulders to streams and rivers	Intentional addition of materials to enhance aquatic habitat conditions within streams and rivers.
2C	Creating/maintaining islands or rafts within impoundments	Naturally occurring islands that result from high water levels cutting off peninsulas, and human-made rafts created from a variety of materials. Both rafts and islands are <0.8 ha. Also includes dredge spoil islands.	2N	Removing coarse woody debris from streams and rivers	Intentional removal of materials from streams and rivers resulting in degradation of aquatic habitat conditions.
2D	Draining wetlands, marshes, ponds, lakes	Effects associated with the draining of fully functional aquatic systems.	2O	Restoring/maintaining beaver populations	Restoring or maintaining beaver populations will retain the primary function of beavers: to deliver down wood to aquatic systems and produce small impoundments (<0.8 ha).
2E	Increasing water supply	Assumes, within the context of a stream, wetland, or small lake (<4 ha), that flooding results in an increase in water supply that is sustained for 2-3 months (or more) over several years.	2P	Retaining riparian buffer strips	Activities associated with maintaining trees and shrubs within 30 m of a waterway.
2F	Decreasing water supply	Flow withdrawal occurs within the context of a stream, wetland, or small lake (<4 ha) and these water bodies normally contain open water for most of the year.	2Q	Armoring banks for erosion control	Enhancing bank stability within streams and rivers (e.g., riprap).
			2R	Controlling sedimentation by revegetation of banks with grass-sedge-forb mixtures	Bank stabilization technique in streams and rivers.
			2S	Controlling water pollution	Controlling point-source pollution discharge into lakes, streams, rivers, or nearshore marine waters.
			2T	Disposing/assimilating wastewater	Controlling waste water effluent discharge into lakes, streams, rivers, or nearshore marine waters.
			2U	Dredging	Periodic dredging and deposition of spoils by large ships or barges within large rivers.
			2V	Locating/constructing stream crossings	The construction of roads and bridges across creeks and small rivers; includes heavy equipment, blasting, and landscape alteration.

Code	Activity	Definition	Code	Activity	Definition
2W	Controlling aquatic plants	Activities, including herbicide application and water drawdowns, to reduce or remove emergent or submergent plants usually associated with reservoirs or impoundments.	4F	Maintaining grasses and forbs within orchards, Christmas tree farms, etc.	Leaving vegetation around desired crops to provide habitat for wildlife.
2X	Channelization	Creating passageways to direct the flow of water.	4G	Providing/maintaining vegetation along field and ditch margins	Includes providing cover in the form of hedge rows, shelterbelts, or other vegetated corridors.
<b>3</b>	<b>Road Management</b>	<b>Roads that are engineered and maintained; the surfaces of which can be pavement, gravel/rock/cinder, or dirt. Does not include skid roads.</b>	4H	Retaining crop residue	Practicing harvest methods that leave crop remains on the ground over the winter.
3A	Road and bridge construction/obliteration	The actual construction (or obliteration) of roads and bridges, which includes heavy equipment, blasting, and landscape alteration.	4I	Implementing farmland conservation programs	Activities focused on the restoration and maintenance of predominantly native vegetation and erosion control measures on lands formerly managed for agricultural commodity production.
3B	Operational aspects of road maintenance and use	Activities associated with the maintenance and use of roads and bridges, which includes roadside vegetation management (mowing, herbicides, ditch cleaning, revegetating roadsides, introducing exotic vegetation, removing hazard snags), removing beaver dams that cause road flooding, spreading oil for dust abatement, and runoff management (e.g., culverts) to reduce erosion, turbidity, and contamination of waterways by heavy metals.	4J	Irrigating	Routine application of water to row crops or pastureland.
3C	Road closures	Limiting road use (seasonal and yearly closures with gates or some other system, but road is still maintained).	4K	Altering drainage	Includes ditching and tiling on a recurrent basis on lands used in the production of agricultural commodities.
3D	Bridges (in general)	Literature search resulted in article(s) that described the general effects of bridges.	4L	Decreasing water supply: flow withdrawal	Pumping water out of streams, rivers, and wetlands for irrigation, resulting in decreased water supply in aquatic habitats.
3E	Roads (in general)	Literature search resulted in article(s) that described the general effects of roads.	4M	No-till or minimum-till farming	Crop production techniques that minimize soil disturbance.
<b>4</b>	<b>Agricultural Activities</b>		4N	Clean farming	Intensive agriculture that uses all available land surface, leaving no crop residues (often due to tilling and burning post-harvest).
4A	Applying fertilizers	Periodic application of fertilizers to agricultural habitats such as row crops, orchards, nurseries, etc.	4O	Strip intercropping	Harvest technique to conserve soil by removing alternate rows of vegetation.
4B	Applying pesticides	Periodic application of pesticides to agricultural habitats such as row crops, orchards, nurseries, etc.	4P	Conversion of native habitats	Replacing native forest or shrubland/grassland habitats with agriculture.
4C	Applying herbicides	Periodic application of herbicides to agricultural habitats such as row crops, orchards, nurseries, etc.	4Q	Control of vertebrates considered to be agricultural pests	Use of repellents, including chemical, visual, and noise, also includes trapping to remove animals causing damage to crops.
4D	Applying fungicides	Periodic application of fungicides to agricultural habitats such as row crops, orchards, nurseries, etc.	4R	Providing artificial nesting sites	Nest boxes placed along roads and near ponds to enhance passerine and waterfowl productivity.
4E	Haying/mowing	Vegetation removal on row crops and pasturelands.	4S	Agriculture (in general)	Literature search resulted in article(s) that described the general effects of agriculture.
			<b>5</b>	<b>Shrubland and Grassland Management</b>	
			5A	Mechanical vegetation management	Physical removal of vegetation, including chaining.
			5B	Burning	Fires that are intentionally lit (or natural fires that are allowed to burn) for a specific management objective. The extent, intensity, and timing are either planned or controlled.
			5C	Use of herbicides	Periodic application of herbicides to shrubland/grassland habitats.

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Code	Activity	Definition	Code	Activity	Definition
5D	Restoration	Activities used to recreate or enhance native grassland or shrubland habitats.	8B	Surface/strip mining and processing	Surface and strip mining are techniques that allow the extraction of shallow ores and coal. Processing associated with these techniques involves the extraction of valuable materials from mixed ore and can include heap leach, vat leach, flotation, and other techniques. These techniques involve the removal of overburden; ore processing; waste rock disposal; tailings disposal and embankment construction; water supply development, storage, and runoff management; and power supply development.
5E	Conversion of shrubland to native or non-native grassland	Conversion to grassland to provide forage for livestock.	8C	Underground mining and processing	Underground mining is the extraction of mineralized zones by underground methods. Processing associated with these techniques involves the extraction of valuable materials from mixed ore and can include heap leach, vat leach, flotation, and other techniques. These techniques involve site preparation; ore processing; waste rock disposal; tailings disposal and embankment construction; and water supply development, storage, and runoff management.
5F	Livestock grazing	Allowing cattle, horses, or sheep to forage on open rangeland.			
5G	Shrubland management (in general)	Literature search resulted in article(s) that described the general effects of shrubland management.			
5H	Grassland management (in general)	Literature search resulted in article(s) that described the general effects of grassland management.			
<b>6</b>	<b>Livestock Management (cattle, sheep, and horses)</b>				
6A	Livestock grazing	Allowing cattle, horses, or sheep to forage over wide areas.			
6B	Conversion of shrubland to native or non-native grassland	Conversion to grassland to provide forage for livestock.			
6C	Creating or providing stockponds	The presence of stockponds and their influence on livestock impacts to the environment (e.g., may reduce impacts to naturally occurring streams).			
6D	Excluding livestock from riparian areas	Removing or preventing livestock from access to streams and the resultant restoration of riparian habitats.			
<b>7</b>	<b>Fencing</b>				
7A	Fencing to control or direct wildlife access	Includes fencing to (1) exclude predators from other wildlife or livestock, (2) exclude ungulates from orchards, hay stacks, and seedlings, and (3) control wildlife access and movements along roadways.	8E	Placer prospecting and mining	Searching for, and recovery of, minerals from streamborne deposits. Usually involves the use of water to aid recovery from these deposits. These activities include excavation of materials from these deposits and processing with various equipment including pans, sluice boxes, suction dredges, and highbankers. The primary impacts of these activities are the redistribution of existing in-stream sediment, introduction of new sediment from adjacent uplands, negative impacts to in-stream invertebrates, fish, and fish spawning areas, and alteration of the stream channel dynamics.
7B	Fencing to protect or restore habitat	Nonriparian, includes aspen and special botanical areas.	8F	Mineral exploration	This activity reflects the exploration of potential mineral deposits and primarily involves significant amounts of road construction (often in a grid pattern), the drilling of test holes, and associated land-clearing activities by heavy equipment.
7C	Fencing to exclude livestock from riparian areas	Preventing livestock access to streams and the resultant restoration of riparian habitats.			
<b>8</b>	<b>Mining Activities</b>				
8A	Site reclamation	The purpose of reclamation is to return the disturbed areas to a stabilized and productive condition following mining and milling activities to protect long-term land, water, and air resources in the area. This most often involves modifying the final grade of gravel and substrate materials, providing for soil stability, planting vegetative cover, and addressing water flow and quality aspects.			

Code	Activity	Definition	Code	Activity	Definition
8G	Sand, gravel (aggregate), and peat mining	Surface mining to extract building and construction materials including sand, gravel, and rock. Activities are typified by rock and gravel quarries. Aggregate mining does not involve the chemical processing of materials. Peat mining is included here as it reflects similar methods for the extraction of subsurface materials.	9B6	Prescribed burning	Fires that are intentionally lit for a specific management objective such as forest health or site preparation. The extent, intensity, and timing are either planned or controlled.
8H	Mining (in general)	Literature search resulted in article(s) that described the general effects of mining.	9B7	Applying insecticides	Periodic application of insecticides to prevent loss of tree vigor and mortality.
8I	Mining activities involving blasting	Literature search resulted in article(s) that described the general effects of blasting.	9B8	Forest management (in general)	Literature search resulted in article(s) that described the general effects of forest management.
8J	Oil and gas extraction	Literature search resulted in article(s) that described oil and/or gas extraction.	9C	Site Preparation/Tree Establishment Activities	
<b>9</b>	<b>Forest Management<sup>a</sup></b>		9C1	Applying herbicides	Application of herbicides to reduce competition to seedlings from encroaching vegetation.
9A	Harvest Operation Activities		9C2	Fertilizing plantations	Application of fertilizers to increase tree growth and site productivity.
9A1	Clearcutting	The harvesting of all standing trees in a given area at the same time.	9C3	Removing slash	Includes use of heavy equipment and piling, burning, or hauling off of slash for chipping; all slash is removed from site.
9A2	Shelterwood cuts	Harvesting in which trees on a site are removed in a series of cuts over time to create an even-aged stand.	9C4	Planting/seeding	Includes the use of vexar tubing, shade cards, and plastic sheeting.
9A3	Seed tree cuts	Harvesting in which a cut removes almost all the trees in an area, but leaves a few scattered mature trees of good genetic stock to produce seed to regenerate the stand.	9C5	Tilling prior to planting	Mechanical preparation of the ground to facilitate tree planting.
9A4	Group selection	The selective removal of small groups of trees in a system of uneven-age management.	9D	Habitat Management Activities	
9A5	Selective harvest across all tree sizes	The selective removal of single trees in a system of uneven-age management.	9D1	Maintaining mature/old growth	Includes maintaining forest corridors.
9A6	Selective harvest of specific tree sizes, conditions, or species	Includes varied silvicultural prescriptions, including salvage harvests.	9D2	Grazing livestock	Allowing horses, sheep, or cattle to freely forage within forested stands.
9B	Silvicultural/Stand Improvement Activities		9D3	Retaining medium green trees	Leaving 28-48 cm dbh trees from prior stand.
9B1	Precommercial thinning	Removal of young trees to increase the growth of remaining trees in a stand. The cut trees are often left as slash on the forest floor.	9D4	Retaining large green trees	Leaving >51 cm dbh trees from prior stand.
9B2	Commercial thinning	Release cuttings to manipulate stocking densities for enhancement of dominant or codominant trees; cut trees have commercial value and are removed from the stand.	9D5	Retaining defective trees	Deformities include cavities, broken tops, heart rot, conks, multiple tops, etc.
9B3	Pruning	The removal of lower limbs to create higher quality wood and enhance tree growth rates.	9D6	Creating/maintaining edges	Many harvesting activities result in contrasting boundaries between forest stands of various successional stage or species composition.
9B4	Simplifying species composition and/or structure	Genetically selecting trees, favoring one or few commercially desired species.	9D7	Retaining mast trees	Leaving hardwood species that produce soft or hard mast for wildlife use.
9B5	Type conversion	Changing grasslands to tree farms, or hardwood stands to conifer stands.	9D8	Retaining forest openings	Pertains to the creation of small forest openings (gaps), or the prevention of tree encroachment into natural meadows.
			9D9	Retaining brush/slash piles	Leaving the unwanted vegetation left from a harvest operation in piles on the site for wildlife use.
			9D10	Retaining/providing dead/down wood	Leaving or providing dead wood from harvest operations on the forest floor for wildlife use (instead of collecting or burning it).

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Code	Activity	Definition	Code	Activity	Definition
9D11	Retaining/creating snags	Allowing standing dead trees to remain in the stand after harvesting, or topping/blasting live green trees to create new snags.	10B	Harbor, marina, and ferry terminal development	Includes both the development and subsequent use of harbors, marinas, and ferry terminals. This category reflects both fresh and saltwater environments. Includes commercial shipping, associated cargo handling, and ferry transport. Recreational boat marinas and associated infrastructure (e.g., parking lots, floats, breakwaters, fueling stations). Commercial harbors and ferry terminals are typified by Elliott Bay, Port Angeles, and Bellingham Bay, Washington; and Newport, Coos Bay, and Portland, Oregon. Recreational marinas are typified by Olympia and Des Moines, Washington; and Astoria, Oregon. Impacts extend to include bilgewater and wakes from large ships.
9D12	Retaining riparian buffers	Activities associated with maintaining trees and shrubs within 30 m of a waterway.			
9D13	Providing artificial nest sites	Employing nest boxes to enhance productivity of selected forested species that use cavities.			
9D14	Creating/maintaining corridors	Deliberately providing or retaining connective habitat to facilitate wildlife travel and use.			
9E	Incidental Activities				
9E1	Introducing exotic vegetation	An example is elk forage mix.			
9E2	Creating water sources	Digging pumper ponds or wildlife ponds.			
9E3	Removing hazard trees	Removal of trees deemed to be hazardous to human safety from roadsides and campgrounds to comply with federal regulations.			
9E4	Building skid roads and landings	The creation of skid roads and landings opens up forest canopies, increasing the amount of edge and early successional habitats.	10C	Residential docks in marine and freshwaters	
9E5	Forest vertebrate pest control	Activities to prevent animal damage or to remove offending individuals.			
9F	Special Forest Products		10D	Toxic spills in fresh and saltwater	
9F1	Firewood cutting	Removal of live trees or snags for the purpose of obtaining fuel.			
9F2	Harvesting wild mushrooms	Commercial harvest of wild mushroom species.			
9F3	Bough collection	The pruning of lower limbs for decorative purposes.			
9F4	Special forest products (in general)	Literature search resulted in article(s) that described the general effects of collecting special forest products.			
<b>10</b>	<b>Marine Activities</b>				
10A	Marine dredging and filling	Mechanically or hydrologically removing bed materials (sand, gravel, mud) and moving them to a new location to provide increased depth for boat and ship navigation. Filling is the placement of dredged material or upland materials in marine aquatic areas. In Puget Sound, fill materials are typically placed to create uplands for commercial purposes (e.g., marina, port developments). Fill material has been used to create dredge spoil islands along the lower Columbia River.	10E	Marine shoreline armoring	Placement of rock, wood, or concrete at the water's edge to prevent shoreline erosion or bank failure. Bulkheads are sometimes placed in no-eroding areas.
			10F	Developing underwater marine structures	The active creation of underwater structures, normally involving placement of large concrete and rock substrates. Objective is to provide vertical relief to create habitat structures for various marine fish and shellfish. These underwater reef structures could be 15 m wide, 61 m long, and 3 m tall. The structures are located primarily in Puget Sound,

Code	Activity	Definition	Code	Activity	Definition
		Washington. Note: oil exploration and associated drilling platforms are currently prohibited off the Oregon and Washington coastlines, and thus are not considered in this assessment.			
10G	Marine fisheries	This activity reflects marine-based harvest and processing of fish. Primary effects are derived from trawlnet, purse-seine, and gillnet fishing techniques. Primary wildlife issues in Oregon and Washington reflect the bycatch of marine seabirds (and marine mammals to a much lesser degree) in active or lost fishing gear (e.g., "ghost nets").			
10H	Aquaculture	Commercial production and harvest of fish (i.e., grown in net pens) and shellfish (e.g., oysters, geoducks, clams, and mussels). This also includes impacts associated with recreational harvest of shellfish.			
<b>11</b>	<b>Urban Development</b>				
11A	Paving	Creation of impervious surfaces, (e.g., concrete or asphalt), and the subsequent impacts associated with the loss of natural vegetation and substrates.			
11B	Building houses and businesses	Converting natural habitats for human occupation, including, for example, single homes, apartments, businesses, subdivisions, shopping malls or industrial parks, and the subsequent impacts associated with the loss of natural vegetation.			
11C	Presence of domestic animals	Refers to the disturbance and impacts caused by dogs and cats.			
11D	Urban aquatic habitat management	Activities associated with the restoration and modification of this habitat, including paving, ditching, and channelization of urban watercourses. Also includes the development and maintenance of ponds and lakes in an urban context, for example, in golf courses or parks.			
11E	Landscaping and vegetation management	The conversion of native vegetation to exotic and ornamental plant species, including lawns.			
11F	Water quality and stormwater management	Activities associated with the prevention of water contamination from runoff.			
11G	Establishing and maintaining greenways/greenbelts	Providing undeveloped areas of primarily natural vegetation within the urban matrix.			
<b>12</b>	<b>Recreational Activities</b>				
12A	Trail use and camping	All activities associated with trails and camping. Includes the use of pack animals and mountain bikes.			
12B	Snowshoeing/snow skiing/sledding	Nonmotorized snow travel.			
12C	Mountain/rock climbing	Disturbance caused to wildlife from climbing of all kinds.			
12D	Motorized boating	Disturbance by and effects of motor boats on wildlife and aquatic habitats.			
12E	Nonmotorized boating	Nonmotorized boat traffic including rafts, canoes, sailboats, and rowboats.			
12F	Swimming	The effects of humans in waterbodies.			
12G	Off-road driving	Includes the effects of all motorized off-road vehicles, including ATVs, four-wheel drive trucks, and dune buggies.			
12H	Snowmobiling	Motorized snow travel.			
12I	Aircraft use	Includes planes, helicopters, and other motorized aircraft.			
12J	Recreational developments	Includes ski areas, and other resorts.			
12K	Fish stocking	Providing fish for recreational use.			
<b>13</b>	<b>Right-of-way Management</b>				
13A	Utility corridors	Linear rights-of-way including power lines, telephone lines, oil pipelines, etc.			

\*Some of the Forest Management Activities were defined by D. Patton, 1992, in *Wildlife Habitat Relationships in Forested Ecosystems*, published by Timber Press, Portland, Oregon.