Draft
Crab Creek
Subbasin Summary

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Crab Creek Subbasin Summary

FISH AND WILDLIFE RESOURCES

Subbasin Description

General Location

The Crab Creek Subbasin is located in central Washington in portions of Douglas, Lincoln, Adams, Grant, and Spokane counties, within the Columbia Plateau Province (Figure 1). It is bounded on the east by the Palouse Subbasin, on the south by the Lower Mid-Columbia Mainstem Subbasin, on the west by the Upper Mid-Columbia Mainstem Subbasin, and on the north by the Rufus Woods and Roosevelt Lake Subbasins. The head waters begin in Lincoln County near the town of Reardan approximately 30 km west of Spokane and include a small part of western Spokane County 13 km west of Cheney. Crab Creek flows southwest for approximately 225 km draining into the Columbia River near the town of Schwana in Grant County, five miles south of the Wanapum Dam. This planning effort includes part of southern Douglas County, which is outside of the Crab Creek watershed, and includes the drainages for McCarteney and Douglas creeks that flow, via Moses Coulee, into the Columbia River 8 km down stream from Rock Island Dam.

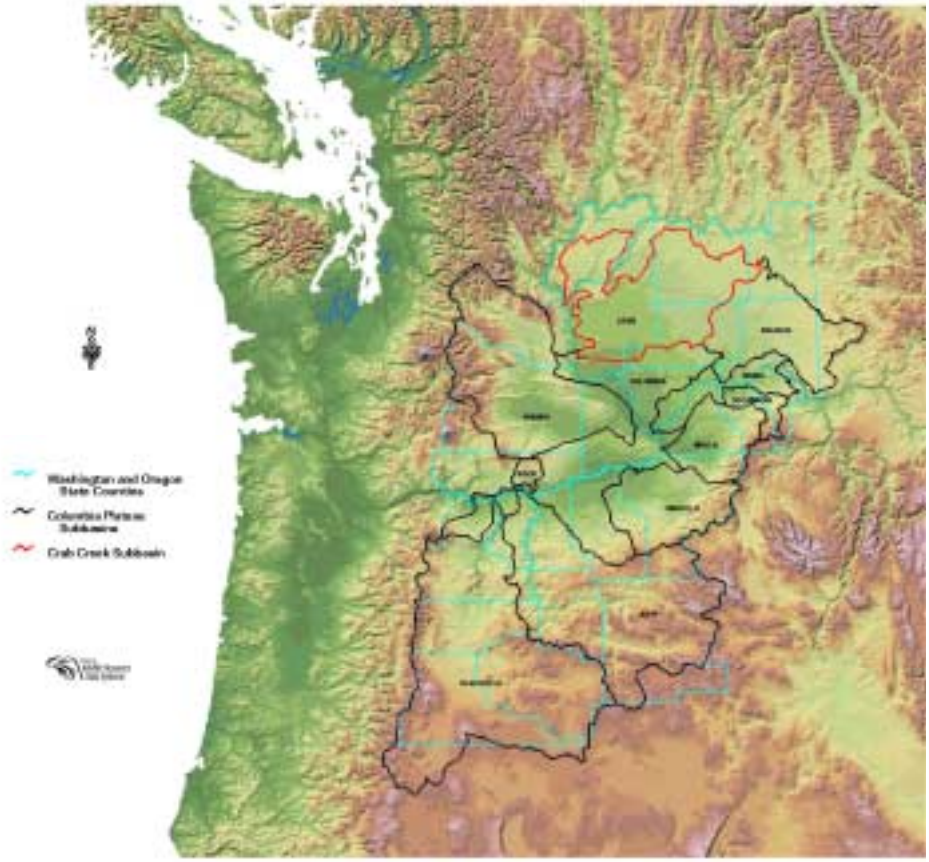

Figure 1. Location of Crab Creek Subbasin in the Columbia Plateau

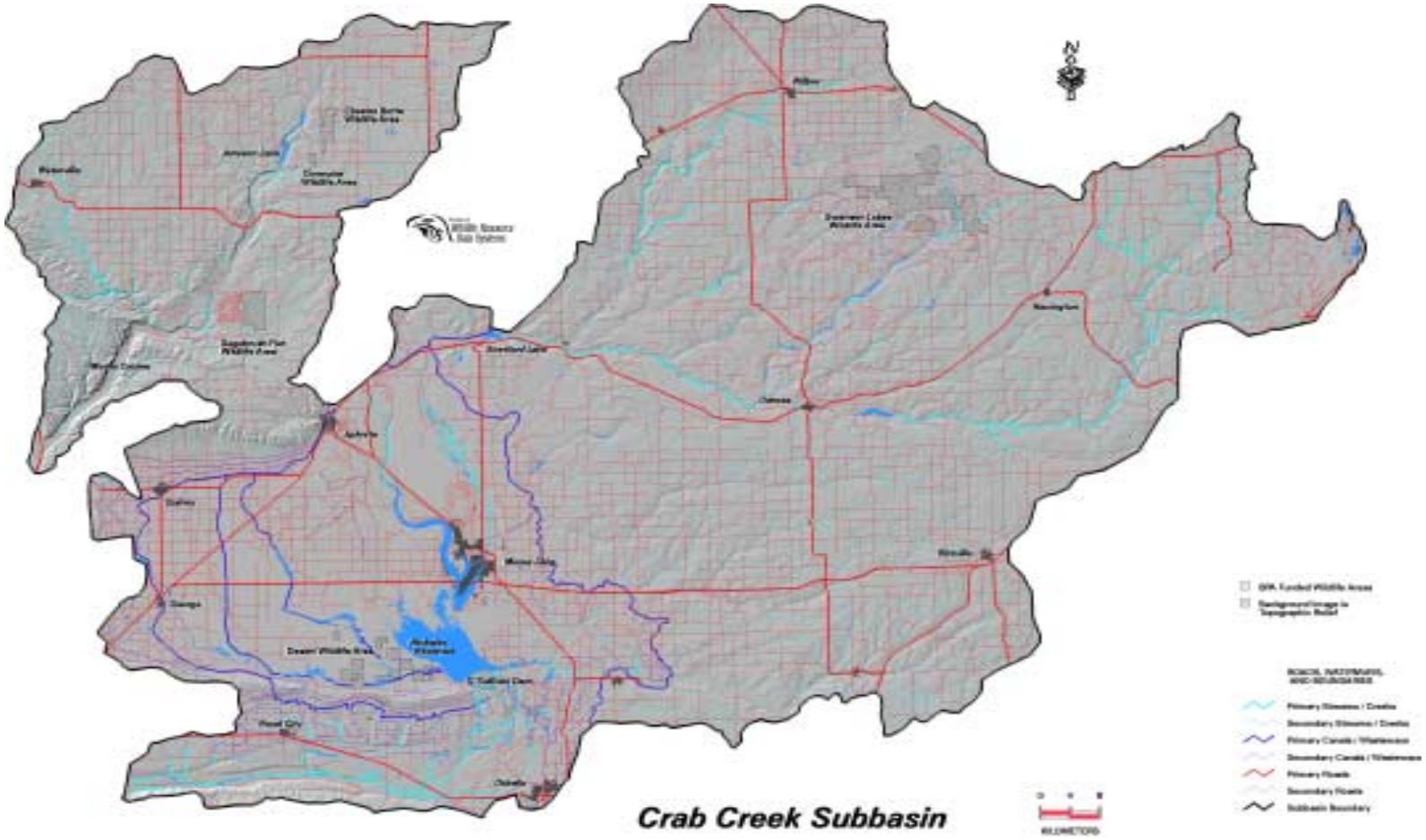

Figure 2. Communities and Landmarks

Drainage Area/Hydrology

The size of this Subbasin is 13,200 square kilometers. Major tributaries of Crab Creek include the following creeks Blue Stem, Rock (Lincoln County), Lords, Coal, Duck, Lake, Canniiwai, Wilson, Homestead Creek and Rocky Ford, and various intermittent and permanent irrigation return-flow (wasteways) of the Columbia Basin Irrigation Project. In addition several coulees that had intermittent streams prior to the Columbia Basin Project now support perennial flow, and include Rocky, Lind, and Red Rock coulees. Crab Creek flows through several lakes starting with Sylvan Lake in south-central Lincoln County, then Brook Lake, Round Lake, Willow Lake, Moses Lake, and Potholes Reservoir in Grant County. In many areas along its way Crab Creek flows below the surface. Changes in adjacent hydrology affect when and where the creek may resurface which can vary from year to year.

In southern Douglas County, the Moses Coulee watershed includes Jameson and Grimes Lakes. The ground-water table in lower Crab Creek has risen between 50 and 500 ft since 1950, as a result of the Irrigation Project. During the same time period upper Crab Creek's ground-water table has declined 150 ft, because of increased ground water withdrawals for irrigation.

Hydrology Within the Crab Creek Subbasin

The Bureau of Reclamation's Columbia Basin Irrigation Project has the greatest influences on hydrology within the Crab Creek Subbasin (www.usbr.gov). More water is pumped into the Subbasin from the Columbia River than all natural sources within the Subbasin. Return flows after irrigation use, excess water, and leakage from the project all contribute considerable water to this system. O'Sullivan Dam impounds Crab Creek below Moses Lake and collects Columbia Basin Irrigation water to create Potholes Reservoir (11,100 hectares). O'Sullivan Dam restricts upstream fish travel. This lower section below the dam contains approximately 40 linear miles of perennial stream habitat. Many lakes now occur as a result of the Irrigation Project that supports significant recreational fisheries.

Crab Creek has been described as the longest intermittent creek in North America. However, the upper portion of Crab Creek, many of its tributaries (such as Sinking Creek), and McCarteney Creek actually have perennial flow of water that occurs immediately below the surface layer of basalt. This pattern of flow has resulted in creeks that fluctuate between surface and subsurface depending on the specific location, time of year, and weather conditions. In contrast, lower Crab Creek now has perennial surface flow as a result of return flow from the Columbia Basin Irrigation Project. Lower Crab Creek has four to five times the flow that occurred prior to the irrigation project (http://wa.water.usgs.gov). This section of the creek has been highly modified with irrigation diversions, water-control structures, and channelization. These modifications along with increased

flow have caused severe erosion, bank sloughing, and head cutting. Fish passage, habitat, and water-quality have all been compromised.

Topography/Geomorphology

Uplands areas of the Plateau are characterized by gently rolling loess-covered hills interspersed with channeled scablands – wide basalt terraces with steep walls. The landscape within much of this Subbasin was sculpted by the torrential Spokane Floods which took place approximately 12,000 to 15,000 years ago. Glaciated areas in portions of Lincoln and Douglas counties are marked with small water bodies, most of which are shallow ephemeral ponds that are watered in wet cycles and dry during drought years. The substrate consists of unconsolidated quaternary sediments and Columbia River basalt. Most of the soils in the subbasin are related to the volcanic history or the subsequent effects of glaciation, runoff, and flooding. The main soils in cropland-dominated areas are Bagdad, Broadax, Hanning, Renslow, Ritzville, Shano, Touhey, Willis, and Zen (Beieler 1978, Stockman 1978). The Aquolls, Haploxerolls, and Esquatzel soils are prone to wetness and/or flooding. The typical soils in rangeland areas include Anders, Bakeoven, Benge, Heytou, Lickskillet, Rock Creek, Roloff, Stratford, and Tucannon. Ponderosa pine areas tend to be dominated with Badge, Ewall, and Springdale soils.

Climate

The average temperatures in the Crab Creek Subbasin are 51°F minimum and 83°F maximum during summer and 21°F minimum and 36°F maximum during winter (U.S. Weather Service Website). The record minimum temperature was -33°F recorded in Waterville and Moses Lake and the record maximum temperature was 115°F recorded in Ephrata and Wilson Creek. Waterville tends to be the coldest location in the subbasin during winter (18 - 33°F average range); other locations tend to be 4 - 6°F warmer. Waterville, Wilbur, and Harrington tend to be the coolest locations during summer (50 - 80°F typical range). The other locations typically reach the mid-80°F range for summer highs and about 50°F for summer lows, with 2 exceptions; Ephrata and Quincy are typically in the upper 50°F range for summer lows.

The average precipitation in the subbasin is 10.1 inches. The driest locations (< 10 inches/year) include Quincy, Ephrata, Moses Lake, Wilson Creek, Lind, and Othello. Locations in the 10 – 12 inch precipitation zone include Ritzville, Odessa, and Waterville. Harrington and Wilbur are in the > 12 inch precipitation zone. The wettest year recorded in any community in the Crab Creek Subbasin was 24 inches in 1948 in Waterville. The driest year was 3 inches recorded for Ephrata in 1976. Winter is typically the wettest season in the subbasin, with substantial portions of the precipitation falling as snow. The average annual snowfall is 21.4 inches. Othello receives the smallest amount at < 10 inches; Odessa, Moses Lake, Quincy, Lind, Ephrata, and Ritzville average 10 – 20 inches; Harrington and Wilson Creek average 20 – 30 inches; and Waterville

averages > 40 inches. The highest annual snowfall was 105 inches recorded in Waterville in 1942.

Major Land Uses

The economy is dominated by agriculture. Although the area has a long history of occupation by native peoples (Coullier et al. 1942), large-scale conversion of land from shrubsteppe to cropland began in the late 1800's and expanded when irrigation became widespread after the damming of the Columbia River in the 1930's (National Research Council 1995). The delivery of irrigation water to the Columbia Basin Irrigation Project in 1952 dramatically changed the appearance and ecology of the southwest corner of this Subbasin from mostly shrubsteppe to a huge system of reservoirs, canals, wasteways, and irrigated farmland. The Columbia Basin Project irrigates greater than 2500 square kilometers of land. Outside of the Irrigation Project dry-land wheat farming and cattle grazing dominate. The major crops in the eastern and northern Crab Creek Subbasin are cereal grains. Agriculture within the irrigation project is more diverse and crops include alfalfa, wheat, corn, potatoes, various tree fruits and many different seed crops. Vineyards and pulp farms have begun to appear recently.

The major municipalities within this Subbasin are Moses Lake (pop. 14,290), Ephrata (pop. 6,170), Othello (pop. 5,445), Quincy (pop. 4,185), Warden (pop. 2,335), Ritzville (1,730), Royal City (pop. 1,680), and Odessa (pop. 987) (Figure 2).

Water Quality

Water quality in lower Crab Creek is poor (USGS 1998). High levels of nutrients occur, primarily from fertilizer. Nitrate concentrations in the groundwater are high and exceed the drinking water standards in many wells. Nitrate concentrations in shallow wells in irrigated areas are among the highest in the nation. Levels of pesticides in water and fish tissue are relatively high, one or more organochlorine compounds exceed aquatic-life guidelines. Concentrations of long-banned organochlorine pesticides (such as DDT) or total PCBs exceed environmental guidelines. Shallow wells in the Quincy area had the highest levels of pesticides and the largest number of different kinds of pesticides.

Riparian habitats have been seriously reduced, and present-day agricultural practices limit natural recovery of vegetation. Over the last 50 years, Moses Lake and its watershed, including groundwater, have been altered permanently by human activities, especially the use of Columbia River water for irrigation farming (Washington Department of Ecology 2000).

During the last 30 years, at least 13 studies of Moses Lake indicate that anthropogenic activities, particularly agricultural practices, have contributed to a hypereutrophic state for the lake. It has been estimated that over 75% of the total phosphorus (TP) load to Moses Lake originates from agricultural fertilizers and

farm animal wastes. As of 1989, it was reported that only 20% of the irrigated land had implemented recommended water and nutrient controls, resulting in a nutrient concentration reduction of less than 2% in the Crab Creek inflows to the lake. In addition to these agricultural impacts, climatic variation, internal loading, and adding dilution water to the lake can also have a significant influence on the water quality of Moses Lake.

Four years of baseline monitoring in upper Crab Creek (Shumacher 1998) indicate local exceedences of pH and fecal coliform bacteria, and high concentrations of suspended sediment and associated phosphorus. Upper Crab Creek is included on the state's "303d list" for exceedences of Class A pH criteria.

In most streams, sediment loading has reduced instream habitat. Riparian habitats have been seriously reduced, and present-day agricultural practices limit natural recovery of vegetation.

Vegetation

Habitats that are not converted are typically shrubsteppe. Daubenmire (1970) described shrubsteppe as vegetative communities consisting of one or more layers of perennial grass with a conspicuous but discontinuous overstory layer of shrubs. In the Crab Creek Subbasin, shrubsteppe also includes 'meadowsteppe' and 'steppe' habitats which may have a relatively low frequency of shrubs. The dominant shrubs include sagebrush (*Artemisia spp.*), rabbitbrush (*Chrysothamnus spp*.), bitterbrush (*Purshia tridentate*), grease wood (*Sarcobatus spp*.), and Spiny hopsage (*Grayia spinosa*). The dominant grasses include native bunchgrasses (*Poa, Stipa,* and *Agropyron spp*.) and non-native downy brome (*Bromus tectorum*). Riparian vegetation consists of willows (*Salix spp*.), rose (*Rosa spp.*), water birch (*Betula occidentalis*), black cottonwood (Populus angustifolia), aspen (P. termuloides), hawthorn (*Crataegus douglasii*), and service berry (Amelanchier anifolia).

Fish and Wildlife Status

Fish

The Crab Creek Sub basin hosts a rather large assemblage of piscine fauna (Table 1). Much of this assemblage has developed over the past 100 years as human settlement in the region contributed to establishment of many alien species and stocks. However, trout were one of the native fishes of Crab Creek.

Perhaps the earliest recorded observations of fish in Crab Creek came from Strong (1906), who spoke of Crab Creek: "At its source near Medical Lake it is a mere brook, and here in 1870, there were trout, little fingerlings, by the hundreds." No mention was made as to the species. This was prior to the first of many hatchery stockings in this watershed, the earliest being two releases of eastern brook trout

in 1903 and 1904, followed by two releases of Westslope cutthroat of Lake Chelan origin in 1907 and 1908 (Riseland 1905; Riseland 1909). The U.S. Bureau of Fisheries workers collected trout in 1908 at a road crossing north of Ritzville, and many miles west of Strong's 1870 observations. They established the trout of Crab Creek as cutthroat (Evermann and Nichols 1909). Dr. Robert J. Behnke, a world authority on trout taxonomy, pondered the descriptions of these trout and concluded they belonged to the Yellowstone cutthroat subspecies *Oncorhynchus clarki bouveri*, a cutthroat not known from any other Washington waters, although he also thought this subspecies might have been in the Palouse Watershed as well (Behnke 1992). Questions still remain on the origin of trout described by Evermann and Nichols (1909) whose 1908 survey came one year after the first release of Westslope cutthroat in Upper Crab Creek. Washington waters, although he also thought that this subspecies might have been in the Palouse Watershed as well (Behnke 1992).

Table 1. Fish species of Interest within the Crab Creek Subbasin.

Common name	Scientific name	Status[1]	Locations/*abundance*
Pacific lamprey	*Entosphenus tridentatus*	N	Possibly sub-basin tributary mouths; *infrequent*
White sturgeon	*Acipenser transmontanus*	Food, G	Moses Lake, likely Banks and Billy Clapp lakes; *rare occurrences*
Lake whitefish	*Coregonus clupeaformis*	G	Banks, Billy Clapp, Moses, Potholes Res., Soda, Long, Crescent lakes; *abundant*
Mountain whitefish	*Prosopiun williamsoni*	G	Crab Creek below Hwy. 26; Red Rock Creek; *uncommon*
Brown trout	*Salmo trutta*	G	Several tribs and most perennial reaches of Crab Creek; several lakes; *common*
Cutthroat trout, Lahontan	*Oncorhynchus clarki*	G	A few lakes connected to Crab Creek; Grimes Lk. (Moses Coulee drainage); *common*
Rainbow trout	*Oncorhynchus gairdneri*	G	Most waters w/in sub-basin; *abundant*
Steelhead, Summer, Upper Columbia stock	*O. gairdneri*	G, SC, FE	Lower Crab Ck; Red Rock Ck; Lower Sand Hollow Ck; mouths of several tribs to Col. River; *uncommon*

Common name	Scientific name	Status[1]	Locations/*abundance*
Brook trout	*Salvelinus fontinalis*	G	A few lakes and streams entering Crab Creek; *locally common*
Lake trout	*Salvelinus namaycush*	G	Deep Lk., Grant County only; *rare*
Chinook salmon, summer/fall run	*Oncorhynchus tshawytscha*	Food, G	Lower Crab, Red Rock, Lower Sand Hollow Cks.; *common in fall*
Sockeye salmon	*Oncorhynchus nerka*	Food, G	Lower Sand Hollow Ck. (observed in 1991 only); *uncommon*
Kokanee	*O. nerka*	G	Banks, Billy Clapp Lks; *common*
Tiger muskellunge	*Esox lucius X E. masquinongy*	G	Evergreen and Red Rock reservoirs; *uncommon*
Common carp	*Cyprinus carpio*	N	Ubiquitous
Grass carp	*Ctenopharyngodon idella*	N	Few small ponds and irrigation ditches; *uncommon*
Goldfish	*Carassius auratus*	N	Moses Lake; *uncommon*
Tench	*Tinca tinca*	N	Lower Crab Ck.; *uncommon*
Redside shiner	*Richardsoni balteatus*	N	Lower Crab Ck.; *locally common*
Longnose dace	*Rhinichthys cataractae*	N	Uncertain distribution
N. pikeminnow	*Ptychocheilus oregonensis*	N	Small numbers in all major reservoirs w/in sub-basin; Lower Crab Cr.; *common*
Tui chub	*Gila bilcolor*	N	Lower Crab Cr.; *uncommon*
Peamouth	*Mylocheilus caurinus*	N	Uncertain distribution
Leopard dace	*Rhinichthys falcatus*	N	Uncertain distribution
Speckled dace	*Rhinichthys osculus*	N	Occurs in a few isolated lakes; all major reservoirs; *locally common*
Largescale sucker	*Catostomus macrocheilus*	N	All major reservoirs w/in sub-basin; Lower Crab Cr.; *common*
Bridgelip sucker	*Catostomus columbianus*	N	Uncertain distribution

Common name	Scientific name	Status[1]	Locations/*abundance*
Channel catfish	*Ictalurus punctatus*	G	All major reservoirs w/in sub-basin; *uncommon*
Brown bullhead	*Ictalurus nebulosus*	G	Ubiquitous
Burbot	*Lota lota*	G	Small numbers in Banks, Billy Clapp, Moses Lks., Potholes Res; *rare*
Three-spine stickleback	*Gasterosteus aculeatus*	N	Ubiquitous
Sandroller	*Percopsis transmontana*	N	Columbia River, possibly tributary mouths; *rare*
Largemouth bass	*Micropterus salmoides*	G	All major reservoirs, many isolated lakes; Crab Cr. below Brook Lake; *abundant*
Smallmouth bass	*Micropterus dolomieui*	G	All major reservoirs, Crab Cr. Below Brook Lk.; *abundant*
Black crappie	*Pomoxis nigromaculatus*	G	All major reservoirs; Crab Cr. below Brook Lk.; *abundant*
White crappie	*Pomoxis annularis*	G	Moses Lake; *uncommon*
Bluegill	*Lepomis macrochirus*	G	All major reservoirs and several isolated lakes; Crab Cr. below Brook Lk.; *abundant*
Pumpkinseed	*Lepomis gibbosus*	G	Ubiquitous
Walleye	*Stizostedion vitreum*	G	All major reservoirs, few isolated lakes; Crab Cr. below Brook Lk.; *common*
Yellow perch	*Perca flavescens*	G	Ubiquitous
Torrent sculpin	*Cottus rhotheus*	N	Uncertain distribution
Prickly sculpin	*Cottus asper*	N	Ubiquitous
Mottled sculpin	*Cottus bairdi*	N	Uncertain distribution

[1]Status: SC = State candidate; G = Game species subject to harvest regulations; FE = Federal endangered; N=no special status; Food = Food fish of commercial value (modified from PHS WDFW 1991; WDFW 1999).

The primary species of commercial or recreational importance within the watershed are lake whitefish, steelhead and rainbow trout, brown trout, Lahontan cutthroat trout, chinook salmon (summer/fall run), kokanee, brown bullhead,

walleye, largemouth bass, smallmouth bass, bluegill, black crappie and yellow perch. More details on the abundance and distribution of these, and a few other species of interest, is presented in the following.

White Sturgeon

Sturgeon are resident in the Columbia River, including upstream of Grand Coulee Dam. A few fish have been seen and/or rescued from the Banks Lake feeder canal during dewatering in the fall. One sturgeon was caught by an angler in Moses Lake in the early 1990s and pictured in the Moses Lake Herald newspaper. Their occurrence is likely in other large waters connected to the irrigation canal system.

Lake Whitefish

Lake whitefish, an alien species, attract a small following of anglers, primarily in Banks Lake, but the species is widespread and abundant in all major lakes/reservoirs of the sub-basin: Banks, Billy Clapp, Brook (Stratford), Moses, Soda, Crescent, and Long lakes, and in Potholes and Red Rock reservoirs. All of these waters have direct connection with Crab Creek. They gained access to the sub-basin via water withdrawal from Franklin D. Roosevelt Lake (Columbia River) into Banks Lake, thence through the irrigation water delivery system. Nothing is known about their biology and interaction with other species within the sub-basin, although limited summer die-offs have been noted in Moses Lake and Potholes reservoirs (J. Foster, WDFW, pers. obs.)

Mountain Whitefish

While not of recreational importance within the sub-basin, of note is that this species has been found in Red Rock Creek, a tributary entering Crab Creek at about stream km 26 from the Columbia River (R. Starkey, former USFWS biologist, pers. comm.). There is no information on reproduction here, or of this species occurring in other parts of the sub-basin.

Brown Trout

The WDFW regularly stocks fingerling brown trout in several lakes and flowages within the sub-basin, many of which have direct connection with Crab Creek. The upper permanent flowing reaches of the creek (generally in Lincoln County) have received hatchery releases intermittently in the past, as have some of the main tributaries in the upper Crab Creek basin. Stocking records indicate releases of browns in upper Crab Creek in eight of the years spanning 1946 – 1996. Most, if not all, were released at the bridge on Marcellus Road, a crossing historically known as Rocky Ford. In the permanent flowing section, between Moses Lake and upstream to Willow Lakes area (including Homestead Creek and Homestead Lake), brown trout are stocked either annually or every two years. Browns do not appear to reproduce well anywhere within the Crab Creek watershed and outside of the lakes, they support very little angling activity. Their overall distribution within flowing waters of the sub-basin is sketchy at best. Hatchery releases of browns are a regular part of the stocking program for many trout lakes, where

they grow well, have minimal impact on rainbow fry releases, and are well received by anglers.

Steelhead Trout

The presence of steelhead (adults) have only been confirmed within Sand Hollow Creek (near the mouth) and in Red Rock Creek. Anglers have caught steelhead in April in Sand Hollow (J. Foster, WDFW, pers. observ.) and at the mouth of Red Rock Creek (M. Spence, retired WDFW biologist, pers. comm.). Steelhead may be able to ascend higher in Crab Creek, but potential passage barriers have not been thoroughly described for most of the reach, which is privately owned. Even so, a natural falls south of McManamon Road may be the uppermost known barrier, about 56 km above the mouth. As with chinook salmon, steelhead use of Crab Creek prior to irrigation development was probably very limited, and most certainly the stream would not have produced smolts, given its ephemeral character. With present perennial flows, no information has yet been discovered that indicates lower Crab Creek produces smolts. Adult steelhead might find some spawning sites in Crab and Red Rock creeks, but any eggs and parr would have to endure heavy silt loads and high summer water temperatures in Crab Creek, and do so for the normal two- to three-year freshwater life before seaward migration. Conceivably, young parr might move out of Crab Creek and finish rearing in the Columbia. Yet surveys over many years in the Columbia downstream of Crab Creek have yielded no evidence of steelhead parr, i.e., mainstem rearing. The presence of resident rainbows in Red Rock suggests that steelhead might well be successful in producing smolts in this tributary. We can find no records of hatchery reared rainbow trout or steelhead being stocked directly into Red Rock Creek. Rainbows were released in Red Rock Lake several times after it first formed in 1966, but the last release was in 1976 (WDFW file data). Since fish may pass out of the lake, these might be the parent stock of present-day populations in the creek.

Rainbow Trout

Rainbow trout provide the mainstay of recreational fishing in the subbasin, rainbow trout stocking totals 1.5 million fish annually, mostly all fry or fingerling size, within the sub-basin. In upper Crab Creek (presumably at Marcellus Road crossing), rainbows have been stocked during all but nine years between 1946 and 1996. Most of these were released at “catchable” sizes, i.e., about 17 - 25 cm (WDFW file data). Roughly, 100 lakes within the subbasin are managed solely for trout angling. Others are managed for both trout and warmwater species, but in these waters, rainbows are usually released at a size of 17 - 25 cm. Although there is no evidence of redband rainbow being native to the subbasin, unconfirmed reports of trout with external characteristics of of redband exist from upper Crab Creek (Van Buren, pers comm.). Little scientific documentation exists regarding existing trout species and their current distribution in upper Crab Creek and its tributaries (Lawlor, WDFW pers. comm.).

As mentioned previously, cutthroat were the only known trout indigenous to the upper permanent reaches of Crab Creek, and likely for its permanent tributaries as well. The original cutthroat stock (*O. c. bouveri*) is believed extirpated early in the twentieth century by any number of causes. However, thorough surveys have not been done in the watershed, leaving the question of cutthroat presence somewhat clouded.

Chinook Salmon

The spring-run race of chinook, listed under the Federal Endangered Species Act as endangered of extinction, has not been identified within the Crab Creek Subbasin. [One documented release of 45,840 chinook (race unknown) into Banks Lake, averaging 53 fish/kg (24/lb.), was made by the former Wash. Department of Fisheries in September 1976.] However, the summer/fall race of chinook has long been noted by WDFW biologists for entering most of the tributaries within the sub-basin, at least for short distances, and of spawning attempts. Crab Creek and Sand Hollow creeks annually attract several adults in the extreme lower end, but the success of their spawning is not clear. Stream survey work, now underway by the U.S. Bureau of Reclamation(BOR), shows that adults travel as far upstream in Crab Creek as the mouth of Red Rock Creek, and on into Red Rock Creek. Spawning redds have been found at various locations in both creeks (M. Bowen, BOR, pers. comm.). This effort (report in preparation) is the most intensive to date on the use of these streams by anadromous species, although the work is restricted to flows within the Columbia Basin Irrigation Project. Given that Crab Creek and Sand Hollow Creek were not perennial streams prior to irrigation development, chinook, with their fall spawning habit, were unlikely to have used Crab Creek historically. According to Strong (1906), Crab Creek below Moses Lake disappeared into the ground.

Kokanee

Kokanee gained access to Banks Lake from water pumped out of the Columbia River at Grand Coulee. Stober et al. (1979) determined they were successfully reproducing in Banks Lake, at least until the late-1970s. However, kokanee were also stocked in Banks as early as 1962 and sporadically thereafter (based on availability). Uninterrupted annual stocking of fry or fingerlings has been done since 1992, with numbers varying between a low of 159,000 and a high of 1,678,000 (WDFW file data). The fishery for kokanee was excellent and very popular during the 1960s and 1970s, based on creel checks by biologists for the former Wash. Dept. of Game (now WDFW)(WDFW file data) and by the later work done by Stober et al. (1979). By mid-1980s, however, kokanee harvest dropped to the point that anglers gave up targeting kokanee.

Cyprinids and Suckers

Redside shiner and speckled dace were probably native to upper Crab Creek watershed where flows were perennial. Several other species may have been as well, but a thorough examination of early-day writings has not been attempted, nor have more recent surveys been conducted. While the species assemblage of

the overall subbasin is large, the majority of this is found within the Columbia Basin Irrigation Project (Project), and obviously a consequence of distribution through the irrigation system and illegal species introductions. Today, vast areas of the subbasin are populated with the near ubiquitous carp, both in waters isolated from and directly connected to the Project. Until the late 1970s when markets declined, carp were an important commercial species, processed into fish feed meal and as fresh fish for table fare. The carp fishery on Moses Lake was the most productive of any in Washington. During the heyday of commercial netting (1959 – 1977), harvests ranged from a low of about 10 tons to a high of over 400 tons, averaging about 305 tons (avdp. measure) per year (WDFW file data).

Brown Bullhead

Another widespread species that occurs throughout Crab Creek and connected reservoirs, the brown bullhead is present in great abundance, especially Moses Lake and Potholes Reservoir where it commonly exceeds 30 cm. The species is not as avidly sought as are other game fish, but do contribute to the fishing enjoyment of juveniles and culinary fare of many ethnic groups. Brown bullhead continues to be a perennial competitor in many waters managed for trout, and as well in lakes dedicated to centrarchid management. Once established, the species all but defies eradication attempts and can quickly deplete productivity of a water for other management species.

Centrachids

All centrarchids are alien species to Washington. Within the Crab Creek subbasin, pumpkinseed sunfish, largemouth and smallmouth bass, black crappie and bluegill are the most abundant and widespread of the centrarchids present. They occur both in several flowing waters, including Crab Creek below Brook (Stratford) Lake, and in many small lakes and all reservoirs. With the exception of the diminutive pumpkinseed, these species are highly sought after by anglers. The Crab Creek Subbasin has the distinction of being noted as the best warmwater fishery in the state with thousands of anglers from across the state attracted to its waters. At least 40 percent of the state's bass tournaments take place in the subbasin. Yet as popular as these species are, their numbers have waned since the early 1980s for reasons undefined. Intensive research is underway on Moses Lake, and to a lesser degree effort is being directed at Potholes Reservoir, to discover remedial actions.

Percids

Yellow perch has long been a staple of the general angler and tremendous numbers were harvested annually until the early 1980s in all major reservoirs of the subbasin. The Potholes Reservoir perch fishery grew to legendary status, surpassing in importance (angler participation and harvest) all fisheries of any other single water body in Central Washington. Other major reservoirs also produced well. But declines began to be noticed in the late 1970s, and by the mid-1980s, the excellence of this fishery faded away to almost nothing. During

this same period walleye began appearing commonly in the catches from Banks Lake, and thence down through the irrigation system to Billy Clapp, Moses lakes, Potholes Reservoir, and other waters connected by surface flow to the irrigation system. Both species alien to Washington and are widespread in the subbasin and the Columbia River. Perch in particular, have also been illegally transplanted to many waters reserved for trout production with consequences unfavorable to trout angling. Walleye are now as nearly as popular in the subbasin with warmwater anglers as fishing for bass, and the subbasin is one of the state's most preferred locations for walleye tournaments. The origin of walleye in Washington is unclear but generally believed from a release made in the Columbia River upstream of Grand Coulee Dam in the 1950s (WDFW 1996)

Caspian Terns Predation

In 1980, at least 3000 pairs of Caspian terns bred at only three locations in Washington (Gray's Harbor, Willapa Bay, and the Potholes Reservoir), and a total of only 200 pairs bred in one location in Oregon (WDFW unpublished data; Craig et al., in press). By 2000, more than 9,500 pairs bred in the Columbia River Estuary on Rice and East Sand islands (Roby et al. 1998, Collis et al. 1999) with additional pairs breeding in at least four locations in eastern Washington, including the persistent colony at the Potholes Reservoir. About 75 pairs of Caspian terns bred at the Potholes Reservoir in 2000 (Roby et al., unpubl. data). At the tern colonies in the Columbia River estuary, between 44% and 91% of their diet is juvenile salmonids, resulting in a total annual depredation of 5 – 15 million juvenile salmonids (6 - 21% of all juvenile salmonids)(Roby et al., unpubl. data). At the site in Commencement Bay near Tacoma, 50% of the Caspian tern diet is juvenile salmonids. At the Potholes Caspian tern colony, nearly 2000 PIT tags were recovered in 2000 from juvenile salmonids, including about 2% of all Steelhead tagged in the mid-Columbia. Although over 80% of juvenile salmonids consumed by terns are hatchery-reared, there is concern that terns may consume sufficient juvenile wild salmonids, including ESA-listed stocks, to pose a significant threat to the future viability of these stocks. In addition, the tern colony on East Sand Island in the Columbia River estuary is the largest in the World, representing about 25% of all Caspian terns in North America, and more than 70% of the west coast population.

Wildlife

Many of the wildlife species found in the Crab Creek Subbasin (Table 2) are listed by the state of Washington or the U.S. government as sensitive, threatened, endangered or as candidates for listing. The presence, distribution, and abundance of these species has been affected by habitat losses due to several factors including hydropower, agriculture, irrigation, urbanization, road construction, legal and illegal wildlife harvest, livestock grazing, and introduction of noxious weeds.

Specific habitat-population impacts have been documented for many of the species in Table 1. For some, like many species of bats, complete life history information is lacking.

Table 2. Wildlife Species of Interest within Crab Creek Subbasin

Common Name	Scientific Name	Status[1]	Behavior[2]	References
MAMMALS: Mammals are addressed in general by the WDFW's Priority Habitat and Species Program (WDFW 2000b).				
Merriam's Shrew	*Sorex trowbridgii*	SC	Y, S	WDFW 2000b
Northern Grasshopper Mouse	*Onychomys leucogaster*		Y, S	WDFW 2000b
Washington Ground Squirrel	*Spermophilus washingtoni*	C, FC	Y, S	WDFW 2000b
Sagebrush Vole	*Lagurus curtatus*		Y, S	WDFW 2000b
Pygmy Rabbit	*Sylvilagus idahoensis*	E, SC	Y, S	WDFW 1995c, 2000b; Musser and McCall 2000
White-tailed Jackrabbit	*Lepus townsendii*	C	Y, S	WDFW 2000b
Black-tailed Jackrabbit	*Lepus californicus*	C	Y, S	WDFW 2000b
Mountain Cottontail	*Sylvilagus nuttalli*	G	Y, S, R, U, D, F	WDFW 2000b
Badger	*Taxidea taxus*	G	Y, S	WDFW 2000b
Bobcat	*Lynx rufus*	G	Y, S, C	WDFW 2000b
Gray Wolf	*Canis lupus*	G	Y, S, C	WDFW 2000b
Raccoon	*Procyon lotor*	G	Y, R, I, F, G, W	WDFW 2000b
Columbian Ground Squirrel	*Citellus columbianus*	G	Y, S	WDFW 2000b
Mink	*Mustela vison*	G	Y, R, W	WDFW 2000b
Muskrat	*Ondatra zibethica*	G	Y, W, R	WDFW 2000b
Beaver	*Castor canadensis*	G	Y, W, R	WDFW 2000b
River Otter	*Lutra canadensis*	G	Y, W, R	WDFW 2000b
Cougar	*Felix concolor*	G	Y, S, C	WDFW 2000b
Black Bear	*Ursus americanus*	G	Y, R, F	WDFW 2000b
Myotis bats: The WDFW's Priority Habitat and Species Program identifies roosting areas for Myotis bats as a priority.				
Little Brown Bat	*Myotis lucifugus*		M, S, C	WDFW 2000b
Yuma mMotis	*Myotis yumanensis*	SC	M, S, C	WDFW 2000b
Keen's Myotis	*Myotiz keenii*		M, S, C	WDFW 2000b
Fringed Myotis	*Myotis thysanodes*		M, S, C	WDFW 2000b

Common Name	Scientific Name	Status[1]	Behavior[2]	References
Small-footed Myotis	*Myotis subulatus*		M, S, C	WDFW 2000b
Long-eared Myotis	*Myotis evotis*		M, S, C	WDFW 2000b
Fringed Myotis	*Myotis thysanodes*		M, S, C	WDFW 2000b
Long-legged Myotis	*Myotis volans*		M, S, C	WDFW 2000b
California Myotis	*Myotis californicus*		M, S, C	WDFW 2000b
Silver-Haired Bat	*Lasionycteris noctivagans*		M, S, C	WDFW 2000b
Western Pipistrelle	*Pipistrellus hesperus*		M, S, C	WDFW 2000b
Big Brown Bat	*Eptesicus fuscus*		M, S, C	WDFW 2000b
Pallid Bat	*Antrozous pallidus*		M, S, C	WDFW 2000b
Hoary Bat	*Lasiurus cinereus*		M, S, C	WDFW 2000b
Townsend's Big-eared Bat	*Corynorhinus townsendii*	C, SC	M, S, C	WDFW 2000b
Spotted Bat	*Euderma maculata*		M, S, C	WDFW 2000b
Mule Deer	*Odocoileus hemionus*	G	Y, G	WDFW 2000b
White-tailed Deer	*Odocoileus virginianus*	G	Y, G	WDFW 2000b
Birds: Birds are addressed in general by the WDFW's Priority Habitat and Species Program (Hickman 1987, Smith et al. 1997, Schroeder 2000, WDFW 2000b).				
Common Loon	*Gavia immer*	S	M, W	Lewis et al. 2000
American White Pelican	*Pelecanus erythrorhynchos*	E	M, W	Doran et al. 2000
Black-crowned Night Heron	*Nycticorax nycticorax*		M, W, R	Smith et al. 1997
Great Blue Heron	*Ardea herodias*		M, W, R	Quinn and Milner 2000
American Bittern	*Botaurus lentiginosus*		B, W, R	WDFW 2000b
Double Crested Cormorant	*Phalacrocorax auritus*		B, W, R, F	WDFW 2000b
Common Egret	*Casmerodius albus*		B, W, R, F	WDFW 2000b
Western Grebe	*Aechmophorus occidentalis*		B, W	WDFW 2000b
Clarks Grebe			B, W	WDFW 2000b
Horned Grebe	*Podiceps auritus*		B, W, R	WDFW 2000b
Eared Grebe	*Podiceps caspicus*		B, W, R	WDFW 2000b
Terns: The Washington Department of Fish and Wildlife's Priority Habitat and Species Program identifies areas where terns breed as a priority.				

Common Name	Scientific Name	Status[1]	Behavior[2]	References
Black Tern	*Chlidonias niger*		M, W	Smith et al. 1997
Caspian Tern	*Sterna caspia*		M, W	Smith et al. 1997
Forster's Tern	*Sterna forsteri*		B, M, W	WDFW 2000b
Swans: The Washington Department of Fish and Wildlife's Priority Habitat and Species Program identifies areas where native swans occur as a priority.				
Tundra Swan	*Cygnus columbianus*	G	M, W, D, I	WDFW 2000b
Trumpeter Swan	*Cygnus buccinator*	G	M, W, D, I	WDFW 2000b
Waterfowl concentrations: Significant breeding areas and locations where regular large concentrations occur are identified as a priority by the WDFW's Priority Habitat and Species Program.				
Greater White-Fronted Goose	*Anser albifrons frontalis*	G	M, W, D, I	WDFW 2000b
Tule White-Fronted Goose	*Anser albifrons gambelli*	G	M, W, D, I,	WDFW 2000b
Canada Goose (multiple subspecies)	*Branta canadensis spp.*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Mallard	*Anas platyrhynchos*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Gadwall	*Anas strepera*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Green-winged Teal	*Anas crecca*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
American Wigeon	*Anas americana*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Northern Pintail	*Anas acuta*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Northern Shoveler	*Anas clypeata*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Blue-Winged Teal	*Anas discors*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b
Cinnamon Teal	*Anas cyanoptera*	G	M, B, W, D, I	Smith et al. 1997, WDFW 2000b

Common Name	Scientific Name	Status[1]	Behavior[2]	References
Ruddy Duck	*Oxyura jamaicensis*	G	M, B, W	Smith et al. 1997, WDFW 2000b
Canvasback	*Aythya valisineria*	G	M, B, W	Smith et al. 1997, WDFW 2000b
Redhead	*Aythya Americana*	G	M, B, W	Smith et al. 1997, WDFW 2000b
Ring-necked Duck	*Aythya collaris*	G	M, B, W	Smith et al. 1997, WDFW 2000b
Lesser Scaup	*Aythya affinis*	G	M, B, W	Smith et al. 1997, WDFW 2000b
Bald Eagle	*Haleaeetus leucocephalus*	T, FT	Y, G	Smith et al. 1997, WDFW 2000b
Golden Eagle	*Aquila chrysaetos*	C	Y, S, C	Smith et al. 1997, WDFW 2000b
Swainson's Hawk	*Buteo swainsoni*		B, S	WDFW 2000b
Ferruginous Hawk	*Buteo regalis*	T, SC	B, S	Richardson et al. 2000, WDFW 1996
Northern Goshawk	*Accipiter gentilis*	C, SC	M, R, F	Smith et al. 1997, WDFW 2000b
Merlin	*Falco columbarius*	C	M, R, F, U	Smith et al. 1997, WDFW 2000b
Peregrine Falcon	*Falco peregrinus*	E, SC	Y, C	Hays and Milner 2000
Prairie Falcon	*Falco mexicanus*	G[3]	Y, S, C	Hays and Dobler 2000
Gyrfalcons	*Falco rusticolus*	G[4]		WDFW 2000b
Sharp-tailed Grouse	*Tympanuchus phasianellus*	T, SC	Y, S, R, D	WDFW 1995b, Hays et al. 1998b, Schroeder et al. 2000a

Common Name	Scientific Name	Status[1]	Behavior[2]	References
Sage Grouse	*Centrocercus urophasianus*	T, SC	Y, S, D	WDFW 1995a, Hays et al. 1998a, Schroeder et al. 2000b
Blue Grouse	*Dendragapus obscurus*	G	B, S, F	Ware 2000, WDFW 2000b
California Quail	*Lophortyx californicus*	G	Y, S, R, R	WDFW 2000b
Gray Partridge	*Perdix perdix*	G	Y, S, D	WDFW 2000b
Chukar	*Alectoris chukar*	G	Y, S, C	Ware and Tirhi 2000a
Ring-necked Pheasant	*Phasianus colchicus*	G	Y, S, I, R	Ware and Tirhi 2000b
Wild Turkey	*Meleagris gallopavo*	G	B, S, D, R, F	Hickman 1998, Ware and Hickman 1999, Morgan et al. 2000
Sandhill Crane	*Grus canadensis*	E	M, D	Bettinger and Milner 2000
Upland Sandpiper	*Bartramia longicauda*	E	X, S	Smith et al. 1997, WDFW 2000b
Long-billed Curlew	*Numenius americanus*	N	B, S	Smith et al. 1997
Phalaropes, avocets, and stilts: The Washington Department of Fish and Wildlife's Priority Habitat and Species Program identifies breeding areas for phalaropes, avocets, and stilts as a priority.				
Wilson's Phalarope	*Phalaropus tricolor*	N	B, W	Smith et al. 1997
American Avocet	*Recurvirostra Americana*	N	B, W	Smith et al. 1997
Black-necked Stilt	*Himantopus mexicanus*	N	B, W	Smith et al. 1997
Yellow-billed Cuckoo	*Cuccyzus americanus*	C, SC	X, R, F	Smith et al. 1997, WDFW 2000b
Snowy Owl	*Nyctea scandiaca*		M	WDFW 2000b
Burrowing owl	*Athene cunicularia*	C, SC	B, S	Smith et al. 1997, WDFW 2000b
Lewis' Woodpecker	*Melanerpes lewis*	C	Y, R, S	Smith et al. 1997, WDFW 2000b

Common Name	Scientific Name	Status[1]	Behavior[2]	References
Olive-sided Flycatcher	*Contopus borealis*	SC	B, R	Smith et al. 1997, WDFW 2000b
Willow Flycatcher	*Empidonax traillii*	SC	B, R	Smith et al. 1997, WDFW 2000b
Sage Thrasher	*Oreoscoptes montanus*	C	B, S	Smith et al. 1997, WDFW 2000b
Loggerhead Shrike	*Lanius ludovicianus*	C, SC	B, S	Smith et al. 1997, WDFW 2000b
Sage Sparrow	*Amphispiza belli*	C	B, S	Smith et al. 1997, WDFW 2000b
Brewer's Sparrow	*Spizella breweri*		B, S	Smith et al. 1997
Grasshopper Sparrow	*Ammodramus savannarum*		B, S	Smith et al. 1997
Reptiles: Reptiles are addressed in general by the WDFW's Priority Habitat and Species Program (Larsen 1997, WDFW 2000b).				
Sagebrush Lizard	*Sceloporus graciosus*	SC	Y, S	WDFW 2000b
Pygmy horned Lizard	*Phrynosoma douglassi*		Y, S	WDFW 2000b
Striped Whipsnake	*Masticophis taeniatus*	C	Y, S	Nordstrom and Whalen 1997
Ringneck Snake	*Diadophis punctatus*	C	S	WDFW 2000b
Western Rattlesnake	*Crotalus veridus*		Y, S, C	WDFW 2000b
Night Snake	*Hypsiglena torquata*		Y, S, C	WDFW 2000b
Amphibians: Amphibians are addressed in general by the WDFW's Priority Habitat and Species Program (Larsen 1997, WDFW 2000b).				
Columbia Spotted Frog	*Rana luteiventris*	C, SC	Y, W, R	Nordstrom and Milner 1997
Northern Leopard Frog	*Rana pipiens*	E	Y, W, R	Nordstrom 1997
Western Toad	*Bufo boreas*	C, SC	Y, W, R	WDFW 2000b
Invertebrates: Invertebrates are addressed in general by the WDFW's Priority Habitat and Species Program (Larsen et al. 1995, WDFW 2000b).				
Yuma Skipper	*Ochlodes yuma*	C	W, R	Larsen et al. 1995
Silver-bordered Bog Fritillary	*Boloria selene atrocostalis*	C	R	Larsen et al. 1995

[1]Status: C = State candidate; T = State threatened; E = State endangered; S = State sensitive; G = Game animal subject to harvest regulations; SC = Federal species of concern; FC = Federal candidate; FT = Federal threatened; and FE = Federal endangered; N=no special status
[2]Behavior and habitat designations: B = Breeding; M = Migratory and/or winter; Y = yearlong resident; X = Extinct in area; S = Shrub steppe; W = Open water; R = Riparian and wetland; C = Cliffs; U = urban; I = Irrigated cropland; D = Nonirrigated cropland; F = forest; and G = General use of most or all habitats.
[3]Take of prairie falcons for recreational purposes (falconry) is by state and federal permits
[4]Take of gyrfalcons for recreational purposes is restricted by state permit to 5 per year; most are taken from the Crab Creek Subbasin.

Birds

Shrubsteppe Obligates

The vast majority of the Crab Creek Subbasin historically consisted of shrubsteppe (Daubenmire 1970). Many of the species of interest (Table 2) are those that require shrubsteppe habitat for all, or a substantial portion, of their annual life cycle. Many of these species have been adversely impacted by habitat conversion to alternate uses, such as irrigated and dry land agriculture, water impoundments associated with dams, and urban/residential development. Changes in the landscape related to habitat conversion that have affected shrubsteppe wildlife include: fragmentation of extant shrubsteppe habitat, differential loss of deep-soil communities, and alteration of the vegetation community resulting from grazing by livestock, invasion by exotic plants, and increased fire frequencies (Vander Haegen et al. 2001).

Sage Grouse

Sage grouse were historically found in shrubsteppe habitats throughout eastern Washington. The current population in Washington is estimated to be around 1000, with about 700 of the birds residing in a contiguous subpopulation in Douglas and Grant counties; almost entirely within the Crab Creek Subbasin (Figure 3)(Schroeder et al. 2000b). An additional subpopulation of 300 birds is found in Yakima and Kittitas counties, approximately 50 km from the Crab Creek population. The 2 populations are largely separated by the Columbia Basin Project in western Grant County. Their populations are continuing to decline in Washington due to long-term effects of habitat conversion, degradation, fragmentation, and population isolation (Hays et al. 1998a, Schroeder et al. 2000b). Sage grouse in Washington declined 77% between 1960 and 1999 (Schroeder et al. 2000b).

Sharp-tailed Grouse

Sharp-tailed grouse were historically found in shrubsteppe and deciduous shrub communities throughout eastern Washington. The current population in Washington is estimated to be 600, with about one third of the birds residing in the Crab Creek Subbasin (Figure 3)(Schroeder et al. 2000a). Sharp-tailed grouse populations in Washington declined 94% between 1960 and 2000. The remaining birds are found in eight relatively small, isolated, subpopulations; one

subpopulation is found entirely within the Crab Creek Subbasin (Lincoln County), and two other subpopulations are on the edge of the subbasin (NW and NE Douglas County). Subpopulations are separated from adjacent subpopulations by at least 20 km. Sharp-tailed grouse are continuing to decline in Washington due to long-term effects of habitat conversion, degradation, fragmentation, and population isolation (Hays et al. 1998b, Schroeder et al. 2000a).

Ferruginous Hawk

Ferruginous hawks were historically found in shrubsteppe habitat throughout the Crab Creek Subbasin. Data from 1995 – 1997 indicate that < 30% of at least 222 historic breeding territories were occupied, mostly along Moses Coulee and Crab Creek (Figure 3)(WDFW 1996; WDFW, unpubl. data). The regional decline in abundance of ferruginous hawks has been tied to shrubsteppe habitat alteration associated with cultivation and grazing, and with subsequent declines in abundance of prey species. Historic information suggests black-tailed jackrabbits, white-tailed jackrabbits, and Washington ground squirrels were important prey for nesting ferruginous hawks in Washington (Watson and Pierce 2000). All three species of mammals currently are candidates for listing within Washington due to their low and/or declining abundance; the Washington ground squirrel is also a candidate for federal listing (Table 1). Research on the Hanford Nuclear Reservation confirmed that adult ferruginous hawks were flying up to 15 km off site to forage for pocket gophers, a small alternate prey species (Leary 1996). These long flights to foraging areas may reduce adult nest attendance and potentially may increase mortality of young.

Golden Eagles

Golden eagles are prominent raptors in shrubsteppe habitats throughout Washington. Data collected since 1987 suggests that < 50% of 200 historic golden eagle territories in Washington are currently occupied (WDFW, unpubl. data). Thirteen golden eagle territories have been documented in the Crab Creek Subbasin, primarily north of Quincy (Figure 3)

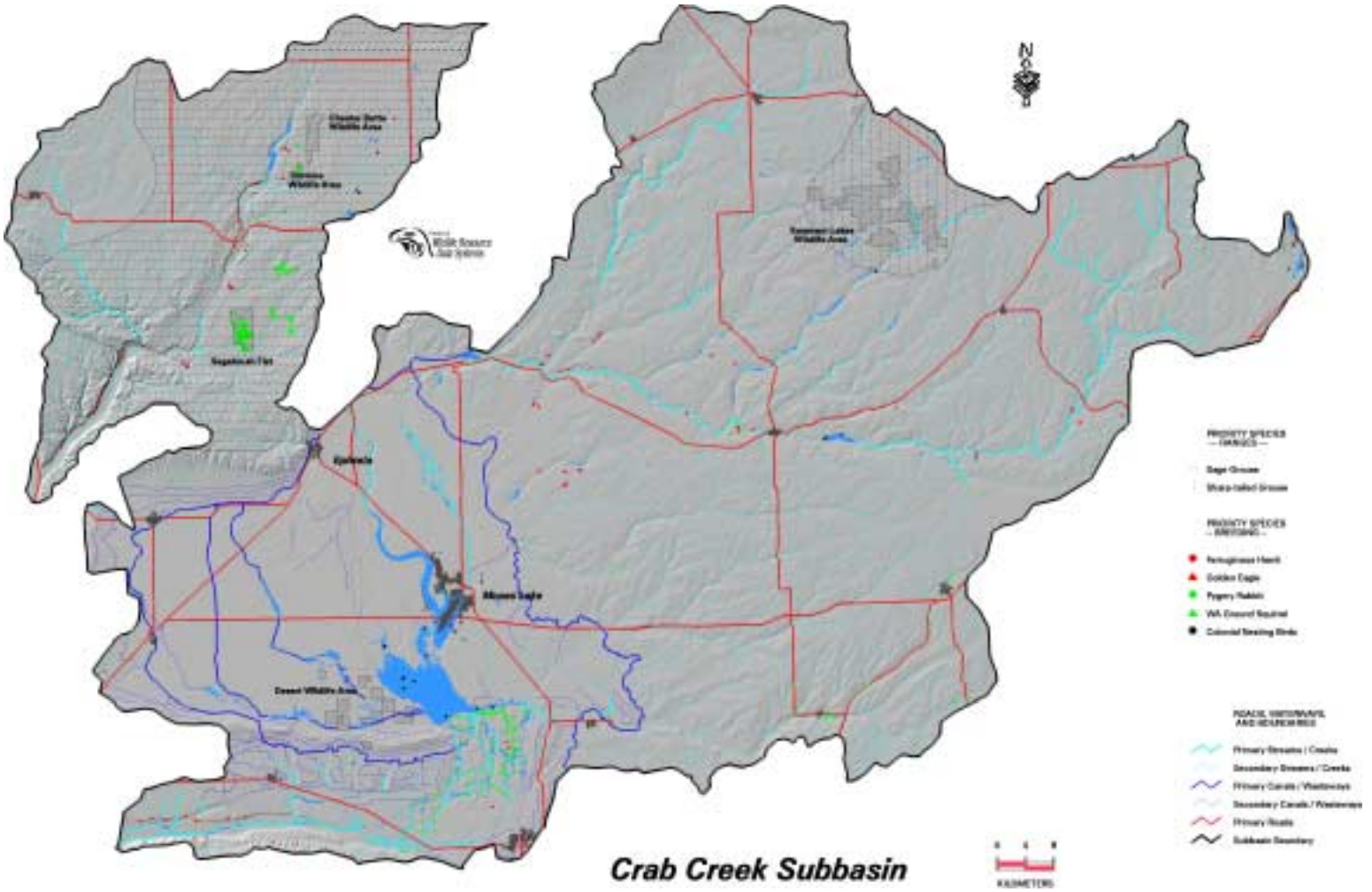

Figure 3. Priority Species

Reasons for low site occupancy in the subbasin may be related to low prey abundance in shrubsteppe habitats near nest sites. Principal prey, such as black-tailed jackrabbits, white-tailed jackrabbits, and Washington ground squirrels, have declined dramatically, largely as a result of conversion and degradation of shrubsteppe habitat. A further concern may be toxic lead poisoning, possibly associated with pesticide residues in orchards along the Columbia River (W. Yake, WDOE, pers. comm.) or with lead shot or bullets in the carcasses of prey (E. Stauber, Washington State University, pers. comm.; T. Talcott, University of Idaho, pers. comm.).

Other Shrubsteppe Obligates

Sage thrasher, loggerhead shrike, sage sparrow, and Brewer's sparrow are neotropical migrants that appear to be closely associated with shrubsteppe habitat (Vander Haegen et al. 2000). Populations of most shrubsteppe-associated songbirds appear to be declining (Saab and Rich 1997). Fragmentation and degradation of shrubsteppe adversely affect some species, although relatively few have been studied. Sage sparrows are less abundant (Vander Haegen et al. 2000) and Brewer's sparrows and sage thrashers are less productive (WDFW, unpubl. data) in fragmented landscapes. In addition, Brewer's sparrows and sage thrashers are less abundant in shrubsteppe habitats of relatively poor quality (Vander Haegen et al. 2000). Habitat-specific population parameters, including productivity, dispersal, and adult and juvenile survival are unknown for most of these species. Numerous species, including sage sparrows and grasshopper sparrows, are not monitored adequately by the Breeding Bird Survey and will require specialized monitoring to detect and monitor population changes (Saab and Rich 1997).

Colonial Nesting Birds

American white pelicans, Caspian terns, black-crowned night herons, double crested cormorants, common Egrets and great blue herons are known to nest in relatively clustered and identifiable locations, typically referred to as colonies (Smith et al. 1997, Doran et al. 2000, Quinn and Milner 2000). Because of the identifiable, and potential limiting nature of colonial habitats (Figure 3), their protection is an important consideration in management. For example, black-crowned night herons, great blue herons, common egrets, and double crested cormorants, use specific riparian habitats in the Columbia Basin Irrigation Project for nesting. In contrast, Caspian terns tend to nest on specific islands that have resulted from the Columbia Basin Irrigation Project, i.e. Potholes Reservoir. Some of these colonial nesters feed on young salmonids in the Columbia River. Their foraging habits and impacts on anadromous fish may be enormous.

Burrowing Owl

Burrowing owls appear to be associated with open habitats, particularly shrubsteppe, in Washington. Although these sites are often relatively disturbed, burrowing owls appear to be declining in the subbasin, based on incidental

observations and recent inventories (Bartels and Tabor 1999). Some of the declines appear to be related to long-term loss in availability of potential burrows. The decline in number of burrows may be an indirect result of declines of mammals including pygmy rabbits, badgers, and ground squirrels whose deserted burrows are readily used by burrowing owls. In some parts of the subbasin, however, burrowing owls have declined at locations where burrows were available. The explanation for these declines is not clear.

Upland Game Birds

Ring-necked pheasant, an introduced species, is the most popular game animal in the subbasin. Although pheasant numbers increased dramatically as a result of the Columbia Basin Project and establishment of irrigated farming in the subbasin, they have declined dramatically in the last 20 years (WDFW 2000a). The specific causes of the decline in recent years have not been accurately identified but are suspected to be related to changing agricultural practices and loss of winter habitat. The other upland game birds (chukar, gray partridge, California quail, wild turkey) have been influenced both negatively and positively by changes in the Subbasin, depending on the species, habitat, and location.

Waterfowl

Waterfowl are seasonally abundant in the Crab Creek Subbasin. The semiarid climate and irregular precipitation patterns support highly productive ephemeral and semi-permanent wetlands, particularly in Lincoln and Douglas counties. During years with adequate precipitation, these wetlands support the most productive and diverse waterfowl breeding communities in the Pacific Northwest. Grasslands and shrubsteppe habitats surrounding these wetlands provide habitat for upland nesting ducks The Columbia Basin Irrigation Project has created numerous wetlands that are more persistent but less productive for breeding waterfowl as a result of wetland succession and invasion by exotic, undesirable vegetation. The cereal grains, corn, and other crops that are grown in this Subbasin, in concert with large reservoirs, wetlands, canals, and wasteways provide ideal conditions for migrating and wintering waterfowl. In general, the Columbia Basin Project has provided major benefits for waterfowl and waterfowl-related recreation.

Other Birds

Common loons, Wilson's phalaropes, American avocets, and black-necked stilts are associated with open water and/or the shallower portions of large bodies of open water. Although populations of these species appear to be declining throughout their broader ranges, there is little evidence that their respective declines are due to declining habitat quantity and quality within the Crab Creek Subbasin. Bald eagles also utilize the open water areas of the Crab Creek Subbasin, primarily for winter habitat and foraging. Although little recent nesting by bald eagles has been recorded in this subbasin, historic nesting was common. Maintaining high quality habitat for prey species, (fish and waterfowl), potential

nesting sites, and winter roost sites is critical to encourage and perpetuate eagle use of the area.

Numerous species such as the olive-sided flycatcher and willow flycatcher are associated with riparian areas during the breeding season. In contrast, sharp-tailed grouse (a shrubsteppe obligate) may use riparian areas during periods of harsh winter weather. Because of the small size, poor condition, and isolated nature of much of the riparian habitat in the Crab Creek Subbasin, this habitat type is critical in its overall importance.

Mammals

Shrubsteppe Obligates

Washington Ground Squirrel

Washington ground squirrels are endemic to Washington and Oregon (Betts 1990), and have declined dramatically in both states (Betts 1999). They are associated with relatively deep soils within shrubsteppe communities (Dobler et al. 1996, Betts 1990, 1999). Because deep soil habitats were preferred areas for conversion, most are now used for irrigated and dryland agriculture. The widespread loss and fragmentation of shrubsteppe has resulted in dramatic declines in the statewide population of Washington ground squirrels (Dobler et al. 1996). Most of the known populations of ground squirrels are within the Crab Creek Subbasin (Figure 3). The remaining populations appear to be at risk of extinction due to their isolation and the continued risk of habitat conversion, fragmentation, and degradation. Recent research in Grant County may reveal additional information on the species (Sherman 1999, 2000).

Pygmy Rabbit

Pygmy rabbit populations are associated with relatively deep soils dominated by shrubsteppe habitat (WDFW 1995c). However because the deep soil habitats were preferred areas for conversion, most are now used for irrigated and dryland crops. The widespread loss and fragmentation of shrubsteppe has resulted in dramatic declines in the statewide population of pygmy rabbits (Musser and McCall 2000). There are only three small and isolated populations of pygmy rabbits remaining in the state, all within the Crab Creek Subbasin (Figure 3). Lack of genetic diversity in the remaining populations of pygmy rabbits may also be contributing to their decline (K. Warheit, WDFW, pers. comm.).

White-tailed Jackrabbits and Black-tailed Jackrabbits

White-tailed jackrabbits and black-tailed of jackrabbits are closely associated with shrubsteppe habitats, and consequently, their populations have shown the same downward trends as other shrubsteppe obligates. White-tailed jackrabbits tend to be closely associated with the more mesic shrubsteppe habitats, and black-tailed

jackrabbits with the relatively arid and/or disturbed sites. Although population figures are not available, the long-term declines appear to be dramatic.

Other Shrubsteppe Obligates

Other species including the sagebrush vole are largely restricted to shrubsteppe habitat and populations appear to be declining. Unfortunately the population, behavior, and habitat information is insufficient to understand the long-term relationships between populations and declining quality and quantity of shrubsteppe.

Mule Deer and White-tailed Deer

Mule deer and white-tailed deer occur primarily in shrubsteppe habitat in the subbasin but also use other habitats including cereal crops if the cropland is near shrubsteppe. Both species are important game species in the subbasin although whitetails are not as widely distributed as mule deer. Neither species appears to have declined in recent years, but both species have been impacted by the changing landscape in the Columbia Province in general, and the Crab Creek Subbasin in particular. This has occurred because of the loss of winter habitat at lower elevations (due to water impoundments associated with dams, irrigated agriculture, and development) and the fact that winter habitat within higher elevations of the Crab Creek Subbasin has declined in both quantity and quality.

Irrigation canals in the Columbia Basin Irrigation Project are problematic for mule deer. These large (approx. 20 ft deep x 100 ft wide) concrete lined and steeply banked canals trap and kill many deer and occasionally moose and elk when stray into the Columbia Basin Irrigation Project within the subbasin. The total number of deer lost in the main canals is estimated at 200-300 per year in the Grant County portion of the subbasin.

Raccoon, coyote, bobcat, badger, mink, muskrat, beaver, and river otter are the primary furbearers in the Crab Creek Subbasin. All but the coyote and muskrat are significantly lower in abundance than they were historically. In general, the declines appear to be related to an overall decline in habitat quality with an associated decline in food and/or prey abundance (J. Tabor, WDFW, pers. comm.)

Bats

The Crab Creek Subbasin is an important area in the state for bats because of their abundance and diversity and because of the presence of unique and/or limiting habitat features. For example, although water is the most limiting factor in the distribution of bats in arid areas, it is available adjacent to roosting, breeding, and wintering (hibernacula) sites in this subbasin. Cliffs, mines, caves, and buildings provide the structures needed to form breeding colonies and hibernacula for most species. Although some species are flexible in their use of these structural features, other species require specific elevations, aspects, and temperature ranges. Spotted Bats appear to be exclusive cliff dwellers during the young-rearing period. The Crab Creek Subbasin probably represents a significant core

of Washington's Spotted Bat distribution. Buildings provide a significant source of roosting habitat in areas where water occurs but no suitable geological roost features exist. Townsend's Big-eared bats are found almost exclusively roosting in buildings in cave-deficient areas. Risks to bats in the Crab Creek Subbasin include loss or degradation of roosting and feeding habitat (mine closure, shrub removal), loss of available clean water, and disturbance of roost, breeding, and hibernation sites.

Reptiles and Amphibians

Shrubsteppe obligates

Eight reptile and two amphibian species in Washington State are Columbia Basin dependent, i.e., their ranges in Washington are contained mostly or entirely within the Columbia Basin. Of these 10 species, the short-horned lizard (*Phyrnosoma douglassi*), sagebrush lizard (*Sceloporus graciosus*), side-blotched lizard (*Uta stansburiana*), night snake (*Hypsiglena torquata*), striped whipsnake (*Masticophis taeniatus*), California mountain kingsnake (*Lampropeltis zonata*), and blotched tiger salamander (*Ambystoma mavortium melanostictum* [formerly *A. tigrinum melanostictum*) are considered at risk (Cassidy et al. 1997). Two species, the California mountain kingsnake and striped whipsnake are also listed as State Candidate species. Three cryptozoic reptiles, the ring-necked snake (*Diadophis punctatus*), the sharp-tailed snake (*Contia tenuis*), and the southern alligator lizard (*Elgaria multicarinata*) reach the northwest limits of their respective distributions in the western margin of the Columbia basin, and are likely to be particularly vulnerable at the edge of their range. Both the blotched tiger salamander the Great Basin spadefoot (*Spea intermontana*), may be especially vulnerable to the hydrological modification of their habitat.

Other Reptiles and Amphibians

The northern leopard frog has declined dramatically throughout its historic range; the Crab Creek Subbasin is one of the few regions where they remain. The historic distribution was principally along wetlands of the Columbia River and its tributaries (McAllister et al. 1999). Surveys since 1992 have located leopard frogs in 2 of 18 historic locations in Washington, both within the Crab Creek Subbasin. Loss of wetland habitat along the Columbia River and its tributaries, competition and predation by non-native fish, and introduced bullfrogs (*Rana catesbiana*) appear to be significant factors in the decline of northern leopard frogs. Current populations also appear to be influenced by fluctuations in water levels within the Columbia Basin Irrigation Project. The Snake River may have provided an aquatic corridor to historically abundant leopard frog populations in Idaho and Montana (McAllister et al. 1999). Alteration of the major rivers and tributaries appears to be a major cause of the current population problems with the northern leopard frog.

Columbia spotted frog (Rana luteiventris) is distributed within the Crab Creek subbasin in portions of Lincoln County (ie. Coal Creek, Wilson Creek, mainstem Crab Creek @ Rocky Forde). Basically the channeled scabland flood coulees with perennial water sources. Columbia Spotted Frog appears to be declining for the same reason most reptiles and amphibians are declining in the Columbia Basin, habitat loss and fragmentation.

Habitat Areas and Quality

Fish

General descriptions of the subbasin habitat setting can be found in the succeeding section on wildlife habitat. This section deals with the major watercourses and lakes and is presented by watershed. Much of the flowages have not been well surveyed for habitat as most courses lie on private ground. Therefore we are limited in knowledge on the amount and quality of habitat, and lack up-to-date precision on fish assemblages within the various watercourses, particularly in areas outside the Columbia Basin Irrigation Project. The following describes what is currently known for each of the significant drainages within the sub-basin. However, the reader should be aware this information is not based on an exhaustive search of historic literature.

Moses Coulee Watershed

The coulee heads in wheat fields north of Grimes Lake in Douglas County and meanders southerly through Sagebrush Flat on the Douglas/Grant County line, and continuing on to join the Columbia River about 18 river km south of Rock Island Dam.

Grimes Lake is the uppermost point of permanent water in Moses Coulee. It receives water from snowmelt feed via several small drainages. The lake occasionally fills to overflow into Jameson Lake, 3.6 km south. Grimes Lake, with relatively high alkalinity, did not support fish life until 1981, when alkaline tolerant Lahontan cutthroat trout were introduced by WDFW. The lake is now stocked each fall with about 5000 fingerling cutthroat and supports a fine fishery for trout up to about 3.6 kg, averaging 1.6 kg.

Jameson Lake has somewhat lower alkalinity and has long been a popular lake for stocked rainbow trout. Annual spring releases of 175,000 - 200,000 fry sustain a fishery that draws anglers from all over Washington State. The lake has been rehabilitated once (1980) with the fish toxicant rotenone to remove redside shiners (WDFW files). Shiners were illegally released into Jameson in the early 1970s (K. Williams, retired WDFW biologist, pers. comm.). An excellent trout fishery existed in Jameson until the mid-1970s, at which time the shiner population swelled to huge numbers and consumed most of the lake's invertebrate food base. Shiners have not been observed since 1980 and the recreational fishery continues at its former excellence.

Jameson has increased greatly in size (more than doubled) since first surveyed by U.S. Army explorers in the mid-1800s (J. Wittig, landowner, pers. comm.). Within the past 15 years water levels have risen several feet and the lake twice has filled to overflowing, a condition unknown to early homesteaders and present-day residents alike. The last flood (1995) was an amazing event in that a late-January thaw brought snowmelt onto the frozen lake, flooding one resort, inundating access to a second, and flooding the basement of one residence located well above historic high water marks. So much water flowed from Jameson that a low rise of gravel and loess beyond the south end of the lake was breached and water cascaded down the coulee, eventually ending at the springs of McCarteney Creek, a distance of about 21 km down the coulee. An ancient flowage channel winds through upper Moses Coulee that speaks to other deluges—either rapid early-spring snowmelt, or thunderstorms that rake across local areas of the upper coulee.

But such events—connection with McCarteney Creek—are obviously rare. Indeed, surface flows starting anywhere in the upper Moses Coulee are very uncommon, and when runoff does enter the coulee, it seldom travels but a short time before disappearing into porous, rocky soils on the coulee floor. Permanent flows within upper Moses Coulee are not found until just north of Rim Rock Meadows. Here, McCarteney Creek issues, from springs, a small but steady stream of cool, clear water, flowing approximately 6.5 Km, all of it on private land. Despite past use of the area for cattle grazing, the stream banks still sprout some fair to good riparian cover. Rainbow trout are found here, likely from private stockings, but have been known since at least 1968 (WDFW file data). Other species may be present, but thorough fish surveys have not been done. There has been one unconfirmed report of sunfish (species unknown) in a diked section of the creek just prior to where it falls into the Palisades part of Moses Coulee (lower Moses Coulee). McCarteney disappears after spilling onto the rubble of Moses Coulee's floor, a point at which upstream fish passage would be impossible, even if floods carrying water from McCarteney Creek ever made it to the Columbia.

The largest stream in the Moses Coulee watershed is Douglas Creek, with fish life restricted to rainbow trout in Douglas Canyon, and rainbow trout and suckers in the Palisades section. Rearing chinook salmon have been found near the mouth (RM 0 – 0.1) (WDFW file data) when flows are sufficient to connect with the Columbia River. The creek originates in dryland wheat country just north of the town of Douglas. The watershed covers approximately 533 sq. km (206 sq. mi.) (So. Douglas Cons. District, circa 1987). Flow is southeasterly, and most years intermittently, into the rugged, steep canyon of Douglas Creek. Even though flow volume near the town of Douglas and the Alstown siding is meager at best during most of the year, a trout persist in desiccated pools and shallow ponds through the dry months (B. Steele, WDFW biologist, pers. comm.). Once into the picturesque canyon, contributions from Duffy Creek, several small springs, and groundwater accretion contribute to a good, permanent flow year around.

Trout do well in the canyon reach, and thrive solely by natural reproduction. Stream surveys document an abundance of trout represented in several age classes (Jackson and Jackson 1994). WDFW records show a long history of stocking from as early as 1933 until 1969, often with extremely high numbers. One year in particular (1943), 105,000 rainbow trout fry were released into Douglas Creek. Along with rainbows, eastern brook trout were planted heavily during much of the 1930s, but did not persist. The tributary Duffy Creek was also stocked with brooks and rainbows during five years between 1940 and 1954. No recent surveys have been done, but rainbow trout were present in Duffy Creek during an electrofishing reconnaissance in June 1987 (WDFW file data). Records do not show any further trout releases since 1969. Retired WDFW biologist L. Wadkins stated that Douglas County, in the early 1900s, operated a small fish hatchery on a spring (probably McCue Spring) draining into Douglas Creek. County records have not been checked to verify this.

In any case, the rainbows of Douglas Creek are an isolated population with extraordinary tenacity and resilience. They flourish in a hostile environment of high summer water temperatures; low flows, both summer and winter; normal annual spring runoffs that bring a heavy soil load from dryland tillage on the Waterville Plateau; infrequent, but torrential, scouring floods that flush hundreds of trout into Moses Coulee to await death as floods recede; floods that flatten cottonwood trees, rip out great chunks of streamside willows, and gouge tons of soils from what appeared to be stable banks. The fish have also weathered through a long and liberal harvest fishery, and, until recent years, an unscreened irrigation intake that claimed untold numbers of trout each year. The transition of Douglas Creek into Moses Coulee permits only downstream passage.

In most years surface flow seldom reaches much beyond the settlement of Palisades. But there are frequent exceptions as the following illustrates. While these figures show periodic high flows, they do not depict what is necessary to achieve connection with the Columbia River. Elmore and Oakley (1974) report peak discharges during the highest floods at the U.S.G.S gauging station near Alstown at 6,420 cfs on June 10, 1948 (based on floodmarks and slope-area measurements); 3,360 cfs on March 18, 1957; and 1,350 cfs on June 15, 1950. Maximum flows for four other years ranged from 214 cfs (March 25, 1952) to 678 cfs (January 29, 1967). In more recent years a devastating flood occurred in early March 1989, causing severe destruction of riparian growth and extensive channel damage. Surprisingly, streamside vegetation rebounded quite rapidly. Major flooding occurred again in late January 1995, but with less devastating consequences, this partly a result of incomplete recovery from the 1989 flood.

Minimum stream flows generally take place a short time after the last spring freshet. During summer and fall months of some years flows at Alstown cease altogether (Elmore and Oakley 1974). At the mouth of Douglas Canyon, minimum flows generally occur in December and January at around 6 – 7 cfs,

followed closely by those of the summer months July – September. Irrigation diversion near here removes 50 percent or more of the creek's discharge into Moses Coulee.

In years of normal snow pack and elevated groundwater storage, Douglas Creek may flow on through Moses Coulee to the Columbia River. Such flows may, but rarely do, continue throughout the year. Usually, spring freshets provide connection for only a brief few weeks with the Columbia. If the timing of runoff is right and of sufficient magnitude, young salmon and steelhead may wander into Douglas Creek for a short distance from the Columbia, as was observed in February 1986 (WDFW file data).

***Summary assessment*:** All told, Douglas Creek offers almost nothing for anadromous salmonids, nor can conditions be improved. There is little that can be done to improve flows for resident fish in Douglas Creek Canyon, short of converting all uplands back to shrub steppe. Reclamation with native plants over a large area of the drainage would reduce the severity of some rapid runoffs, but storms and flash floods will continue to raise havoc in the watershed. Any improvement in slowing runoff would improve trout populations in Douglas Creek Canyon, but nowhere else. The only practical enhancements would be to work with landowners in vicinity of the town of Douglas and throughout the drainage basin to use farming practices that lessen erosion, and to reestablish trees, shrubs and protective grasses in draws and swales feeding into Douglas Creek Canyon.

Trinidad Creek: Draining Lynch Coulee, this small creek empties into the Columbia River at the upper end of Crescent Bar, approximately 9.6 km due west of Quincy, Washington. It is mentioned here only to note that juvenile rainbow (or steelhead?) rearing has been observed in the lower few hundred yards of the creek (J. Foster, WDFW, pers. observ.). The drainage extends some 22 km northeasterly, draining entirely wheat farms and rangeland. A significant amount of farmland in this drainage has been converted to the Conservation Reserve Program. Except for subsurface infusion of irrigation wastewater out of Babcock Ridge and Crater lakes some 1.6 km above the mouth, the drainage is strictly a snowmelt or storm water discharge vessel, with perennial flow existing but a short distance above its mouth.

During late summer, flow in the creek is so reduced that it is doubtful that the creek attracts spawning chinook. And there is virtually no riparian vegetation in the drainage owing to xeric conditions, and possibly to some lesser extent, decades of cattle grazing.

***Summary assessment*:** Nothing can be improved upon.

Sand Hollow Creek: This "creek" discharges excess irrigation water to the Columbia River about 1.6 km south of the Highway I-90 Bridge at Vantage,

Wash. The flow is appreciable and year around, but its permanence exists as a consequence of irrigation development on lands of the Royal Slope area of Grant County. Prior to irrigated farming, the natural drainage contained water only during periods of snowmelt or random thunderstorm events. Indeed, except for the lower 4 km or so, the creek is nothing more than a channeled drain ditch. It crosses via culverts under Highway 26 at stream km 1.6, the approximate boundary of upstream fish passage. Adult steelhead have been caught by anglers below the highway crossing. Sockeye have been collected there on one occasion, and spawning chinook are an annual fall spectacle in this shallow, roadside stream. The channel banks are sometimes littered with carcasses in late October (J. Foster, WDFW, pers. observ.). The success of smolt production in this stream has not been determined.

Summary assessment: The drain channel above Highway 26 should be examined for potential anadromous production over its length. If such surveys show favorable cost/benefits, then removal of passage barriers is in order, provided smolt production can be demonstrated in the downstream reach.

Crab Creek Watershed: Sometimes referred to as the longest ephemeral stream in North America, Crab Creek defies simple description. Some 225 km in length, it drains a vast area of some 13,200 square kilometers. The creek winds through scabrock channels for most of its length, channels believed carved by floods of ancient Lake Missoula. For ease of discussion, we separate the creek into to three reaches in the following: (1) Upper Crab Creek—from its source near Reardon, Washington downstream to Brook (Stratford) Lake; (2) Middle Crab Creek—from Brook Lake to, and including, Potholes Reservoir; (3) Lower Crab Creek—from below Potholes Reservoir to the Columbia River.

Upper Crab Creek was historically, and remains to present-day, a disappearing stream---reaches of permanent flow interspersed with miles of dry creek beds, or at best, isolated, stagnant pools during most of the year. Several tributaries (e.g., Wilson, Duck and Coal creeks) exhibit the same hydrologic patterns. Whether modern land use has changed flow volume and the lengths of permanent reaches is unknown, yet as discussed earlier, the ground water table has dropped some 45 m (150 ft.) over the past few decades. Over a century of livestock use within the upper watershed have likely changed the amount and character of riparian vegetation somewhat, but has not obliterated it entirely. Tillage of the uplands for wheat production has undeniably increased soil erosion and contributed to heavy silt transport during snowmelt and rainwater runoff. Yet in spite of this perturbation, permanent reaches in general lack heavy deposits of silt and run cool enough in summer, at least near springs, to hold rainbow trout. Perhaps the greatest impact on salmonids are carp. These are established at least as far upstream as 2.4 km west of Odessa.

Portions of creek between Odessa and Brook Lake have been channeled and diked to reduce spring flooding of farm crops in the coulee floor. Numerous springs

occur throughout the upper basin. One rather large drainage--Lake Creek, with its numerous lakes and recreational trout population--feeds southwest to within a few miles of Crab Creek before disappearing into the ground. There is likely subterranean contact with the Crab channel.

Summary assessment: Water quality could be enhanced in the Upper Crab Creek basin from a practical standpoint. Removal of dikes in channeled reaches could lessen soil transport to, and deposition in, Middle Crab Creek (especially Moses Lake) by allowing diffusion of flows (velocity reduction) over the valley bottom. Improved soil conservation practices on croplands throughout the upper basin could further benefit downstream areas, as well as permanent flows in the upper watershed.

Middle Crab Creek is the most heavily populated reach within the Crab Creek subbasin, with Moses Lake as the main human population center. It is this reach that bears the brunt of winter and spring runoff that carry agricultural chemicals and eroded soils from Upper Crab, although Brook Lake intercepts Crab flows and acts as a sump for much of the silt and chemicals.

Historical information indicates that long before irrigation development perennial connection between Crab Creek at Brook and/or Round lakes and Moses Lake did not occur (Evermann and Nichols 1909). Groves (1951) states that only two tributaries fed Moses Lake: Rocky Ford Creek, and a small tributary emanating from two points above Parker Horn (probably in the Willow Lakes area and at Homestead Creek). Only during high water conditions did Upper Crab thread its way through the present Willow Lakes area and on to Moses Lake at Parker Horn. Today, several springs join the Crab Creek channel in this reach, a result of elevated groundwater from irrigation development. The springs creating the seven miles of Rocky Ford Creek are widely accepted now as connected by underground flows to Crab Creek in the vicinity of Round and Willow lakes (Bain 1990).

Groves (1951) also mentions that an Indian legend held that Moses Lake was once dry. The concept has plausibility given that shifting sand created large dunes on the south end of the lake, effectively damming the outlet. A disastrous flood in 1904 washed through the dune and lowered the lake eight feet. Groves (1951) leaves a telling note: “Soon after the great flood of 1904 when the Moses Lake overflow reached the Columbia River, carp were noticed.” The deduction then is that Crab Creek did not reach the Columbia River except during flood events. At least temporary connections with the Columbia undoubtedly occurred off and on prior to 1904, as Northern pikeminnow, a species indigenous to the Columbia River, was one of the original inhabitants of Moses. Carp were first introduced to the Northwest in 1880, and escaped into the Columbia in 1881 (Lampman 1946).

Water quality has been touched on earlier in this document. More detail for this reach can be found in Williamson, et al. (1998). Several waters are on the federal Clean Water Act "303 (d) list" as not meeting water quality standards. With one exception, listed waters fail to meet standards for one or more of the parameters temperature, pH and dissolved oxygen (Weaver 1999). Dieldrin has been found in edible fish tissue (largemouth bass and lake whitefish) in Potholes Reservoir. Moses Lake has come of interest to the Washington Department of Ecology in the last 15 years because of high levels of nutrients (primarily nitrates and phosphates). On-farm demonstration projects sought to lower nutrient discharge to Moses Lake (Bain 1990). While effective, the methods have not been widely employed. Flushing the lake with fresh water directly out of canals has had some benefits, where water is poured into Rocky Coulee Wasteway, which drains into Crab Creek a short ways above Parker Horn.

Summary assessment: The middle reach of Crab Creek suffers from muddy water during spring through summer from several causes: flood-born silt from eroded soils in the upper watershed; carp that stir up mud in shallow areas of lakes and streams; and irrigation return water bearing silt and fertilizers from croplands. The repository for these flows is Moses Lake. Most of this cannot be helped. Temperature and dissolved oxygen, while unsatisfactory at times and contributing to small, localized losses of fish during summer, do not presently have major negative impacts on fish life within either Middle Crab Creek or Moses Lake. Further increases in nutrient loading may at some point, however, have detrimental effects on existing fisheries.

Lower Crab Creek (from below O'Sullivan Dam on Potholes Reservoir to the Columbia River): This is the only reach supporting anadromy. Fall chinook and steelhead have been found upstream as far as, and into, Red Rock Creek. Chinook in significant numbers spawn near the mouth of Crab, and do so in Rock Creek. It is presumed that steelhead also spawn in Red Rock , and may be the progeny of steelhead smolt releases made several decades ago (WDFW file data). Adults have long been known to move into the stream in spring, and occasionally steelhead have been caught by anglers near the mouth of Red Rock and in the over the years (M. Spence, retired WDFW biologist). That steelhead show some affinity to the creek hints that reproduction may be successful, at best in the cooler and cleaner waters of Red Rock. The converse is that these adults are pioneers from another run. This seems most probable, considering the long freshwater life of juvenile steelhead. Requiring two or more years of rearing in freshwater before heading seaward, young steelhead would, in Lower Crab Creek probably succumb to temperatures that approach the high 80s from late spring to late summer. Fall chinook are better adapted to such places with their fall spawning habit (during cool temps) and the departure of age-0 young prior to deadly summer heat. The small rainbow trout of Red Rock are of undefined origin. Are they resident rainbows with origins in long-since discontinued hatchery stockings in Red Rock Lake? Or are they young steelhead? The U.S. Bureau of Reclamation is completing a report on two years of inventory on

anadromous fish in the Columbia Basin Project. This will be the most thorough work to date on presence, distribution, spawning sites and habitat use and may shed more light on steelhead origins and use within the drainage.

The extent of anadromous passage upstream is uncertain. A falls just downstream of McManamon Road is probably a formidable barrier. Private land below the road has not been assessed for passage barriers.

From O'Sullivan Dam where several springs join into the renewal of Crab Creek, WDFW for many years stocked fingerling rainbow and brown trout in the stream, and as well the many nearby lakes whose outlets contribute to Crab Creek flow. The section down to McManamon Road produced fat and large trout, some well over 2.3 kg. This fishery was maintained for several years with periodic rotenone treatments to control carp and other competitor species. Unable to prevent the return of carp, and a change in management emphasis by the U.S. Fish and Wildlife Service (Columbia National Wildlife Refuge) on key parts of the area, led WDFW abandoning efforts to maintain this fishery. Below the falls near McManamon Road, there is little opportunity to develop a notable fishery for any species. Too much of the fish biomass is comprised of sunfish, carp, sculpins and several other species to allow even a modest warmwater fishery.

The stream passes through an area dotted with scores of small lakes and marshes. Nearly all contain fish. Many are managed solely for warmwater species, primarily largemouth bass, bluegill, crappie. Several lakes support a large mix of warmwater fishes, in addition to the species listed above: smallmouth bass, yellow perch, walleye, pumpkinseed sunfish, bullhead and channel catfish, and may also contain carp. These latter lakes generally yield low catch rates to anglers and offer sporadic success. Very popular trout fisheries exist in many other lakes. The management aim here is to keep these lakes free of non-salmonid species to maintain high yield to anglers. Lakes that have gained high notoriety over years include the ten-lake Pillar-Widgeon group, Hampton Lakes, Hutchinson and Shiner Lakes. All of the above lie on the Columbia National Wildlife Refuge. Elsewhere, anglers favor the Warden Lakes, Corral, Canal, Heart and the Windmill group of lakes. The darlings of Washington's fly anglers are Lenice, Merry and Nunnally near the mouth of Crab Creek. This Lower Crab Creek reach of the subbasin has a long history as a destination fishery, providing lowland lakes fisheries equal to the best that Washington has to offer. Almost 75 percent of the anglers using this area reside outside the Crab Creek drainage, with over 60 percent originating in Western Washington.

Water quality and habitat of the stream itself is poor throughout and contaminants include PCBs and dieldrin (Weaver 1999). Temperatures reach lethal levels for salmonids in the lower end. Soil laden irrigation return flows, the activities of carp, and occasional flooding disallow good water clarity during warm months and have left much of the streambed buried in muck, mostly that downstream of Highway 26. Much of the Lower Crab reach from below Highway 26 and west to

its juncture with Red Rock Creek is contained within dikes to protect adjacent croplands. Cattle operations over past 100 years and poor tillage practices have directly and indirectly stripped channel banks of riparian cover.

Summary assessment: Irrespective of these perturbations, Lower Crab Creek flows in quantities far above historic levels (pre-irrigation development), and it flows year around. This alone makes the lower reach better habitat for fish and wildlife than it ever was during pre-settlement. Water temperatures are elevated to extreme levels in summer, as much a natural condition for desert streams as a consequence of warmed discharge of lakes and irrigation return flows high in the reach. Riparian development along Lower Crab Creek, although appealing to the eye, will decrease stream temperatures only slightly.

Wildlife Habitat

Shrubsteppe

The historic habitat within the Crab Creek Subbasin included shrubsteppe (including, meadow steppe, and steppe [grass]), forest/shrub, cliffs, open water, and riparian (Daubenmire 1970) (Figure 4). Shrubsteppe habitat types were clearly the most dominant, covering > 95% of the overall subbasin. Habitat within the subbasin has been dramatically altered (Dobler et al. 1996, Jacobson and Snyder 2000) (Figure 5). Substantial portions (> 60%) of the shrubsteppe have been converted, primarily for the production of irrigated and dryland crops (Table 2). Significant quantities of original habitat have also been converted to urban, commercial, and residential sites in addition to being altered by road construction, canal construction, and recreational development and use. Moreover, the pattern of cropland conversion has resulted in a disproportionate loss of deep soil communities (Vander Haegen et al. 2000). In addition, much of the remaining shrub steppe has been fragmented into relatively small patches of habitat that are degraded in quality (Dobler et al. 1996). Ownership in the Crab Creek Subbasin is extremely diverse (Figure 6). Although most of the land is privately owned, there are substantial quantities owned by local, state, and federal government agencies (Table 4 and Table 3).

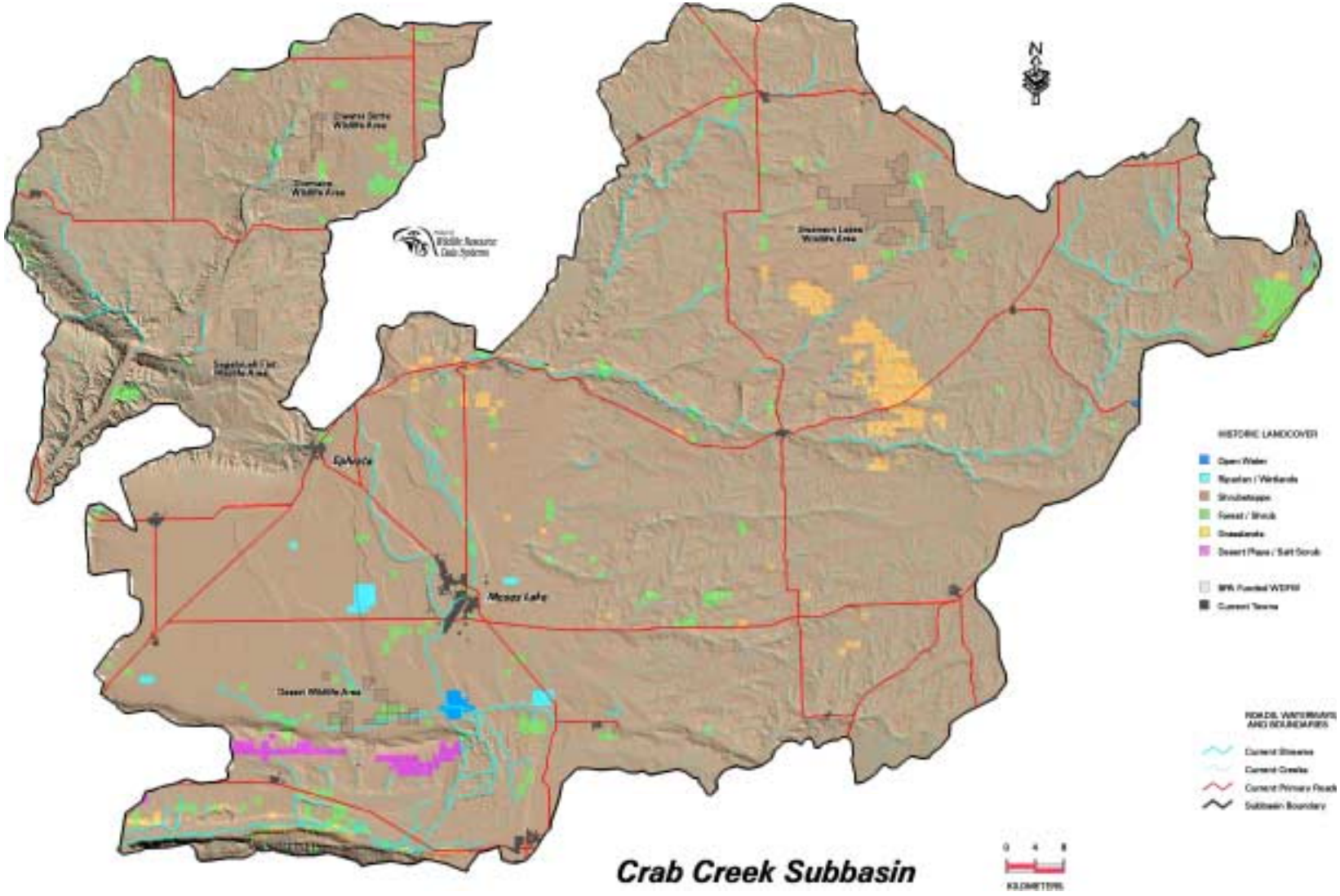

Figure 4. Historic Landcover

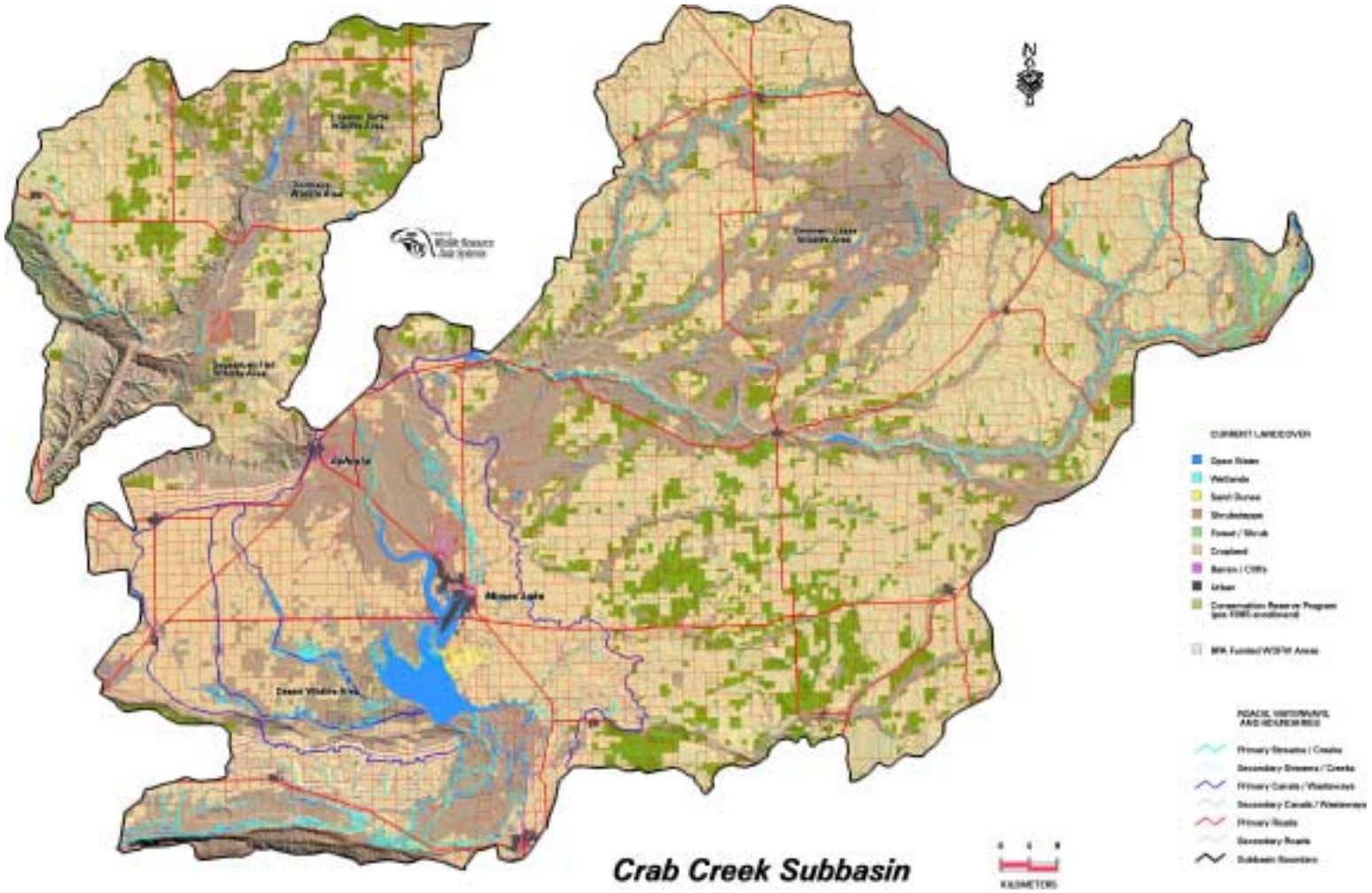

Figure 5. Current Landcover

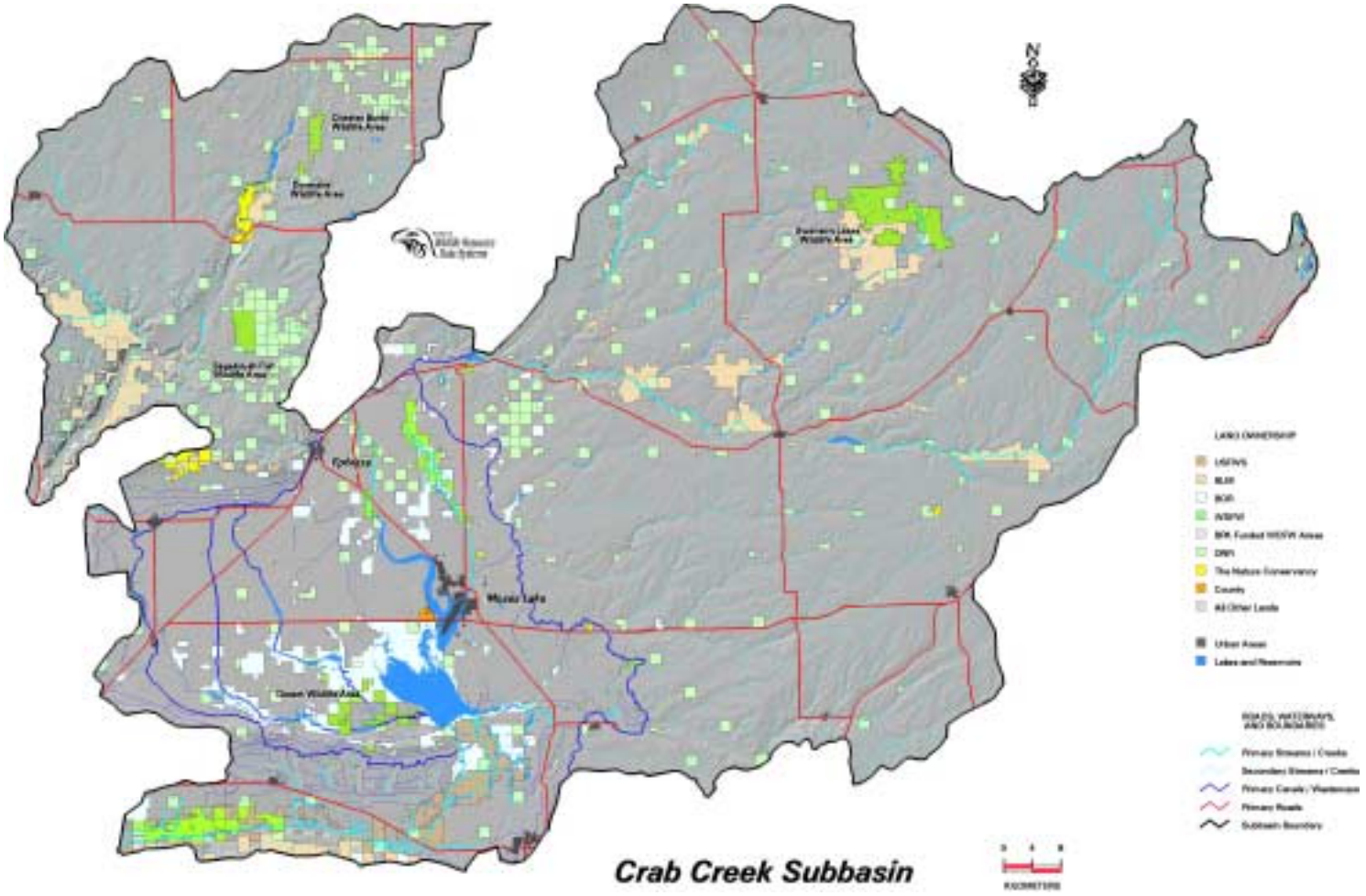

Figure 6. Current Ownership

Table 3. Historic Landcover Type by Ownership (Johnson and O'Neil, 2001)

Historic Land Cover by Ownership in Hectares

Ownership	Water	Wetlands and Riparian	Shrubsteppe	Forest/ Shrub	Cropland	Urban	Grasslands	Salt Scrub	Background (no data)	Total Hectres by Entity
Private	132	2240	1117951	22183	0	0	16826	4941	6439	**1170713**
Unknown	2	0	5392	67	0	0	0	0	0	**5461**
TNC		0	2810	0	0	0	0	0	202	**3012**
NSFWS	0	0	10860	378	0	0	261	0	8	**11508**
BLM	0	0	35815	1183	0	0	459	0	164	**37622**
Dept of Energy	0	0	50	0	0	0	0	0	0	**50**
Bureau of Reclamation	1189	60	39436	1945	0	0	182	96	162	**43069**
WDFW	0	0	21083	747	0	0	468	0	73	**22371**
Wa State Parks	0	0	0	0	0	0	0	0	1	**1**
Wa DNR	0	0	56228	1269	0	0	480	59	288	**58324**
City	0	0	278	0	0	0	0	0	0	**278**
Other	0	0	346.85545	0	0	0	0	0	29.781987	**377**
Total Hectres by class	**1323**	**2300**	**1290252**	**27773**	**0**	**0**	**18676**	**5096**	**7367**	**1345420**
									1352787	

Table 4. Current Landcover Type by Ownership (Jacobson and Synder 2000)

Current Land Cover by Ownership in hectares

Ownership	Water	Wetlands and Riparian	Shrubsteppe	Forest/ Shrub	Cropland	CRP Lands	Urban	Grass	Total Hectres by Entity	% of Total
Private	7754	9453	281691	904	715309	135899	7875	126	**1159012**	**86.47**
Unknown	368	206	3988	0	892	1	0	0	**5457**	**.41**
TNC	16	2	2729	0	38	7	0	0	**2792**	**.21**
NSFWS	482	788	9008	6	1223	0	0	0	**11507**	**.86**
BLM	381	240	34631	18	1950	363	11	0	**37594**	**2.80**
Dept of Energy	0	0	50	0	0	0	0	0	**50**	**00**
Bureau of Reclamation	8695	3139	25506	8	5566	114	36	0	**43064**	**3.21**
WDFW	733	1210	16925	1	3046	455	0	0	**22370**	**1.67**
Wa State Parks	0	0	1	0	0	0	0	0	**1**	**.00**
Wa DNR	753	834	29455	126	24451	2083	122	53	**57877**	**4.32**
University	0	0	0	0	0	0	0	0	**0**	**.00**
County	0	0	0	0	0	0	0	0	**0**	**.00**
City	2	23	68	0	105	0	80	0	**278**	**.02**
Other	22	33	16	17	68	0	211	8	**376**	**.03**
Total Hectres by class	**19207**	**15928**	**404070**	**1080**	**752650**	**138922**	**8334**	**188**	**1340380**	**100**

Cropland

Crop production is the most abundant current land use within the Crab Creek Subbasin (Figure 5), (Table 4). Most croplands are in irrigated or dryland crops or cattle pasture (Jacobson and Snyder 2000, Johnson and O'Neil, 2001 (in press)). The major crops include cereal grains like wheat, barley, and corn, potatoes, onions, and fruit (apples, cherries, peaches, and pears). Most of the cereal grains (other than corn) are produced without irrigation; the other crops are typically irrigated, most with the benefit of the Columbia Basin Irrigation Project. Although certain amounts of cropland have been shown to benefit wildlife, particularly when configured appropriately with native habitat, the widespread and continuous nature of the current croplands have been shown to be detrimental for most species (Buss and Dziedzic 1955).

The deep soil habitats were the first areas to be used for commercial crops by the earliest pioneers. Buss (1965) indicated that the first pioneers were homesteading in the valleys and canyons and that domestic livestock created ecological disturbances which helped to modify the wildlife community. For example, as agriculture became more common in the Crab Creek Subbasin, Canada geese became year round residents and nested here (Buss, 1965), and sandhill cranes became less common except during migration. Generally, "monoculture agriculture" has greatly changed the distribution and abundance of wildlife species in this subbasin. Examples are sharp-tailed grouse, sage grouse, mule deer, and neotropical migrants (sage sparrow, sage thrasher, loggerhead shrike, and others).

CRP

CRP (Conservation Reserve Program) is a federal program with contracts of at least 10 years that resulted in the 'set-aside' of approximately 25% of the cropland in the Crab Creek Subbasin (Figure 5). These habitats were planted with perennial grasses starting in the mid-1980's. Although most of the earlier CRP was planted in a monoculture of crested wheatgrass (*Agropyron cristatum*), most of the recent CRP includes a diversity of native grasses, forbs, and shrubs. Research has indicated that CRP may benefit key species of wildlife within the Crab Creek Subbasin including sage grouse and sharp-tailed grouse (Schroeder et al. 2000a, b). This benefit appears be due, in part, to a synergistic relationship between CRP and native shrubsteppe habitat. The quality of CRP appears to be improved when it's adjacent to shrubsteppe and the quality of shrubsteppe appears to be improved when the remaining native habitat is interconnected by CRP.

Cliffs

Barren ground such as steep canyon walls and cliffs can offer protective habitat for numerous species of wildlife. This may include nesting and roosting habitat, perches for hunting, and hibernacula for winter. Cliffs form a relatively small but

important part of the habitat within this Subbasin. Indirect impacts to this habitat and the species that depend on it include conversion and alteration of the surrounding habitats and direct disturbance from mining and human recreation (target shooting, rock climbing, camping near bat roost sites, etc.).

Open Water

Water is an important resource in the Crab Creek Subbasin, especially for wildlife. The usefulness of open water is increased when the adjacent habitats are of high quality and quantity and offer necessary cover for nesting, roosting, and feeding. In addition, the negative consequences of poor land use in adjacent habitats can negatively impact the quality of the open water by adding numerous chemicals such as pesticides, herbicides, and fertilizers (Williamson et al. 1998). These chemicals can impact wildlife directly through poisoning or indirectly through reduction and/or alteration of the food base.

Riparian and wetland

Riparian and wetland habitats are limited geographically and are vulnerable to loss and degradation through human activities and land use decisions. Since the arrival of settlers in the early 1800's, 50 to 90% of riparian habitat in Washington has been lost or extensively modified. (Buss 1965). Protecting riparian habitat may yield the greatest gains for fish and wildlife while involving the least amount of area (Knutson and Naef 1997). Negative impacts of fragmentation on wildlife require that increased attention be given to buffer zone design around riparian habitats (O'Connell et at. 2000). Currently, riparian buffers average 9.1 m for Crab Creek tributaries (Washington State Forest Practices Board 1988).

Other Habitats

Other habitats include infrequent types like sand dunes, forest/shrubs, and urban. Although none of these habitats are abundant, urban habitats are increasing in size, distribution, and influence throughout the Crab Creek Subbasin. The subbasin has grown in popularity as a preferred area for primary residential and secondary recreational home sites. As the population increases, more impacts to habitat and water quality are inevitable. Residential growth is moderate in most communities in this subbasin with the exception of Moses Lake where growth is occurring rapidly. Development is particularly rapid along lakeshores and streams.

Major Limiting Factors

Fisheries

Hydropower facilities without fish passage have eliminated functional fish passage upstream and downstream. Consequently, most of the fishery in the Crab

Creek Subbasin is non-native and/or altered dramatically by widespread changes in land-use. For example, rainbow trout are not native to Crab Creek but have been able to survive in those stretches of the stream where cool temperatures make life possible. Artificial habitats (islands for nesting Caspian terns) and altered fish and wildlife communities have resulted in high levels of predation and competition. Restoration of native fisheries is also limited by the direct and indirect impacts of runoff from croplands including extreme water flows (quantity and speed), movement of sediments and chemicals, and alteration of habitat. The current definition of riparian corridors and standards for protection of riparian buffers appear to be insufficient to protect Crab Creek, McCarteney Creek, and the associated tributaries from damage due to agricultural runoff.

Wildlife Limiting Factors

Isolation and fragmentation of native habitat are the biggest factors influencing the long-term changes in abundance and distribution of wildlife populations in the Crab Creek Subbasin (Buss and Dziedzic 1955, Buss 1965, Swenson et al. 1987, McDonald and Reese 1998). This habitat alteration has occurred due to conversion of native habitat for production of irrigated and dryland crops, degradation of remaining native habitat, development and urbanization, road construction, and hydropower. Fragmentation has severely reduced habitat for area-sensitive species. Sage sparrows, for example, are generally found only in blocks of shrubsteppe greater than 1,000 ha (2,470 acres) (Vander Haegen et al. 2001). Populations of species with small home ranges and limited dispersal capabilities are likely to become isolated and vulnerable to extirpation. The isolation and fragmentation of shrubsteppe habitat also has reduced the integrity of the remaining populations of sharp-tailed grouse, thus putting them at risk of extinction. Wildlife populations in fragmented habitats may be more vulnerable to predation. In Washington, Brewer's sparrows, lark sparrows, and sage thrashers had greater nest predation rates in fragmented habitats than in continuous habitats (WDFW, unpubl. data).

Agricultural conversion has decreased the overall quantity of habitat for many native species, but loss of specific communities may be particularly critical for habitat specialists. Pygmy rabbits, for example, require deep-soil big sagebrush communities. This community type has been severely reduced on the landscape (Vander Haegen et al. 2000), possibly driving pygmy rabbits towards extirpation.

Lack of knowledge for some species but in particular regarding herptiles further imperils these Columbia Basin dependent species. Specifically, our lack of understanding of habitat-use patterns and the population dynamics under different land use scenarios prevents us from making reasonable management recommendations that would protect these species where they still occur.

The single most significant habitat alteration in the subbasin occurred as a direct result of the construction of Grand Coulee Dam (Pitzer 1994). The Bureau of

Reclamation's Columbia Basin Irrigation Project (CBIP), which began water deliveries in 1952, essentially resulted in the conversion of approximately 750,000 acres of irrigated farmland 70% of which occurs in the Crab Creek Subbasin.

The CBIP caused the formation of numerous new wetlands, wasteways, reservoirs and canals that have provided significant benefits for some species of wildlife in terms of surface water and an interspersion of irrigated agriculture. These conditions have been particularly beneficial for migrating waterfowl and nesting ring-necked pheasants. However these benefits have been countered to some degree by negative impacts including: 1) relatively low nesting success for breeding waterfowl (Guidice et al. 2000); 2) direct mortality of 200-200 deer in irrigation canals (WDFW 1997; J. Tabor, WDFW, pers. comm.); and 3) expansion of non-native species of plants, fish, and wildlife. Non-native species have resulted in reduction and extirpation of many native species; a trend that will likely continue without intervention. For example, introduced bullfrogs and non-native fish have likely contributed to the decline of the endangered northern leopard frog (McAllister et al. 1999).

Restoration direction in the subbasin is limited by a lack of information on the type, distribution, quality, and quantity of habitat, and the wildlife response to habitat management activities. The CRP (Conservation Reserve Program) is one example of current restoration activities. Lands enrolled in CRP appear to be improving the situation for numerous species of interest including sage grouse, sharp-tailed grouse, and some species of waterfowl (Schroeder et al. 2000a, b). This improvement appears to be related to the direct increase in quantity of shrubsteppe habitat (CRP), the indirect enhancement of habitats adjacent to CRP, and the improvement in the science of restoration.

Artificial Production

Artificial production in the Crab Creek Subbasin is used to support non-native recreational fisheries. Artificial production is not currently being used to restore native fisheries.

Existing and Past Efforts

BPA Funded Projects

Swanson Lakes Wildlife Area

The 8,094 hectare (20,000 acre) Swanson Lakes Wildlife Area (SLWA) is located in Lincoln County, Washington approximately 21 kilometers (35 miles) southeast of Grand Coulee Dam (Figure 7). This wildlife area was established in 1992 primarily to support the recovery of sharp-tailed grouse and to partially mitigate for wildlife losses resulting from the construction of Grand Coulee and Chief

Joseph Dams. More than 16,000 sharp-tailed grouse habitat units (HUs) were lost due to construction of Grand Coulee Dam and over 1,000 HUs were lost at Chief Joseph Dam (both totals reflect only state losses – not tribal losses). The SLWA is comprised of lands purchased and/or owned by WDFW (2,517 hectares/6,220 acres), Bonneville Power Administration (5,059 hectares/12,500 acres), and the Washington Department of Natural Resources (518 hectares/1,280 acres). In addition, the Bureau of Land Management (BLM) owns approximately 6,071 hectares (15,000 acres) that adjoins SLWA on the south.

Figure 7. Location of the Swanson Lakes Wildlife Area in Crab Creek Subbasin

Shrubsteppe is the dominant cover type on the SLWA (Table 6). WDFW manages the SLWA principally for shrubsteppe obligate wildlife species such as sharp-tailed grouse and sage grouse and to provide public recreational opportunities. Mule deer is also a high priority management species because of its high recreational value (Anderson and Ashley 1993). Sharp-tailed grouse,

sage grouse, and mule deer are loss-assessment species associated with Grand Coulee and Chief Joseph Dams (Howerton 1986, Berger and Kuehn 1992).

Table 5. Habitat type and quantity on the Swanson Lakes Wildlife Area.

Habitat type	Acres
Shrubsteppe (including meadowsteppe and steppe)	14,676
Ephemeral pond	98
Lacustrine (includes semi-permanent water)	132
Wetland	83
Wet meadow	1,754
Riparian shrub	35
Ponderosa pine	1
Cliff/talus	485
Agriculture	275
Conservation Reserve Program (includes 'soil bank' fields)	2,396
Farmstead	65
Total	20,000

Swanson Lakes Wildlife Area management strategies address several critical landscape scale limiting factors, such as shrubsteppe habitat conversion, degradation, and fragmentation (Hays et al. 1998b, Schroeder et al. 2000a), as well as species-specific limiting factors. Management activities that have been implemented to address habitat conversion and degradation factors include seeding agricultural fields to native-like vegetation, removing livestock, protecting and maintaining existing habitat, and controlling introduced vegetation (Anderson and Ashley1993, WDFW 1998). These activities and strategies also address factors that limit local populations of sharp-tailed grouse and sage grouse such as quality and availability of nesting and wintering habitat (WDFW 1995a, b). The large project acreage and contiguous nature of the parcels that comprise the wildlife area reduces shrub-steppe habitat fragmentation within this portion of the subbasin.

Swanson Lakes Wildlife Area management goals, objectives, and strategies for sharp-tailed grouse (see section on Sagebrush Flat Wildlife Area for information on goals and objectives for sage grouse) support WDFW statewide goals and objectives for this species (WDFW 1995b). The sharp-tailed grouse population in Washington will be considered secure when statewide objectives have been met or exceeded for 10 consecutive years. Management goals and objectives for sharp-tailed grouse on the SLWA are listed below.

Goal 1: Establish and maintain a viable sharp-tailed grouse population at the Swanson Lakes Wildlife Area. This goal is consistent with the statewide goal to increase the population size and distribution of sharp-tailed grouse (WDFW

1995b). This goal is also consistent with the Crab Creek Subbasin goal to recover sharp-tailed grouse populations to viable levels within the subbasin.

Objective 1: Conduct research on sharp-tailed grouse on the SLWA through 2005 in conjunction with WDFW's statewide sharp-tailed grouse research program.

Strategy: Monitor population size, determine population viability, and evaluate population responses to habitat alteration.

Objective 2: Increase the number of sharp-tailed grouse from approximately 180 (estimated number currently occupying SLWA [M. Schroeder, pers. comm.) to 400 by 2010. This objective is consistent with the statewide objective to increase the breeding population of sharp-tailed grouse to more than 2,000 distributed throughout four management zones (SLWA is considered the 'core' property in WDFW's Sharp-tailed Grouse Management Zone 4, Figure 8). This objective also is consistent with the Crab Creek Subbasin objective to establish a population of at least 1,000 sharp-tailed grouse by 2010.

Goal 2: Protect, enhance, and maintain 20,000 acres of shrubsteppe habitat for sharp-tailed grouse and other shrubsteppe obligates. This goal is consistent with the statewide goal to protect, enhance, and increase shrubsteppe habitat (WDFW 2000b).

Objective 1: Implement management activities and schedules described in the SLWA Enhancement Plan (Anderson, J. Ashley, P. R. 1993). This objective is consistent with the statewide objective to protect at least 98,000 acres of high quality, relatively contiguous (<2 mile gaps) habitat that is currently occupied (WDFW 1995b). This objective also is consistent with the Crab Creek Subbasin objective to improve the quantity, quality, and configuration of shrubsteppe habitat necessary to support a viable population of sharp-tailed grouse by 2010.

Objective 2: Monitor wildlife and habitat response to protection, maintenance, and enhancement measures annually. This objective is consistent with the Crab Creek Subbasin objective to evaluate habitat restoration activities.

Figure 8. WDFW Sharp-Tailed Grouse Management Zones

Monitoring

(WDFW 1995b). Swanson Lakes Wildlife Area is located in zone 4. Sharp-tailed grouse leks (traditional display sites for concentrations of males) have been monitored on and near SLWA annually since the early 1970s. Sharp-tailed grouse movements have also been documented with the aid of radio telemetry. In addition, WDFW personnel and/or volunteers conduct neotropical bird surveys, sage grouse surveys, mule deer production counts, and hunter harvest surveys annually. Although less frequent, small mammal transects, winter raptor counts, and habitat data are also conducted on the SLWA.

This BPA funded mitigation project provides habitat for several threatened and endangered species and is an important link in WDFW's ongoing efforts to reverse downward population trends in shrubsteppe obligate wildlife species such as sharp-tailed grouse and sage grouse. Continued funding and support for the SLWA is crucial to addressing impacts caused by fragmentation, degradation and conversion of shrubsteppe habitat.

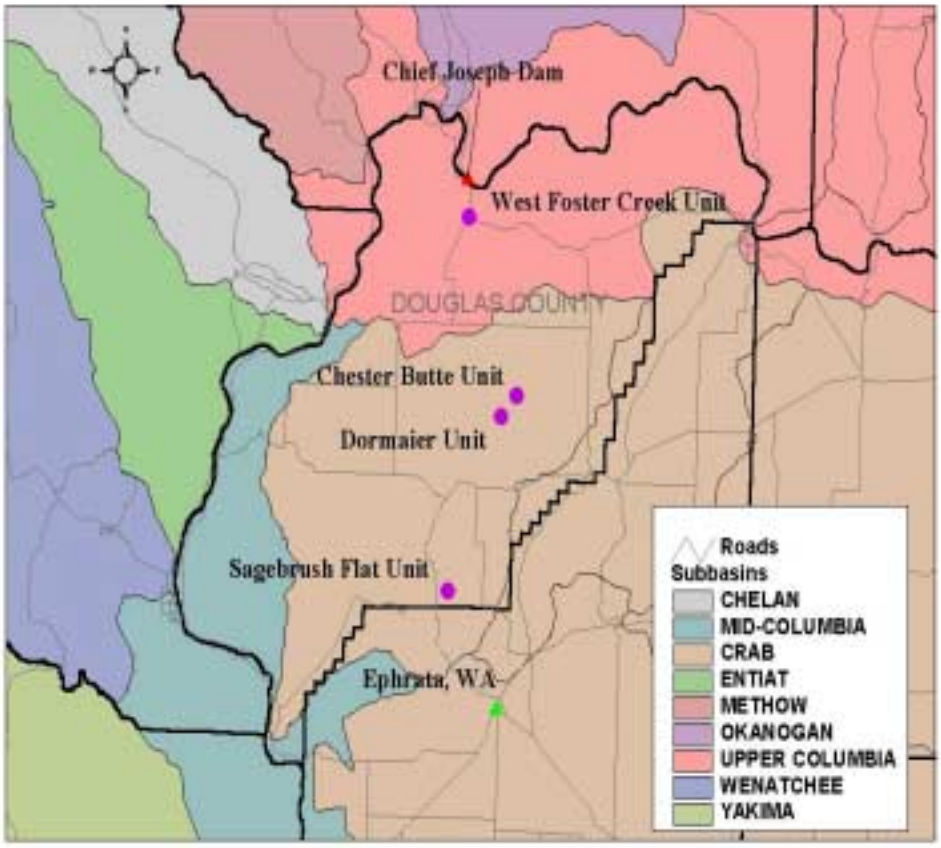

Figure 9. Location of Specific Management Units within the Sagebrush Flat Wildlife Area.

Sagebrush Flat Wildlife Area

The 3,487 hectare (8,616 acres) Sagebrush Flat Wildlife Area (SFWA) is located in Douglas County, Washington and is comprised of four separate parcels (Units) owned and/or managed by the Washington Department of Fish and Wildlife. The SFWA includes the 1,515 hectare (3,740 acres) Sagebrush Flat Unit, the 130 hectare (320 acres) Dormaier Unit, the 893 hectare (2,206 acres) Chester Butte Unit, and the 951 hectare (2,350 acres) West Foster Creek Unit (Figure 9).

The Sagebrush Flat Unit was acquired by WDFW in1997 from the Washington Department of Natural Resources (DNR) through a Washington Wildlife and Recreation Program (WWRP) grant administered by the Interagency Committee (IAC) for outdoor recreation. The entire Dormaier (purchased in 1995) and Chester Butte (purchased in 1998) Units were purchased by BPA. A 152 hectare (376 acres) portion of the West Foster Creek Unit was purchased in 2000 through a WWRP grant

The SFWA was established to promote recovery of sage grouse, sharp-tailed grouse, and pygmy rabbits. In addition, mule deer and a host of shrubsteppe obligate species benefit significantly from habitat protection, maintenance, and enhancement measures already implemented and/or planned for the wildlife area. Sage grouse, sharp-tailed grouse, and mule deer are loss assessment species for Grand Coulee and Chief Joseph Dams (Howerton 1986, Berger and Kuehn 1992). The SFWA partially mitigates for wildlife losses resulting from construction of Grand Coulee and Chief Joseph Dams.

Shrubsteppe (including shrub- and grass-dominated types) is the dominant habitat on the Sagebrush Flat Wildlife Area (WDFW 1998, WDFW 2001) (Table 6).

Table 6. Sagebrush Flat Wildlife Area cover types and acreage.

Habitat type	Sagebrush Flat Unit	Dormaier Unit	Chester Butte Unit	West Foster Creek Unit[1]
Shrubsteppe – shrub dominated	3,410	320	1,986	1,605
Shrubsteppe – grass dominated	100		2	647
Cropland	230			7
CRP			171	59
Wet meadow			45	
Ephemeral pond			2	
Riparian				21
Cliff/talus				11
Total	3,740	320	2,206	2,350

[1]The West Foster Creek Unit described here includes a larger area than the smaller 376 acre portion involving the BPA; it is outside the Crab Creek Subbasin.

SFWA management strategies address several key subbasin landscape scale limiting factors, such as shrubsteppe habitat conversion, degradation, and fragmentation (Hays et al. 1998a, Schroeder et al. 2000b), as well as species-specific limiting factors. Management activities that have been implemented to address habitat conversion and degradation factors include seeding agricultural fields to native-like vegetation, removing livestock and/or modifying grazing operations, protecting and maintaining existing habitat, and controlling introduced vegetation (DNR 1997, WDFW 1998, WDFW 2001). These same activities and strategies either address factors that limit sharp-tailed grouse and sage grouse populations, such as nesting and wintering habitat quality and availability (WDFW 1995a, b), or they support management of pygmy rabbits. Although geographically separated, the SFWA Units provide protected ‘core’ habitat areas

for many shrubsteppe obligate species. These parcels will become increasingly important in future efforts to manage larger landscapes.

The West Foster Creek Unit was purchased to provide habitat primarily for sharp-tailed grouse and mule deer. This Unit occurs within WDFW's sharp-tailed grouse Management Zone 3 (WDFW 1995b, Figure 8). Management goals and objectives for Sharp-tailed grouse are similar to the goals and objectives described for the Swanson Lakes Wildlife Area.

The Chester Butte, Dormaier, and Sagebrush Flat Units were acquired to protect and enhance habitat primarily for sage grouse, pygmy rabbits and other shrubsteppe obligate species. As described below, SFWA management goals, objectives, and strategies support statewide and subbasin goals, objectives, and strategies for sage grouse and pygmy rabbits (WDFW 1995a, c) as well as addressing subbasin limiting factors and needs.

Goal 1: Recover populations of sage grouse to viable levels on the Sagebrush Flat Wildlife Area and adjacent lands. This goal is consistent with the statewide goal to increase the population size and distribution of sage grouse (WDFW 1995a). This goal is also consistent with the Crab Creek Subbasin goal to recover sage grouse populations to viable levels within the subbasin.

> **Objective 1:** Conduct research on sage grouse on the SFWA through 2005 in conjunction with WDFW's statewide sage grouse research program.
>
> > **Strategy:** Monitor population size, determine population viability, and evaluate population responses to habitat alteration.
>
> **Objective 2:** Increase the number of sage grouse to approximately 400 on the SFWA and adjacent properties by 2010. This objective is consistent with the statewide objective to increase the breeding population of sage grouse to more than 1,500 distributed throughout six management zones (SFWA is considered the 'core' property in WDFW's Sage Grouse Management Zone 2, Figure 10). This objective also is consistent with the Crab Creek Subbasin objective to establish a population of at least 1,000 sage grouse by 2010.

Goal 2: Protect, enhance, and maintain shrubsteppe habitat for sage grouse and other shrubsteppe obligates. This goal is consistent with the statewide goal to protect, enhance, and increase shrubsteppe habitat (WDFW 2000b).

> **Objective 1:** Improve shrubsteppe habitat quality and configuration on the SFWA by 2005. This objective is consistent with the statewide objective to protect >16,000 (40,000 acres) of high quality, relatively contiguous habitat that is currently occupied (WDFW 1995a). This

objective also is consistent with the Crab Creek Subbasin objective to improve the quantity, quality, and configuration of shrubsteppe habitat necessary to support a viable population of sage grouse by 2010.

> **Strategy:** Base habitat management activities on sage grouse habitat research results and 'best science' principles.

Objective 2: Monitor wildlife and habitat response to protection, maintenance, and enhancement measures annually. This objective is consistent with the Crab Creek Subbasin objective to evaluate habitat restoration activities.

Figure 10. WDFW Sage Grouse Management Zones

(WDFW 1995a). Sagebrush Flat Wildlife Area is located in Zone 2.

Like sage grouse, pygmy rabbits are dependent upon sagebrush for >90% of their winter diet. The pygmy rabbit is the smallest rabbit in North America and is the only rabbit known to dig its own burrow. Dense sagebrush and relatively deep, loose soil are important characteristics of pygmy rabbit habitat. As a result, protection, enhancement, and/or development of suitable shrubsteppe habitat is critical to the recovery of this species.

The current Washington population is estimated to be less than 250 rabbits. Of the three pygmy rabbit areas known to remain in Washington (all in Crab Creek Subbasin), the SFWA supports the largest remaining concentration of pygmy rabbits which may be fewer than 150 rabbits (Figure 3). The other two populations are significantly smaller (WDFW 1995c; T. McCall, WDFW, pers. comm.). As described below, SFWA management goals, objectives, and strategies for pygmy rabbits are consistent with state and subbasin goals, objectives, and strategies.

Goal: Establish and/or maintain two viable populations of pygmy rabbits on the SFWA; one population on the Sagebrush Flat Unit and a second population on the Dormaier/Chester Butte Units. This goal is consistent with the WDFW statewide goal (WDFW 1995c) and the Crab Creek Subbasin goal to recover and maintain a viable pygmy rabbit population in Washington and the Crab Creek Subbasin, respectively.

Strategy 1: Protect and increase the remaining pygmy rabbit population and associated habitats on the Sagebrush Flat and Dormaier (may not have any rabbits currently) Units. This strategy is consistent with the statewide objective to establish and maintain four populations with at least 500 adults each and eight populations with at least 100 adult rabbits each for a minimum 5-year average total of 2,800 pygmy rabbits (WDFW 1995c).

Strategy 2: Monitor and conduct research on pygmy rabbit populations, determine population viability, and evaluate population responses to habitat alteration and other management activities. This strategy is consistent with statewide objectives to: 1) investigate genetic similarities and differences between pygmy rabbits in Oregon, Idaho, and Montana; 2) determine if the genetic diversity of Washington's pygmy rabbit population is sufficient for the species to persist for a long time period; 3) evaluate the effectiveness of rearing pygmy rabbits in captivity; 4) monitor existing pygmy rabbit populations and survey areas of potential pygmy rabbit occurrence; and 5) monitor the effectiveness of translocation techniques (WDFW 1995c).

Strategy 3: Manage and improve the quantity, quality, and configuration of shrubsteppe habitat as needed to benefit pygmy rabbits. This strategy is consistent with the statewide objective to protect and manage pygmy rabbit habitat to increase their abundance and distribution (WDFW 1995c).

Strategy 4: Conduct searches on the Dormaier and Chester Butte Units to locate additional pygmy rabbit populations and/or suitable habitat for relocations. Augment existing pygmy rabbit populations and establish new populations in suitable habitat through captive rearing or

translocations. This strategy is consistent with the statewide objective to establish pygmy rabbit populations in new areas (WDFW 1995c).

Monitoring

A cooperative study (including Washington State University, WDFW, BPA, DNR, and local cattlemen) has been funded by BPA to examine vegetation differences between grazed and ungrazed areas on the Sagebrush Flat Unit and the potential impacts to pygmy rabbits resulting from grazing or lack of grazing. Sharp-tailed grouse and sage grouse leks (traditional display sites for concentrations of males) are also monitored annually. In addition, WDFW personnel and/or volunteers conduct annual neotropical bird surveys, mule deer production counts, and hunter harvest surveys.

This BPA funded mitigation project provides habitat for several threatened and endangered species and is an important link in WDFW's ongoing efforts to reverse downward population trends in shrubsteppe obligate wildlife species such as pygmy rabbits, sharp-tailed grouse, and sage grouse. Continued funding and support for the SFWA is crucial to addressing impacts caused by fragmentation, degradation and conversion of shrub-steppe habitat.

Efforts Funded Outside of Columbia Basin Fish and Wildlife Program

Adams County Conservation District

The Adams Conservation District's resource management efforts are focused upon three sub drainages all of which flow into Crab Creek. Recognizing the large volume of sediment that has accumulated in the Lind Coulee Arm of the Potholes Reservoir, the primary emphasis has been toward developing solutions that would quickly educate cooperators about methods to control and reduce future storm water runoff events. One major concern was from conventional tillage practices by dry land wheat farmers, which left 50% of agriculture ground in a fallow condition resulting in tremendous sediment erosion events.

In support of that concern a four-year Odessa aquifer erosion control study was initiated to seek solutions and this project concluded in 1989. A DOE funded Weber Coulee "Watershed Plan" followed and was completed in 1992. A Weber Coulee "Implementation Program" supported by NRCS technical assistance developed cost effective sediment containment projects in addition to numerous upland treatment concepts. The introduction of the Conservation Reserve Program (CRP) also idled thousands of acres of Adams County farm ground resulting in significant increases in the wildlife population habitat.

Through support from Washington Conservation Commission, Department of Ecology and Environmental Protection Agency additional funding was located to initiate the development of a larger "Agriculture Best Management Practice" project. Through this program GIS mapping technology was developed and

offered producers improved farm conservation plans with useful maps for documenting specific tasks associated to targeted goals. An "Irrigation Water Monitoring" (IWM) program provided informative and useful data for identifying specific water application rates for avoiding over the application of water. One new concept that has been on leading edge technology for the agriculture industry is minimum tillage direct seed concepts where we maintain annual cover crops. While the concept works in most of the areas, selling the method takes a great deal of persuasion. Numerous other conservation practices were implemented. A final report was submitted in March 2000.

Among the long term goals and objectives are to develop a harmony between agriculture needs while expanding the habitat needs as required for our wildlife through natural resource preservation and conservation opportunities.

Washington Department of Fish and Wildlife

The Washington Department of Fish and Wildlife (WDFW) administers the Columbia Basin Wildlife Areas, 14 scattered management units encompassing approximately 200,000 acres in the subbasin. These lands include owned lands (38,000 acres) with the balance administered through agreements with other state and federal landowners. Most of the Columbia Basin Wildlife Areas, 142,000 acres, are U.S. Bureau of Reclamation lands acquired as part of the Columbia Basin Irrigation Project. The Columbia Basin Wildlife Areas were established in 1952 by a 50 year Management Agreement between U.S. Bureau of Reclamation and Washington State. Land acquisitions adding to the wildlife areas were mostly completed by 1984.

The three most common habitats in the Columbia Basin Wildlife Areas are open water (63,500 acres), shrubsteppe (106,500 acres), and riparian (7,200 acres). The open water and riparian areas are almost entirely a result of the irrigation project. Both of these habitats were probably shrubsteppe before 1950. The wildlife areas are managed to preserve priority habitats and to benefit a variety of wildlife. Although the highest priority wildlife are native species listed as threatened or endangered, the shrubsteppe habitats within the Columbia Basin Wildlife Areas are managed primarily for introduced exotics (ring-necked pheasants), small game, and native wildlife species. Riparian and shallow areas of open water are managed primarily for dabbling ducks. Open water is managed for game fish, waterfowl and native wildlife.

Compatible recreation is allowed in all of the Columbia Basin Wildlife Areas. The total use on the wildlife areas is estimated to be over 800,000 visitors per year. Fishing is the most popular recreation activity on the Wildlife Areas and accounts for 50% of the total. Hunting accounts for about 10% of the use and other uses, such as water sports, camping, horseback riding, rock climbing, and wildlife viewing, make up the balance. There are fifteen grazing agreements and nineteen farming agreements on the wildlife areas that involve about 27,000 acres. All but two of these leases are on federal land.

Between 1991 and 1994 the WDFW purchased 18 properties (1,117 acres) within the Columbia Basin Irrigation Project. These are managed along with 19 other parcels (600 acres owned or managed) for farmland wildlife. Activities on these properties include noxious weed control, and habitat development primarily for ring-necked pheasant.

WDFW continues to work cooperatively with the Natural Resources Conservation Service, the Farm Service Agency, and private landowners on implementation of the Conservation Reserve Program. To date, over 280 water guzzlers have been installed and thousands of acres enhanced on private lands (150 Habitat Protection Agreements with private landowners) within the subbasin by WDFW's Upland Wildlife Restoration Program.

Washington Department of Natural Resources

The Department of Natural Resources (DNR) manages approximately 144,000 acres in the subbasin (Table 2). Approximately 69,800 acres are in rangeland, 43,700 acres are in dryland agriculture, and 6,500 acres are in irrigated agriculture. These lands are managed to generate revenue for state trust beneficiaries. The DNR's land management activities are designed to provide good stewardship and resource protection necessary to ensure that state trust lands provide support to the beneficiaries in perpetuity.

Approximately 480 acres of DNR land within the subbasin are managed as Natural Area Preserves. These areas are set aside for research and education and help to maintain Washington's native biological diversity. They protect the highest quality examples of native ecosystems and rare plant and animal species, as well as features of state, regional or national significance.

U. S. Fish and Wildlife Service

The Columbia National Wildlife Refuge (CNWR) includes 23,200 acres of core lands surrounding Crab Creek downstream from O'Sullivan Dam. The refuge was established in 1944 as a feature of the Columbia Basin Irrigation Project (CBIP). A majority of the refuge was purchased in fee title, but more than 2,600 acres, mostly along the dam face and Potholes Canal, are owned by U.S. Bureau of Reclamation and managed by the U.S. Fish and Wildlife Service. The refuge was established "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" and "as a refuge and breeding ground for migratory birds and other wildlife."

The original acquisition boundary of the refuge included the entire length of Crab Creek below Potholes Reservoir to its junction with the Columbia River. More than 6,000 acres outside the current primary management area were acquired from Public Domain lands and through fee purchase. Priorities for purchase were

reduced when the Columbia Basin Irrigation Project was scaled back and the flood zone associated with using Crab Creek as a wasteway capable of sustained 2000 cubic-feet-per-second flows was no longer needed. Approximately 4,000 acres of intermingled refuge lands along lower Crab Creek are currently managed through agreement by WDFW. The U.S. Fish and Wildlife Service owns an additional 5,787 acres adjacent to Lake Lenore (once a national wildlife refuge) that is managed cooperatively by WDFW.

The most common habitats on CNWR are wetland (including lake, marsh and riparian) and shrubsteppe (19,000 acres). Before the CBIP changed the hydrology of the refuge area, the scenery was dominated by scablands combining expansive rock outcrops carved by glacial flood flows 12-15,000 years ago. The Refuge is the largest single land holding in the Drumheller Channels National Natural Landmark, designated in 1986 for its scenic beauty and geologic history. Water was restricted to a few shallow lakes and Crab Creek, which was reduced to intermittent and subsurface flows during the summer. The majority of the vegetation was shrubsteppe. Leakage through O'Sullivan Dam, the Potholes Canal, a higher water table, and drainage via wasteways has increased the wetland acreage from less than 300 to the current 3,800 acres, and has turned lower Crab Creek into a stream with perennial surface flow.

Bureau of Land Management

The Bureau of Land Management (BLM) administers approximately 100,900 acres of federal lands within the subbasin (Table 2). These lands are located primarily in the Moses Coulee area and along upper Crab Creek. The lands vary from scattered small tracts of less than 40 acres to blocks of approximately 15,000 acres. All of the larger blocks were created by land tenure adjustments, primarily through land exchange. BLM has had an active land exchange program since the mid 1970's, however the majority of the consolidation has occurred in the last 10 years. Some lands also have been acquired by purchase with federal Land and Water Conservation Funds and by donation. The BLM has been targeting acquisition of shrubsteppe and associated riparian area in their land tenure adjustment program. This program is expected to continue at least in the near future.

Most of the BLM lands in the subbasin are classified as shrubsteppe. About 2% of the BLM lands are converted dryland wheat fields or old CRP. The BLM also manages an estimated 40 miles of important riparian habitat along Douglas Creek, upper Crab Creek, and the major tributaries of Crab Creek (Lake Creek, Coal Creek, and Rock Creek). The BLM also manages lakeshore habitat on several lakes in the upper Crab Creek drainage. The BLM lands are managed under the principle of multiple use. Dispersed recreation and grazing are common uses of BLM lands. Access to public lands has been a major component in their consolidation program. BLM policy gives priority to habitat for sensitive species and riparian areas.

Bureau of Reclamation

The Bureau of Reclamation (BOR) owns about 144,600 acres in the Crab Creek Subbasin (Table 2). Most of this acreage is in the Potholes Reservoir area and is managed as part of the Columbian Basin Wildlife Areas by the WDFW or as part of the Columbia National Wildlife Refuge by the U.S. Fish and Wildlife Service. The lands were acquired as part of the Columbia Basin Irrigation Project.

The Nature Conservancy

The Nature Conservancy (TNC) owns 3,500 acres within Moses Coulee, 325 acres on Badger Mountain, and 5,000 acres in the Beezley Hills. TNC also has 2,800 acres in a conservation easement within Moses Coulee near Sagebrush Flats (Rimrock Meadows). The lands are owned and managed primarily for the protection and restoration of shrubsteppe habitat and associated wildlife, although educational, research and permitted recreational uses are allowed.

SUBBASIN MANAGEMENT

Existing Plans, Policies, and Guidelines

Federal Government

Management within the Crab Creek Subbasin is coordinated by numerous federal agencies including The Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the Bureau of Land Management. Most lands are managed with considerations of agricultural requirements and compromises between resource use and protection. Current policies give priority to areas and/or habitats occupied by sensitive, threatened, and/or endangered species.

State Government

Washington Department of Fish and Wildlife

The Department of Fish and Wildlife has the responsibility to preserve, protect, and perpetuate all fish and wildlife resources in the state of Washington. The WDFW also enforces all laws pertaining to fish and wildlife resources within the state including marine and fresh waters. The Wild Salmonid Policy (WSP)(State of Washington 1997) is one of the guidance documents used to review and modify current management goals, objectives, and strategies related to wild salmonids and their ecosystems to sustain ceremonial, subsistence, commercial, recreational, and non-consumptive fisheries, and other related cultural and ecological values. The WSP will serve as the primary basis for watershed-based plans that insure adequate habitat protection.

Washington Department of Ecology

The mission of the Department of Ecology (Ecology) is to protect, preserve, and enhance Washington's environment, and to promote the wise management of its air, land, and water for the benefit of current and future generations. Ecology's

goals are to prevent pollution, clean up existing pollution, and support sustainable communities and natural resources. A major role is to allocate surface and ground water rights between industry, agriculture, homes, and wildlife.

Ecology has administered two water quality monitoring grants performed by Lincoln County Conservation District, and in October 2000 funded the Initiating Phase of an Upper Crab (WRIA 43) Watershed Planning Act project authorized under HB 2514. Ecology also participates on the local planning unit representing the State of Washington.

Ecology will soon begin working with local jurisdictions, agricultural interests and others to develop clean-up plans, or Total Maximum Daily Loads (TMDLs) for pollutants exceeding state water quality criteria in upper Crab Creek. The initial primary concern is phosphorus loading to Moses Lake, and pH. More data is required to determine if Crab Creek exceeds other parameters, such as temperature, fecal coliform bacteria, and dissolved oxygen.

Local Government

Local public utility districts, conservation districts, water boards, noxious weed boards, county commissions, and city governments have an impact on resource planning within the Crab Creek Subbasin. Because the economy of this subbasin is largely driven by agriculture, there is a tremendous involvement by local governments in resource-related issues, particular those related to water.

Lincoln County is Lead Agency for the Upper Crab (WRIA 43) Watershed Planning Unit, which will address water supply, and consider water quality, fish and wildlife habitat, and instream flows. Lincoln County Conservation District facilitates the Planning Unit, which, after completing the Initiating Phase, will have four years to produce a watershed assessment and develop a plan to address water supply and related issues.

Douglas County HCP

The Foster Creek Conservation District in Douglas County is developing a countywide Habitat Conservation Plan (HCP). The District's mission in undertaking this project is to enhance the local quality of life in Douglas County by protecting and increasing wildlife species habitat while at the same time providing regulatory certainty and protection from incidental takings for local farmers, ranchers, and orchardists.

Adams County Conservation District

The Adams County Conservation District recently (March 2000) submitted a final report to Department of Ecology for a three year Agriculture BMP Implementation plan that addresses specific conservation practices for that conservation district. They have previously completed a comprehensive Weber Coulee Watershed Plan, and followed with a Weber Coulee Implementation plan.

Lincoln County Conservation District

Lincoln County Conservation District has completed four years of baseline water quality monitoring at 19 locations along Crab Creek and its tributaries. They have worked with local crop and livestock producers to reduce erosion and nonpoint pollution utilizing programs such as Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Centennial Clean Water Funds, and EPA Section 319 nonpoint source funds.

Goals, Objectives, Strategies, and Recommended Actions

Fish

Overall Goal: Protect, enhance, and restore fish populations to ensure population viability, self-sustaining persistence, and ecological, cultural, and sociological benefits.

Goal 1: Restore viable populations of native salmonids to the Crab Creek Subbasin.

Goal 2: Minimize negative consequences of hydropower on fisheries in the Crab Creek Subbasin.

Goal 3: Assess current distribution of trout species in upper Crab Creek.

Goal 4: Maintain and enhance a harvestable recreational rainbow trout fish population in upper Crab Creek and tributaries, including Lake Creek.

Wildlife

Overall Goal: Protect, enhance, and restore native habitats, particularly shrubsteppe, to provide the quality and continuity necessary to support viable populations of wildlife within the Crab Creek Subbasin.

Habitat Distribution

Habitat mapping within the Crab Creek Subbasin in particular, and eastern Washington in general, is a priority for numerous agencies and organizations including the WDFW (Dobler et al. 1996; Jacobson and Snyder 2000; Hays et al., in prep.), DNR (R. Crawford, pers. comm.), BLM (T. Thompson, pers. comm.), TNC (N. Warner, pers. comm.), and the Foster Creek Conservation District (M. Mazola, pers. comm.). Although the distribution of basic habitats such as shrubsteppe and cropland is known (Figure 5), the distribution of specific variations in the types and condition of shrubsteppe is not. In addition, the location of CRP was mapped based on NRCS data from the mid-1990's; the current distribution of CRP is different and it has not been mapped.

Status: Shrubsteppe is considered a priority habitat by the WDFW (2000b). A general map of shrubsteppe habitat in eastern Washington and in the Crab Creek Subbasin was completed in 2000 (Jacobson and Snyder).

Limiting Factors: The lack of an adequate map of distribution of specific shrubsteppe habitats is adversely impacting management efforts in the Crab Creek Subbasin.

Goal 1: Map specific types of shrubsteppe habitat within the Crab Creek Subbasin.

Objective: Map all habitat within the subbasin using a method that permits evaluation of habitat potential, habitat condition, and endemic features of the landscape such as slope, aspect, soil, and weather by the year 2005.

Task 1: Use current habitat map for subbasin (Jacobson and Snyder 2000) as a 'starting point' for distribution of habitat by general habitat category.

Task 2: Define specific habitat types within general categories that reflect variation in habitat potential (Daubenmire 1970), habitat condition, and endemic features of the landscape such as slope, aspect, soil, and weather.

Task 3: Map CRP with aid of aerial photography in county offices of the National Resources Conservation Service.

Task 4: Use digitized maps for soil type (when and where available) to refine current maps on habitat potential.

Task 5: Use satellite data to refine mapped distributions of habitat.

Task 6: Use ground-reconnaissance data to evaluate specific variation within general habitat categories and to refine and finalize subbasin habitat maps.

Goal 2: Monitor periodic changes in habitat distributions.

Objective: Develop a system for monitoring changes in habitat on a regular 5-year interval by the year 2005.

Task 1: Develop the funding and resources necessary to insure a periodic (every 5 years) evaluation in habitat, and hence, habitat changes.

Task 2: Evaluate periodic changes in abundance of specific habitats within broad categories of shrubsteppe and CRP and changes in condition within identifiable habitat types.

Shrubsteppe Restoration

Numerous species of shrubsteppe obligates are found in the Crab Creek Subbasin including sage grouse, sharp-tailed grouse, pygmy rabbits, Washington ground squirrels, sage thrashers, sage sparrows, Brewer's sparrows, loggerhead shrikes, and ferruginous hawks (WDFW 2000b). Although all have current distributions that are dramatically reduced from their historic ranges, they are all still found within the Crab Creek Subbasin (Figure 3). Because of the presence of many shrubsteppe obligates and the dramatic efforts to restore shrubsteppe habitat in the Crab Creek Subbasin, this subbasin is an ideal location to evaluate the effectiveness of ongoing restoration activities.

Status: Most populations of shrubsteppe obligates appear to be declining and some species appear to be close to extinction (WDFW 2000b). The Washington ground squirrel, sage sparrow, and loggerhead shrike are candidates for state listing; the sage grouse, sharp-tailed grouse, and ferruginous hawk are listed as threatened; and the pygmy rabbit is listed as endangered.

Limiting Factors: Declining quantity and quality of shrubsteppe habitat is both a direct and an indirect cause for the declines in distributions and populations of shrubsteppe obligates (Vander Haegen et al. 2000, WDFW 2000b).

Goal: Recover populations of shrubsteppe obligates in the Crab Creek Subbasin to the level where populations are viable.

Strategy 1: Evaluate shrubsteppe restoration activities, including the Conservation Reserve Program, the WDFW's Habitat Restoration Program, and species-specific restoration activities on BPA-funded Wildlife Areas (Swanson Lakes and Sagebrush Flats Wildlife Areas).

Task 1: Evaluate characteristics of shrubsteppe habitat including distribution, configuration, fragmentation, quantity, condition, and potential.

Task 2: Compare shrubsteppe characteristics with management history, but particularly restoration activities.

Task 3: Evaluate relationship between shrubsteppe habitat restoration activities and associated species of shrubsteppe

obligates (including sage grouse, sharp-tailed grouse, pygmy rabbits, Washington ground squirrels, ferruginous hawks, loggerhead shrikes, Brewer's sparrows, sage sparrows, and sage thrashers).

Strategy 2: Develop restoration guidelines for shrubsteppe habitat including grazing management, seed mixtures for revegetation efforts, weed control methods, and considerations for landscape configuration.

Strategy 3: Improve quantity, quality, and configuration of shrubsteppe habitat so that viable populations of shrubsteppe obligates will be supported.

Task 1: Improve CRP plantings throughout the subbasin so that they meet standards for plant composition and for distribution and configuration in relation to shrubsteppe habitat.

Task 2: Continue restoration of habitat on public lands and education of private landowners about restoration opportunities on private land.

Task 3: Purchase properties or easements based on their applicability to published objectives for management and recovery plans for shrubsteppe obligates.

Sage Grouse

Sage grouse were historically found in shrubsteppe habitats throughout eastern Washington. Sage grouse populations in Washington declined 77% between 1960 and 1999 (Schroeder et al. 2000b). One of the 2 remaining populations is centered in Douglas County, within the Crab Creek Subbasin (Figure 3). The subbasin also includes an additional 5 zones designated for recovery of sage grouse populations (Hays et al., in prep.).

Status: The current population in Washington is estimated to be about 1,000 and is listed as a threatened species by the state of Washington. (Schroeder et al. 2000b).

Limiting Factors: Availability of shrubsteppe habitat with a substantial component of herbaceous cover (grasses and forbs). The lack of big sagebrush in shrubsteppe habitats may also limit sage grouse in the Crab Creek Subbasin, but to a lesser extent.

Goal: Recover populations of sage grouse in the Crab Creek Subbasin to the level where populations are viable.

Objective 1: Conduct research on sage grouse through 2005 to monitor population size, determine population viability, and evaluate population responses to habitat alteration.

Task 1: Monitor all traditional sage grouse display sites (leks) on an annual basis throughout the Crab Creek Subbasin.

Task 2: Collect and examine tissue samples of sage grouse to monitor genetic heterogeneity and population viability.

Task 3: Evaluate movement of radio-marked sage grouse in the Crab Creek Subbasin to examine population viability and habitat connectivity.

Task 4: Monitor changes in sage grouse populations in relation to habitat restoration activities.

Objective 2: Improve quantity, quality, and configuration of the shrubsteppe habitat necessary to support a viable population of sage grouse by 2010.

Task 1: Improve CRP plantings throughout the subbasin so that they meet standards for plant composition and for distribution and configuration in relation to shrubsteppe habitat.

Task 2: Continue restoration of habitat on public lands and education of private landowners about restoration opportunities on private land.

Task 3: Purchase properties or easements based on their applicability to published objectives for management and recovery plans for sage grouse.

Objective 3: Use translocations of sage grouse into Washington from populations in other states so that a population of at least 1,000 is supported in the Crab Creek Subbasin by 2010.

Task 1: Select a source population in another region based on genetic similarity to birds in Washington.

Task 2: Translocate sage grouse into portions of the Crab Creek Subbasin where they are currently absent, such as the Lincoln County area.

Task 3: Translocate sage grouse into portions of the Crab Creek Subbasin where population and/or genetic augmentation will be useful for long-term improvement in population viability.

Task 4: Monitor and evaluate the success and/or failure of all translocation activities.

Sharp-tailed Grouse

Sharp-tailed grouse were historically found in shrubsteppe and deciduous shrub habitats throughout eastern Washington. Sharp-tailed grouse populations in Washington declined 94% between 1960 and 2000 (Schroeder et al. 2000a). About 33% of the remaining birds are found within the Crab Creek Subbasin (Figure 3). The subbasin includes 6 zones designated for recovery of sharp-tailed grouse populations (Hays et al., in prep.).

Status: The current population in Washington is estimated to be around 600 and is listed as a threatened species by the state of Washington. (Schroeder et al. 2000a).

Limiting Factors: Availability of shrubsteppe habitat dominated by herbaceous cover (grasses and forbs). The distribution of riparian habitats dominated by deciduous shrubs also limits wintering opportunities.

Goal: Recover populations of sharp-tailed grouse in the Crab Creek Subbasin to the level where populations are viable.

Objective 1: Conduct research on sharp-tailed grouse through 2005 to monitor population size, determine population viability, and evaluate population responses to habitat alteration.

Task 1: Monitor all traditional sharp-tailed grouse display sites (leks) on an annual basis throughout the Crab Creek Subbasin.

Task 2: Collect and examine tissue samples of sharp-tailed grouse to monitor genetic heterogeneity and population viability.

Task 3: Evaluate movement of radio-marked sharp-tailed grouse in the Crab Creek Subbasin to examine population viability and habitat connectivity.

Task 4: Monitor changes in sharp-tailed grouse populations in relation to habitat restoration activities.

Objective 2: Improve quantity, quality, and configuration of the shrubsteppe habitat necessary to support a viable population of sharp-tailed grouse by 2010.

Task 1: Improve CRP plantings throughout the subbasin so that they meet standards for plant composition and for distribution and configuration in relation to shrubsteppe habitat.

Task 2: Continue restoration of habitat on public lands and education of private landowners about restoration opportunities on private land.

Task 3: Purchase properties or easements based on their applicability to published objectives for management and recovery plans for sharp-tailed grouse.

Objective 3: Use translocations of sharp-tailed grouse into Washington from populations in other states so that a population of at least 1,000 is supported in the Crab Creek Subbasin by 2010.

Task 1: Select a source population in another region based on genetic similarity to birds in Washington.

Task 2: Translocate sharp-tailed grouse into portions of the Crab Creek Subbasin where they are currently absent, such as the Lincoln County area.

Task 3: Translocate sharp-tailed grouse into portions of the Crab Creek Subbasin where population and/or genetic augmentation will be useful for long-term improvement in population viability.

Task 4: Monitor and evaluate the success and/or failure of all translocation activities.

Pygmy Rabbit

Pygmy rabbit populations are associated with relatively deep soils dominated by shrubsteppe habitat. The availability of this habitat has declined dramatically in Washington (WDFW 1995c). There are only three small and isolated populations of pygmy rabbits remaining in the state, all within the Crab Creek Subbasin (Figure 3).

Status: The current Washington population is estimated to be less than 250 rabbits and is listed as an endangered species by the state of Washington.

Limiting Factors: Quantity and distribution of shrubsteppe habitat with relatively deep soil.

Goal: Recover populations of pygmy rabbits in the Crab Creek Subbasin to the level where populations are viable.

Strategy 1: Monitor pygmy rabbit populations, determine population viability, and evaluate population responses to habitat alteration.

Task 1: Monitor all known pygmy rabbit populations annually with the aid of burrow surveys.

Task 2: Conduct regular searches for 'new' and or additional populations of pygmy rabbits.

Task 3: Develop a habitat model to predict likely locations of pygmy rabbits.

Task 4: Evaluate the effectiveness of captive rearing pygmy rabbits.

Task 5: Monitor rabbits returned or released into the wild.

Task 6: Evaluate the effectiveness of translocation techniques for pygmy rabbits.

Task 7: Evaluate the applicability and effectiveness of the recommended habitat restoration activities.

Task 8: Develop techniques for estimating numbers of pygmy rabbits.

Task 9: Conduct research on viability of pygmy rabbits in the Crab Creek Subbasin, and throughout Washington, Idaho, and Oregon.

Task 10: Determine the amount of habitat needed to support a recovered population.

Task 11: Investigate genetic similarities and differences between pygmy rabbits in Washington and those in Oregon, Idaho, and Montana.

Task 12: Determine whether the genetic diversity of Washington's pygmy rabbit population is sufficient for the species to persist for a long period of time.

Strategy 2: Improve quantity, quality, and configuration of shrubsteppe habitat needed to support a viable population of pygmy rabbits in the Crab Creek Subbasin.

Task 1: Protect the remaining pygmy rabbit population and associated habitats.

Task 2: Take measures to reduce the potential for destructive fires in pygmy rabbit habitat.

Task 3: Reestablish sagebrush immediately after wildfire in areas supporting pygmy rabbits.

Task 4: Support continuation and improvement of CRP throughout the subbasin by conducting the necessary research and by providing both education and resources.

Task 5: Restore additional pygmy rabbit habitat.

Task 6: Increase habitat availability for pygmy rabbits with the aid of acquisitions and easements.

Strategy 3: Improve viability of pygmy rabbit populations in Washington, with the majority in the Crab Creek Subbasin.

Task 1: Augment the remaining pygmy rabbit populations through captive rearing or translocations, or a combination of methods designed to increase or maintain population size while preserving the genetic integrity of Washington's population.

Task 2: Reduce predation where populations are in danger of extirpation.

Burrowing Owl

Burrowing owls are rare raptors of the shrub-steppe and meadow steppe communities. Once a common inhabitant of the Columbia Basin, the current range of burrowing owls has declined significantly. Burrowing owls are no longer found in Okanogan, Spokane, Kittitas, and Lincoln counties, and have declined greatly in Yakima, Douglas, Whitman, and Adams counties. Approximately 200 occupied burrows were found during surveys in 1999 and 2000 (WDFW 2000). Remaining owls are principally found in Grant, western Adams, Franklin and Benton counties. Burrowing owls have colonized some disturbed and developed habitats in a portion of their range, such as golf courses, industrial areas and adjacent to irrigation canals.

Status: Burrowing owls are a candidate species in Washington State, federally endangered in Canada and Mexico, and a federal species of concern.

Limiting Factors: Despite widespread declines of burrowing owls, the reasons for the declines are not well known. Agricultural development has likely adversely affected their habitat, and declines in ground squirrels, pygmy rabbits, and in some areas badgers may contribute to a loss of available burrows for nesting. Winter habitats are not known for Washington's burrowing owls, and potentially could be limiting.

Goal: Halt the decline of burrowing owls, increase distribution of burrowing owls to include many of the historic regions occupied in the Columbia Basin, and maintain a stable population of burrowing owls in Washington.

Objective 1: Determine factors limiting burrowing owl populations in Washington.

Task 1: Investigate burrowing owl habitat selection in native habitats. Determine factors influencing burrow occupancy and burrow fidelity in native habitats.

Task 2: Investigate winter habitat and survival of burrowing owls on winter ranges.

Task 3: Evaluate nesting productivity, natal recruitment, and annual survival in eastern Washington. Compare these parameters between large, stable colonies and more ephemeral sites. Also compare these parameters between native and disturbed habitats used.

Task 4: Monitor year round movements and long-term survival through marking and radio- telemetry. Determine dispersal distances and colonization potential of adjacent areas.

Objective 2: Develop conservation measures to protect burrowing owls.

Task 1: Develop management strategies for continued occupancy and enhancement of both native and disturbed habitats, like irrigation canals, golf courses, and other disturbed habitats.

Task 2: Evaluate the usefulness of artificial burrows in enhancing and re-establishing burrowing owl colonies in both native and disturbed habitats.

Task 3: Determine management strategies for re-establishment, augmentation, and re-colonizing unoccupied habitats.

Ferruginous Hawk

Ferruginous hawks are prominent shrub-steppe raptor throughout Washington state. Statewide, occupancy rates of this species are low. Since 1987, <27% of historic ferruginous hawk territories (n = 222) have been occupied annually. Thirty ferruginous hawk territories are documented within the Crab Creek Subbasin and are primarily distributed along Moses Coulee and Crab Creek. Breeding data in 3 years for which complete surveys were conducted in the basin (1995-97) found <30% annual rate of occupancy. The Crab Creek Subbasin is located in the North Recovery Zone for ferruginous hawks (WDFW 1996).

Status: The ferruginous hawk is a state designated threatened species.

Limiting Factors: Reasons for low occupancy of ferruginous hawk territories in Washington State and in the Crab Creek Subbasin are unknown. Regional declines of ferruginous hawks have been tied to changes in native habitat conditions from such factors as cultivation and grazing, that may be associated with prey declines. Changes in the abundance and distribution of prey associated with shrubsteppe habitats in the Subbasin, particularly blacktail jackrabbits (*Lepus californicus*) and Washington ground squirrels (*Spermophilus washingtoni*), may reduce nesting of ferruginous hawks. Historic information suggests black-tailed jackrabbits were important prey for nesting ferruginous hawks in Washington, but a sampling of 34 nests in 1995 found an absence of jackrabbits and ground squirrels and a predominance of northern pocket gophers in the diet. Due to statewide declines, blacktail jackrabbits are being considered for threatened species listing, and Washington ground squirrels are a Protected Species in the state. Low occupancy of ferruginous hawk nest sites could also result from low survival of adults on winter areas. Recent research suggests the possibility of poisoning from rodenticides used widely in California where Washington ferruginous hawks winter.

Goal: Recover ferruginous hawks from threatened status by maintaining a population of at least 60 nesting pairs statewide, including at least 10 pairs in the North Recovery Zone (WDFW 1996).

> **Objective 1:** Improve our understanding of the suitability and security of ferruginous hawk nesting habitats (see Goal 3.1 and research topics in section 7 of Recovery Plan, WDFW 1996).
>
> > **Task 1:** Investigate ferruginous hawk occupancy and productivity characteristics in relation to jackrabbit and ground squirrel distribution and abundance in shrubsteppe habitats.
> >
> > **Task 2:** Investigate rates of prey delivery, food habits, and adult nest attendance to nestling survival through video monitoring.

Task 3: Evaluate habitat alteration and human activity relationships to ferruginous hawk productivity and occupancy, including the efficacy of existing platform nests erected to enhance nesting.

Objective 2: Assess the importance of survival rates and contaminants of adult and juvenile ferruginous hawks to low rates of nest occupancy, and relate these to hawk movements (see Goal 3.1 and research topics in section 7 of Recovery Plan, WDFW 1996).

Task 1: Capture and take blood samples from adult and juvenile hawks for pesticide analysis.

Task 2: Monitor year round movements and long-term survival through marking and satellite telemetry.

Objective 3: Improve ferruginous hawk nest occupancy by identifying and promoting protection and enhancement (i.e., erect nest platforms) of the highest quality nesting habitats based on assessment of prey, survival, and human activity. Refine recommended spatial and temporal management buffers around nests and provide site specific recommendations for nest protection.

Washington Ground Squirrel

Washington ground squirrels are associated with relatively deep soils within shrubsteppe communities (Dobler et al. 1996, Betts 1990, 1999). Because most deep soil habitats have been converted, Washington ground squirrels have declined. Most remaining populations of ground squirrels are within the Crab Creek Subbasin (Figure 3).

Status: Washington ground squirrels are candidates for both state and federal listing as a threatened or endangered species.

Limiting Factors: Lack of shrubsteppe habitat with relatively deep soil.

Goal: Recover populations of Washington ground squirrels in the Crab Creek Subbasin to the level where populations are viable.

Strategy 1: Determine distribution and abundance of Washington ground squirrels in Crab Creek Subbasin.

Task 1: Monitor all known Washington ground squirrel populations annually.

Task 2: Conduct regular searches for ‘new’ and or additional populations of Washington ground squirrels.

Task 3: Determine habitat characteristics at occupied and unoccupied colonies.

Task 4: Evaluate the effects of habitat management on Washington ground squirrels.

Strategy 2: Develop habitat management strategies for Washington ground squirrels and incorporate specific management objectives into Wildlife Area and landscape plans.

Northern Leopard Frog

Surveys since 1992 indicate that northern leopard frogs may be found in only 2 locations in Washington, both within the Crab Creek Subbasin.
The historic distribution was principally along wetlands of the Columbia River and its tributaries; most of these habitats have been dramatically altered (McAllister et al. 1999).

Status: The northern leopard frog has declined dramatically throughout its historic range resulting in its listing as an endangered species by the state of Washington.

Limiting Factors: Loss of wetland habitat along the Columbia River and its tributaries, competition and predation by non-native fish, introduced bullfrogs (*Rana catesbiana*), and fluctuations in water levels within the CBIP appear to be significant factors in the decline of northern leopard frogs.

Goal: Conserve the remaining populations of northern leopard frogs in Washington and reestablish additional populations.

Strategy 1: Develop needed information on distribution, habitat and relationships with other species, and implement recovery of leopard frogs.

Task 1: Complete surveys and determine specific distribution of northern leopard frogs in Crab Creek Subbasin.

Task 2: Investigate breeding, migratory, and over-wintering habitat relationships of northern leopard frogs.

Task 3: Evaluate range of suitable habitats, juxtaposition of habitats, and appropriate conditions for northern leopard frogs.

Task 4: Determine effects of reservoir inundation on habitat for the Potholes Reservoir population of northern leopard frogs.

Task 5: Determine effects of non-native fish and introduced bullfrogs on northern leopard frogs.

Task 6: Determine effects of wetland restoration projects for waterfowl on northern leopard frogs.

Strategy 2: Plan and implement recovery programs, translocations and re-establishment of leopard frogs throughout the historic range of the species.

Breeding Ducks within the Columbia Basin Irrigation Project

As a byproduct of the Columbia Basin Irrigation Project, extensive wetland and deepwater habitats were created in central Washington (Johnsgard 1956). WDFW's Desert Wildlife Area (DWA) contains about 3,035 hectares of wetlands associated with Frenchman Hills and Winchester wasteways; in the early 1980's these habitats supported breeding densities as high as 77 breeding-duck pairs per km^2. At least 10 species of ducks are known to breed on the DWA, with mallards and redheads being the most numerous.

Status: The breeding waterfowl population on the DWA has declined steadily since the mid 1980's. The numbers have declined form about 25,000 to about 5,000 in the last 16 years. This decline is common to all breeding duck species and may be due to several factors including decline in the quantity and quality of wetland habitats. Shallow wetlands have filled with organic deposits and wind-blown sediments, dense stands of emergent vegetation have replaced open-water habitat, and non-indigenous plants have replaced native species. Carp have also changed or eliminated the submerged-plant community. Recent research indicates that nesting success and brood survival is very low, and populations cannot maintain themselves without annual immigration from other populations (Giudice et al. 2000).

Limiting Factor: Habitat that can support successful nesting and brood-rearing for ducks breeding on the Desert Wildlife Area.

Goal: Recover breeding duck populations within the Desert Wildlife Area to the levels found in the late 1980's (>10,000 breeding ducks).

Strategy 1: Limit populations of nest predators and monitor response by nesting ducks.

Task 1: Eliminate Russian olive stands within 1 mile of wetlands managed for breeding duck species (Russian olives support nest sites and perches for magpies, and provide structure to support raccoon and striped skunk populations).

Task 2: Measure nest success before and after Russian olive removal.

Tasks 3: Remove large debris from the wildlife area that may harbor unwanted nest predators (raccoons and skunks).

Strategy 2: Improve nesting habitat to provide extensive and uniform stands of dense nesting cover.

Task 1: Plant areas where Russian olive has been removed to native grass/legume mixes and evaluate mixes to determine best mix for area.

Task 2: Plant areas with persistent exotic-weed problems to native grass/legume mixes.

Task 3: Remove cattle grazing remove from areas that have significant nesting potential.

Strategy 3: Enhance wetlands to improve the productivity of foods for breeding ducks and ducklings.

Task 1: Remove carp from wetlands managed for breeding waterfowl

Task 2: Manage water-level, where possible, to simulate the natural drought-wet cycle of natural wetlands and enhance productivity of invertebrates and plant foods.

Task 3: Control exotic wetland plants such as purple loosestrife and Eurasian milfoil in favor of more beneficial native plants.

Pheasants and Farmland Wildlife

Much of the native shrub-steppe habitat that once was present within the Crab Creek Subbasin has been converted to agricultural lands. Although it is impossible to reconstruct or replace this vast amount of native vegetation, it is not impossible to enhance these lands for wildlife. Pheasants and other farmland wildlife thrived in response to new federal irrigation projects initiated in eastern Washington over 50 years ago. During the early to mid-1960s, pheasants in particular, provided exceptional hunting opportunities in those areas converted to irrigated farmland. In 1963, the pheasant harvest in Grant County alone was in excess of 134,000 birds. Increases and diversity of other wildlife was also evident due to the changing landscape that provided the necessary habitat for farmland wildlife.

Status: Farmland wildlife (primarily pheasant and California quail) that were abundant during the 1960s and 1970s are now present in much lower densities (WDFW 2000). Significant changes in irrigation and other farming practices

have had a major impact on the ability of irrigated lands within the Columbia Basin Project to support large populations of pheasant and quail. .

Limiting Factors: The decline in farmland wildlife was the result of the reduction in the amount, distribution, and quality of permanent wildlife habitat. Modern agriculture, grazing, and other developments (i.e., residential) have reduced the habitat base to small isolated patches of cover. Pheasant and other farmland wildlife densities are now approaching levels similar to those that existed prior to irrigation development.

Goal: Prevent further declines in populations of pheasant and quail in irrigated portions of the Columbia Basin Project within the Crab Creek Subbasin.

> **Objective:** Increase pheasant productivity brood survey index by 25% over current levels in specific areas within the Columbia Basin Irrigation Project.
>
> > **Task 1:** Continue and complete the ecosystem model acquisition project within the Columbia Basin Irrigation Project (specifically Irrigation Block 43). In addition, purchase other strategically placed properties in other areas where this acquisition process has already occurred. Maintain and manage these sites for increased levels of wildlife throughout the entire localized area.
> >
> > **Task 2:** Continue to create and foster wildlife partnerships with private landowners within the Crab Creek Subbasin. Cooperative agreements for habitat restoration and public access are a key element in providing wildlife benefits and wildlife related public opportunities.
> >
> > **Task 3:** Continue to assist and participate with landowners in the Conservation Reserve Program (CRP). Technical assistance, cost share participation, and habitat restoration efforts by WDFW can provide immense benefits for wildlife during contract periods and beyond.
> >
> > **Task 4:** Continue to foster partnerships with conservation organizations, sporting groups, and the general public. Volunteer time and donated funds have greatly assisted in meeting farmland wildlife restoration goals during the past decade.

Mule Deer

Mule deer are found throughout the Crab Creek Subbasin and are especially abundant in the north and east portions of the subbasin. Most mule deer populations in the subbasin are migratory and may move up to 120 km between

summer and winter ranges. Each year 200-300 deer drown in irrigation canals in the summer or become stranded in the empty canals during winter.

Limiting Factors: Large, concrete lined irrigation canals are barriers to herd movement and hazards for individual deer that either try to swim across the canal or become stranded inside the canals during the winter.

Goal: Reduce or eliminate deer mortality in CBIP canals.

> **Strategy:** Develop technologies to keep deer out of the canals and minimize the canals impact as a barrier to movement within and between home ranges.
>
> > **Task 1:** Construct additional deer escape ramp in the West Canal between Soap Lake and Ephrata (location has already been identified during consultations with Quincy Columbia Basin Irrigation District)
> >
> > **Task 2**: Construct additional deer escape ramp in the East Canal east of Stratford Road and below the second siphon.
> >
> > **Task 3**: Fence the main canal from Billy Clapp Lake to the Soap Lake Siphon.
> >
> > **Task 4**: Develop mechanism to permit deer movement across the main canal between Billy Clapp Lake and the Soap Lake Siphon.

BPA-funded Research, Monitoring, and Evaluation Activities

Adaptive Management

Monitoring is a tool for detecting change and identifying problems. If detected early, problems can be addressed while cost effective solutions are still available. For example, an invasive weed species is much easier to eradicate/control at the initial stages than attempting to eradicate it once established. Monitoring is also critical for measuring management success. Good monitoring can demonstrate that management strategies are working and provide evidence supporting the continuation of management. Conversely, monitoring can also show a need to change current management strategies. Monitoring is a key component of 'adaptive management' in which monitoring measures progress towards, or away from, management goals and objectives. Monitoring provides evidence to continue or change current management strategies (Ringold et al. 1996).

The adaptive management cycle consists of 4 basic steps: 1) resource objectives are developed to describe the desired condition; 2) management is designed to meet the objectives; 3) the response of the resource is monitored to determine if the management objective has been met; and 4) management is adapted (changed)

if objectives are not reached. Note that monitoring provides the link between objectives and adaptive management. Monitoring, as part of the adaptive management cycle, has two primary components. The first is that monitoring is driven by management objectives (what is measured, how it is measured, and how often it is measured). The second component is that monitoring is only initiated if opportunities for management change exist. If no alternative management options are available, expending resources to monitor something is probably futile.

Vegetation monitoring

Habitat evaluation procedures (HEP) should be conducted by WDFW Wildlife Area staff, Vegetation Management Team personnel, and volunteers every five years to monitor general habitat trends. At least two baseline transects should be replicated in each cover type for each area evaluated. Areas should be selected on the basis of differences in cover type, management history, and current management/restoration protocols. Data on shrub and herbaceous cover (Daubenmire 1970), visual obstruction (Robel et al. 1970), and species composition should be systematically collected using standard techniques. HEP surveys should be conducted within the same general time frame and location as the original baseline transects to ensure similar plant phenology. All transects should be documented with standard photographs.

Substantial areas of noxious weeds should be mapped and monitored every two years. Standard and periodic photographs should be taken at each area monitored. Site specific enhancement/maintenance monitoring should be done with similar techniques, but with more flexibility in periodicity (every 1 to 5 years). All techniques should be designed to be rigorous under field conditions, to produce data that is statistically sound when analyzed, and to document results that are potentially useful with regard to future management opportunities.

Wildlife Monitoring

Monitoring should occur annually or on a rotating basis depending on the status of the species. The primary species to be monitored include shrubsteppe obligates and those that are listed as species of concern, candidates, threatened, or endangered (Table 1). The technique used to monitor wildlife should be determined based on the species monitored and the purpose of the research (Table 5). Furthermore, coordination between habitat and wildlife surveys will help ensure valid assessments of wildlife responses to habitat management efforts.

Non BPA-funded Research, Monitoring, and Evaluation Activities

Research and monitoring activities are ongoing for numerous species of wildlife in the Crab Creek Subbasin (Table 5). Despite the relatively thorough list, many of the listed activities are temporary and/or project related. In addition, many of the activities are influenced by annual variations in the availability of personnel and/or budget.

Table 7. Efforts to monitor wildlife and habitat in Crab Creek Subbasin

Surveys and research projects	Agency conducting survey or research
Eastern Washington mule deer study	WDFW, CTCR, Chelan County PUD
Pre-season aerial and/or ground surveys for deer	WDFW
Post-season aerial and/or ground surveys for deer	WDFW
Columbian sharp-tailed grouse lek surveys	WDFW, CTCR
Sage grouse lek surveys	WDFW
Upland game bird brood counts	WDFW
Waterfowl pair and brood counts	WDFW, USFWS
Bald eagle nest surveys	WDFW, Douglas County PUD
Peregrine falcon survey	WDFW, NPS
Columbian sharp-tailed grouse lek surveys	WDFW, CTCR
Ferruginous hawk nest occupancy and productivity surveys	WDFW
Ferruginous hawk ecology study	WDFW
Monthly waterfowl surveys	WDFW, USFWS
Mid-Winter waterfowl survey	WDFW, USFWS
Pygmy rabbit burrow survey	WDFW, WSU, TNC
Pygmy rabbit habitat evaluation	WDFW, WSU
Burrowing owl surveys	WDFW, WSU, BLM, USFWS
Northern leopard frog habitat and movement	CWU
Washington ground squirrel social interaction study	Cornell University
Washington ground squirrel surveys	Eastern Oregon University
Amphibian and reptile surveys	DNR
Bat Surveys	The Nature Conservancy,
Shrubsteppe breeding bird surveys	WDFW
Fragmentation effects on migratory songbirds	WDFW

Statement of Fish and Wildlife Needs

Fisheries

- Obtain baseline information on status of native fish communities.
- Reduce negative impacts of non-native fish on native species of fish and wildlife.
- Minimize negative impacts of Caspian terns of survival of salmonids.

- Enhance instream flows, water quality and habitat conditions to benefit resident salmonids

Wildlife

- Obtain detailed distribution and description of shrubsteppe habitats with reference to dominant plant species, vegetative condition, and habitat potential.

- Continue and/or expand surveys to monitor distribution, abundance, and viability of species of interest including sage grouse, sharp-tailed grouse, pygmy rabbit, Washington ground squirrel, ferruginous hawk, golden eagle, and neotropical migrants.

- Evaluate shrubsteppe habitat characteristics in relation to use by shrubsteppe obligates such as sage grouse, sharp-tailed grouse, pygmy rabbits, Washington ground squirrels, and neotropical migrants.

- Evaluate shrubsteppe restoration activities in relation to wildlife potential; including activities associated with BPA, WDFW, BLM, USFWS, NRCS, and private land.

- Evaluate landscape configuration in relation to population viability for species of interest including sage grouse, sharp-tailed grouse, pygmy rabbits, Washington ground squirrels, and neotropical migrants.

- Expand shrubsteppe quantity with the aid of acquisitions, easements, and landowner incentives such as the Conservation Reserve Program.

- Enhance shrubsteppe in poor quality with implementation and expansion of shrubsteppe restoration activities.

- Enhance and maintain artificial wetlands within the Columbia Basin Irrigation Project to support habitat diversity and wildlife production including breeding ducks and northern leopard frogs.

- Enhance artificial wetlands within the Columbia Basin Irrigation Project to allow for water level management, where possible, to maximize wildlife benefits and better simulate the drought/wet cycle experienced by natural wetlands within the subbasin.

- Control invasive-exotic vegetation throughout the subbasin to improve nesting habitats, food sources, and reduce nest-predator habitat.

- Provide a suitable matrix of breeding, feeding, drinking, and hibernating habitat for bats.

- Improve riparian habitats along Crab Creek and associated tributaries for fish and wildlife; reduce and mitigate impacts from crop production and livestock grazing activities.

- Obtain financial support to continue operation and management of existing government property that is critical for wildlife.

- Integrate Crab Creek Subbasin needs with those of adjacent subbasins.

- Coordinate with multiple agencies, groups, and individuals to achieve goals, objectives, and strategies

Summary

This document represents the efforts of many individuals who in turn represented numerous state, federal, county and private interests in the Crab Creek Subbasin. Together they attempted to bring together, under one cover, a physical description of the subbasin's current and past natural history along with a record of efforts directed at protecting its natural resources. Considering the size of the landscape and the limits of time and personnel, this document should serve as an excellent guide and reference for future natural resource planning efforts within the Crab Creek Subbasin.

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