U.S. Fish & Wildlife Service

Habitat Management Plan

Turnbull National Wildlife Refuge

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Prepared by
U.S. Fish and Wildlife Service
Turnbull NWR
26010 South Smith Road
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Turnbull National Wildlife Refuge
HABITAT MANAGEMENT PLAN APPROVAL
U. S. FISH AND WILDLIFE SERVICE, REGION 1

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I. Introduction

The overall purpose of the habitat management plan is to meet identified resource challenges in order to achieve the established mission and goals of the National Wildlife Refuge System and the refuge. To fulfill this purpose, established refuge goals were reviewed and new habitat based goals were developed that reflect current mission and direction. This plan contains objectives based on meeting refuge goals. Management strategies were developed and actions planned to achieve these objectives.

A. Area/Location

Turnbull National Wildlife Refuge is located on the eastern edge of the Columbia Basin in Spokane County in northeastern Washington (Figure 1). Cheney the nearest town with a population of 10,000 is located only two miles north of the refuge. Spokane a major metropolitan area of nearly 500,000 people is 25 miles northeast of the refuge. Spokane County is growing at a rate of 10% per year and becoming increasingly urbanized.

B. Climate

The climate is semi-arid with an average annual precipitation of 16.5 inches. The majority of precipitation falls as snow from November to February with a yearly average of 50 inches. Above average snow-years occur 3 out of every ten years. Drought periods are common. Summers are warm and dry with average daily highs above 80 degrees F. Winter months are cool with mean daily temperatures between 25 and 30 degrees F.

C. Environment

Located on the eastern edge of the Columbia Basin, the refuge is situated in an area referred to as the 'Channeled Scablands'. The channeled scablands were formed approximately 15,000 years ago when several ice age floods scoured away the loess soils of the Palouse in large tracts exposing the underlying basalt. Numerous channels and depressions were eroded in the basalt. These channels and depressions later became a diverse complex of lakes, sloughs and ponds. Around many of these wetlands developed aspen, water birch, alder and hawthorne riparian communities. The upland areas with its mixture of exposed rock, soil mounds

Figure 1. Vicinity Map

and depressions containing deeper soils now support a mosaic of steppe and forested plant associations. The shallow rocky soils of the flood channels provided an avenue for a narrow extension of the ponderosa pine zone of the north into the steppe habitats of the Columbia Basin. The 7,000 acres of refuge pine forest represents a significant percentage of the ponderosa pine zone in the state of Washington that is managed strictly for bio-diversity (Grue et al. 1995). The small portion of meadow steppe habitat (1,000 acres) on the refuge represents half of the remaining intact and protected Palouse prairie in the state. Eighty-eight percent of this ecosystem has been converted to agriculture and much of the remainder is grazed by livestock. The 3,200 acres of wetlands represents one of the last remaining complexes of scabland wetlands. On most of the private lands surrounding the refuge, all but the small pothole wetlands have been drained and converted to hay and pasture.

D. History

Since settlers of European descent first came to the refuge in the 1870's, the landscape has been altered. Timber was harvested, livestock grazed native plant communities, wetlands were drained and farmed, exotic species were introduced both intentionally and accidentally, and natural disturbance regimes were interrupted and altered. Fire a key natural disturbance was for the most part suppressed. The quantity, distribution and quality of various plant communities that existed prior to settlement of the region have been significantly altered. These changes have invariably affected the structure of the wildlife community associated with this landscape.

Since refuge establishment in 1937 by Executive Order No. 7681 of President Franklin D. Roosevelt, the primary focus of habitat management has been waterfowl, and in recent years it has been directed more specifically at managing for redheads. Early management focused on restoring refuge wetlands that had been drained and the production of grain crops for migratory waterfowl. In later years, management moved from restoration to enhancement, the goal always being to produce or maintain as many waterfowl as possible. Enhancement involved creating additional semi-permanent wetland habitat for breeding diving ducks, especially redheads, and the creation of numerous nesting islands for upland nesting ducks. Habitat manipulation for redheads involved deepening seasonal and temporary marshes and increasing the interspersion of open water to emergent vegetation with heavy equipment. Management of other refuge habitats included timber harvest, grazing, and prescribed burning. Timber harvest was suspended in 1976 and grazing was discontinued in 1994. The refuge continues to use prescribed burning and has begun some small scale non-commercial thinning.

E. Mission and Direction

The management direction for the refuge is provided for in legislation that identifies the mission of the National Wildlife Refuge System and the enabling legislation that sets forth the purpose for establishment of each individual refuge. Further guidance is provided in the Refuge Manual. These sources have been used to develop refuge specific goals for wildlife and habitat.

> The mission of the National Wildlife Refuge System is "to administer a national network of lands and waters for the conservation, management and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Improvement Act of 1997, P.L. 105-57).
>
> Turnbull National Wildlife Refuge was established by President Franklin Roosevelt on July 30, 1937 by Executive Order 7681. He stated that the purpose of the refuge shall be "... as a refuge and breeding ground for migratory birds and other wildlife." Further definition of the refuge purpose is provided by other authorities as follows:
>
> > "...for use as an inviolate sanctuary, or for any other management purpose for migratory birds." 16 U.S.C. & 715d (Migratory Bird Conservation Act)
> >
> > "...suitable for - (1) incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species..." 16 U.S.C. &460k-1 (Refuge Recreation Act).
>
> The Refuge Manual (USFWS 1982) provides policies and guidelines for managing National Wildlife Refuges and lists the specific goals for refuges (2 RM 1.4 A-D).
>
> a) To preserve, restore and enhance in their natural ecosystem (when practicable) all species of animals and plants that are endangered, or threatened with becoming

endangered.

b) To perpetuate the migratory bird resource

c) To preserve a natural diversity and abundance of fauna and flora on refuge lands.

d) To provide an understanding and appreciation of fish and wildlife ecology and man's role in his environment, and to provide refuge visitors with high quality, safe, wholesome, and enjoyable recreational experiences oriented toward wildlife to the extent these activities are compatible for the purposes for which the refuge was established.

A determination of compatibility is a statutory requirement that must be met before any activity will be permitted on a National Wildlife Refuge. A compatible use is defined by the Refuge System Improvement Act of 1997 as " ...one which, in the sound professional judgement of the Refuge Manager, will not materially interfere with or detract from fulfillment of the Refuge System Mission or refuge purpose(s).” Permitted activities such as public use, haying and grazing, timber harvest must meet this compatibility standard.

Historically, the primary focus of habitat management at Turnbull NWR has been waterfowl, and in recent years it has been directed more specifically at managing for redhead ducks. Although managing for wildlife diversity is implicit in the refuge purpose and has been a stated goal on the refuge for much of the past 20 years, establishing specific objectives has not received adequate attention. Traditional migratory waterfowl programs continued to drive refuge management. This single species focus to management is, however, changing. Conservation of biological diversity is becoming increasingly critical as members of the native faunal community decline and disappear as the ecosystems upon which they depend are dramatically altered through management actions and both agricultural and urban development. The U. S. Fish and Wildlife Service is formulating new policies governing the role of refuges in conserving biodiversity. Adopting a comprehensive ecosystems approach to management is at the core of this new policy.

Although migratory birds and other federal trust resources will continue to be a management priority at Turnbull, conserving biodiversity has been elevated to a primary refuge goal. Habitat management planning will address not only the needs of waterfowl, but all the plant and animal species that define the 'channeled scablands' ecosystem.

Utilizing our prior guidance and policy and new policy that emphasizes ecosystem management and the conservation of native biodiversity, the following refuge mission statement and goals have been established to guide habitat management.

Turnbull National Wildlife Refuge Mission

Restore and maintain ecosystem processes that provide for a natural diversity of flora and fauna native to the wetland, steppe and ponderosa pine communities of Eastern Washington.

Habitat specific refuge goals;

1) Provide habitat conditions essential to the conservation of migratory birds and other wildlife within a variety of wetland complexes.

2) Protect and restore water quality and quantity sufficient to maintain native wetland flora and fauna.

3) Restore refuge forest to a natural distribution of stand structural and successional stages to benefit forest dependent wildlife.

4) Protect and restore the natural distribution and diversity of grassland and shrub steppe habitats to benefit wildlife.

5) Support the conservation of threatened and endangered species in their natural ecosystems

6) Support the maintenance of biologically effective landscape linkages and corridors between the refuge and other intact areas of the vegetation zones representative of this ecoregion.

II. Resource problems and challenges

Over the past several years inventories of both refuge and regional wildlife habitats and populations have made it possible to identify challenges to meeting refuge goals. These challenges occur both on the refuge and at a larger regional scale.

A. Regional Scale

Turnbull NWR is an ecotonal area on the edge of both the northeastern Washington and Columbia Basin ecoregions of Washington State. A recent state-wide analysis of the role of national wildlife refuges in the conservation of biodiversity highlighted the importance of the portions of the Ponderosa Pine Zone and the Palouse Zone that occur on Turnbull NWR (Grue et al. 1995). Both zones are poorly represented in areas where the primary mission is the conservation of biodiversity. Only 10.6% of the Palouse zone remains unplowed or undeveloped. The 1000 acres on the refuge represents the majority of the 1200 protected acres of this zone. Only 2.1% of Ponderosa Pine zone in the Northeast Region of the state is protected and managed for biodiversity. The refuge occurs on a narrow extension of this zone into the Columbia Basin. This peninsula of ponderosa pine forest surrounded by intensively developed agricultural land is in danger of being isolated from the rest of the forested zones to the north by urban development around Spokane and along the Interstate 90 corridor. Further isolation has resulted from forest practices on private lands surrounding the refuge. Past and current timber management activities on these lands have created either suppressed stands of ponderosa pine vulnerable to catastrophic fire or relatively young even aged stands of trees with little structural diversity.

The refuge is located within the Pacific Flyway and provides important habitat for migrating and breeding waterfowl and other waterbirds. Although once a major migration corridor for waterfowl prior to the Coulee Dam Project and agricultural development in the Columbia River Basin, much of the fall and spring migration now takes place to the west of the refuge in the lower Columbia Basin. Refuge wetlands, however, continue to be a valuable breeding area for waterfowl and other migratory waterbirds in the flyway. Refuge wetlands represent one of the last remaining complexes of permanent, semi-permanent and seasonal wetlands in northeastern Washington. Increasing rural and urban development adjacent to the refuge has the potential to affect the quantity and quality of both groundwater and surface run-off that reaches the refuge.

Significant non-point sources of nitrogen and phosphorus are entering the refuge from private lands north and east of the refuge (Whalen et al 1992). Nutrient enrichment has occurred in several wetlands resulting in eutrophication and algal blooms. Algal blooms caused severe oxygen debt and the death of fish and invertebrate species. Dense algal mats in late summer restrict access of young waterfowl to invertebrate and plant food resources.

B. On Refuge Challenges

1. Water quantity

Although natural drought cycles have resulted in regular deficits in the past, recent droughts have been more severe than precipitation inputs indicated. As previously mentioned, increased usage of the water table for domestic and agricultural purposes may already be having a negative impact on the hydrology of refuge wetlands. Refuge actions and conditions that may have exacerbated drought conditions include past extensive management drawdowns creating artificial deficits, decreasing water yield from increased forest cover in refuge watersheds, and greater evapotranspiration due to the encroachment of reed canarygrass into wetland basins.

2. Ponderosa Pine Forest

a. Tree Density and Age Structure

Past logging, grazing and suppression of fire has created pine stands with tree densities 2 to 4 times the pre-settlement condition. Large trees greater than 24 inches (60 cm) in diameter constitute less than 10% of the stands. Large portions of the refuge ponderosa pine forest have a similar age and size structure. The forest understory is dominated by decadent snowberry and a dense layer of organic debris that suppresses the growth of native bunchgrasses and forbs. Fuel loading in refuge pine stands is 5 times greater than the average for this forest type. Gone is the open park-like savanna of large ponderosa pine trees with an understory of bunchgrasses and forbs typical of this forest type. Conditions are ripe for catastrophic loss due to insects, disease, and fire.

b. Snags

The average density of snags in refuge forest stands is less than 1 per acre. Optimum conditions for cavity nesting birds require on the average 3 suitable snags per acre greater than 15 inches (38 centimeters)in diameter. Past logging and suppression of fire has resulted in the loss of mature and old growth stands that produce large diameter snags that persist over long periods of time. Existing stands are overstocked with pole and sapling sized pines that suppress tree growth and root development. Most snags are less than 15 inches (38 centimeters) in diameter and are extremely susceptible to blow down.

3. Aspen/Deciduous shrub Riparian Zones.

These habitat types have been significantly reduced on the refuge by competition from encroaching ponderosa pine and the suppression of aspen and shrub regeneration by past grazing. Aerial coverage of aspen and deciduous shrub dominated plant communities has been reduced by 65%. Existing stands are dominated by overmature trees with little regeneration. In the past, periodic fire removed encroaching pines and encouraged regeneration of aspen and understory shrubs.

4. Wet meadows and seasonal wetlands.

Wet meadows have been invaded by reed canarygrass (*Phalaris arundinacea*), an exotic perennial grass which out competes nearly all native plant species. Gone are the diverse seasonal wetland habitats dominated by native sedges, rushes, and grasses. Water howellia, a federally threatened aquatic plant species restricted to seasonal wetlands, is at risk of being displaced by reed canarygrass.

From 1968 to 1985, nearly 300 acres of vernal and seasonal wetland habitat has been impacted through the creation of over 700 nesting islands. These islands were created from spoil pushed up in the seasonalor vernal portion of several large sloughs and smaller potholes. Built too close to shore and each other and in water too shallow to prevent access by predators, these islands have not been used successfully by nesting waterfowl.

5. Steppe and grassland habitats

Exotic species such as cheatgrass brome (*Bromus tectorum*), Canada thistle (*Cirsium arvense*), dalmatian toadflax (*Linaria dalmatica*), St. Johns wort (*Hypericum perfoliatum*), spotted and diffuse knapweed (*Centaurea diffusa* and *C. maculosa*), and leafy spurge (*Euphorbia esula*) are present in refuge steppe communities. The latter three species are limited in distribution on the refuge through integrated pest management. The potential exists for expansion without continued management effort. Cheatgrass is dominant in many areas of the refuge displacing native perennial grass communities. Ponderosa pines have encroached on nearly 1000 acres of steppe habitats adjacent to established pine stands. Conversion of steppe habitats to a pine savanna is primarily the result of fire suppression.

III. Meeting the Challenge

In order to assure that the native faunal diversity of the refuge is restored and maintained, a guild management approach was used to develop habitat objectives and management strategies to meet these objectives. Individual wildlife species have been grouped into guilds based on the primary resources utilized for either reproduction or foraging. Breeding and foraging resources are defined as habitat strata. There are 10 major strata that a species can use for either foraging or breeding (Table 1 and Figure 2). Guild assignments are made based on the primary strata a species utilizes within a plant community.

Table 1. Breeding and foraging strata for Guild assignments

Strata	
WC	Water column
WS	Water surface
EM	Emergent vegetation
SS	Terrestrial sub-surface
SB	Terrestrial bare surface
SC	Terrestrial covered surface
SH	Shrub
TB	Tree bole/Snag
TC	Tree canopy
CC	Cave/Crevice(only breeding strata)
AF	Aerial (only foraging strata)

Habitat structure is the most susceptible to change due to management or natural forces. Guilds based on the use of strata provided a means whereby current vegetative conditions could be evaluated and habitat management strategies developed. This assures that the diversity and distribution of strata is available to support the variety of guilds that occurred in the region under natural conditions (Short and Burnham 1982).

Certain species of high management priority due to either legislative mandate, their significance to conserving biodiversity, the critical status of their populations, or the fact that their habitat requirements represent a subset of the membership of their respective guild are used as key management species. Although the needs of all species in a guild are considered, these indicator or key management species provided the focus for developing management guidelines and monitoring plans. Special management status was conferred on all federal trust species including migratory waterfowl and waterbirds, neotropical migratory landbirds, and threatened and endangered

Figure 2

species. The significance of a species to the conservation of biodiversity has been determined by ranking the importance of the 'channeled scablands' area to the conservation of each species thereby focusing on more endemic species. Other population status indicators taken into consideration in the selection of indicator or key management species include nationally and regionally designated sensitive species, the management and monitoring priorities established for neotropical migratory birds by Partners in Flight in Washington State (Andelman et al 1994), and state threatened and endangered species designations.

Habitat requirements of individual species in a guild, the factors that potentially limit maintenance of the guild, and habitat requirements of individual key species have been summarized by ten major breeding guilds for those species that reproduce on the refuge. The indicator or key management species for each breeding guild and the criteria for selecting them is provided in Table 2. Explanation of criteria codes is provided in Appendix A. Appendix B. provides a complete listing of each breeding guild. The use of foraging strata by breeding species are discussed in relationship to breeding strata. The needs and management guidelines of species that primarily utilize the area during migration are summarized by individual foraging guilds. A complete listing of each foraging guild can be found in Appendix C. Full narrative description of each guild is provided in a separate Guild Management Guidelines Document (unattached Appendix). The management guidelines for each guild is provided in Appendix D.

Although management for all wildlife guilds will more than likely provide habitat for the diversity of native flora, specific management guidelines and strategies have also been incorporated into this plan for the federal threatened plant species, water howellia. Guidelines for the management of water howellia are also provided in Appendix D.

Table 2. Key indicator species by breeding guild (Column descriptions at end of table)

Species name	CLASS	FGUILD	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
Breeding Guild: CC Cave/crevice breeder											
Yuma myotis	MAMMAL	AF	B	4				NO		3	4.
long-eared myotis	MAMMAL	AF	B	3				SM		3	4.
Breeding Guild: EM Emergent Breeder											
Virginia rail	AVES	EM	B	2	A			TR		4	4
yellow-headed blackbird	AVES	EM	B	3		12	1	TR	5	5	4
redhead	AVES	WC	B	4	B			TR,SS		5	5
muskrat	MAMMAL	EM	B	2				NO		5	5
Breeding Guild: SB Bare surface breeder											
common nighthawk	AVES	A	B	2	A	5.25	1	TR	0	0	4
spotted sandpiper	AVES	SB	B	2	A			TR		5	4
Breeding Guild: SC Covered surface breeder											
mallard	AVES	WC	B	2	B			TR,S		3	3
gadwall	AVES	WS	B	2	B			TR		3	3
cinnamon teal	AVES	WC	B	3	B			TR		4	4
grasshopper sparrow	AVES	SC	B	2	A	11	1	SM,TR	3	5	5
sharp-tailed grouse	AVES	SC	P	4				FC2,SC	5	4	4
Townsend's solitaire	AVES	AF	B	3	A	5	1	TR	0	2	3
vesper sparrow	AVES	SC	B	2	A	10	0	SM	3	4	4
vagrant shrew	MAMMAL	SC	B	4				NO		3	4

rubber boa	REPTILIA	SC	B	4				NO		3	3

Table 2. Continued

Species name	CLASS	FGUILD	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
Breeding Guild: SH Shrub breeder											
yellow warbler	AVES	SH	B	2	A	11	5	TR,SS	3	5	4
willow flycatcher	AVES	AF	B	2	A	8.	0	TR,SS	3	5	5
MacGillivray's warbler	AVES	SH	P	4	A	9	1	TR	3	3	5
black-chinned hummingbird	AVES	SH	B	3	B	9	1	TR	3	3	2
Breeding Guild: SS Sub-surface breeder											
Columbian ground squirrel	MAMMAL	SS	B	4				NO		4	4
yellow pine chipmunk	MAMMAL	TC	B	5				NO		5	3
badger	MAMMAL	SS	B	2				NO		3	4
montane vole	MAMMAL	SC	B	2				NO		1	4
northern pocket gopher	MAMMAL	SS	B	3				N0		3	4
Breeding Guild: TB Tree bole breeder											
red-napped sapsucker	AVES	TB	B	4	A	7	0	TR	0	4	4
Lewis' woodpecker	AVES	AF	P	4	B	9	1	SC,SS	1	4	3
western bluebird	AVES	SC	B	4	C	6.6	1	SC,SS	0	4	3
pygmy nuthatch	AVES	TB	B	5	C			NO		5	3
northern flicker	AVES	TB	B	3	C	5	1	NO	0	3	4
California myotis	MAMMAL	AF	B	3.				NO		4	2
big brown bat	MAMMAL	AF	B	2				NO		2	3
Breeding Guild: TC Tree canopy breeder											
western wood-pewee	AVES	AF	B	4	A	5	0	TR	0	2	4

black-headed grosbeak	AVES	SH	B	3	A	8	1	TR	1	4	2

Table 2. Continued

Species name	CLASS	FGUILD	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
chipping sparrow	AVES	SC	B	1	A	9	5	TR	0	2	3
red-tailed hawk	AVES	SC	B	2	B			TR	0	3	3
red crossbill	AVES	TC	B	4	C			NO		5	5
Breeding Guild: WC Water column breeder											
Columbian spotted frog	AMPHIBIA	WS	B	4				FC2,SC	5	5	
blotched tiger salamander	AMPHIBIA	SS	B	3				SM		3	4
Breeding Guild: WS Water surface breeder											
eared grebe	AVES	WC	B	3	A			T		5	5
black tern	AVES	W	B	3				FC2,SM	5	5	5

Field Descriptions

FGUILD = Foraging Guild BREED = Breeding status on refuge IA = Importance of area

NTMB = Neotropical migratory bird status PIF = WA State Partners in Flight management index ED = Evidence of decline in WA State

Status = Legal Status SHS = Statewide habitat specialization RHS = Refuge habitat specialization

RSS = Refuge vegegation strata specialization

Explanation of codes found in Appendix A.

A. Habitat Objectives

In order to achieve refuge goals and resolve resource challenges, both qualitative and quantitative objectives were established that address the habitat needs of breeding and foraging guilds as well as maintaining the integrity of the refuge in its ecoregional setting. Habitat objectives for guilds are more quantitative and were set to restore and maintain specific habitat elements using guild management guidelines. Recognizing that these guidelines represent optimum conditions, refuge objectives were tempered by the natural capacity of the refuge to provide these elements. The overriding theme in the objective setting process is the restoration and maintenance of ecological processes that produce a natural diversity and distribution of habitats. These ecological processes are dynamic resulting in variations in the abundance and distribution of habitat strata both spatially and temporally. Because of this variability, objectives generally cover a range of values. Objectives for achieving goals necessary to maintain the ecological integrity of the refuge in the larger landscape are mostly qualitative and deal with minimizing the effect of off-refuge activities on refuge resources.

Goal#1. Provide habitat conditions essential to the conservation of migratory birds and other wildlife within a variety of wetland complexes.

Objective 1A. Manage the 22 refuge wetlands with water control capability at a level that maintains between 500 and 750 acres of permanent open water annually to support the water surface breeding guild.

Objective 1B. Establish an annual operating level for the 22 managed wetlands that maintains an emergent plant strata that covers between 10% and 30% of the wetland basin to support the emergent stratum breeding and foraging guilds. Fifty percent of this zone should have a width of greater than 100 feet.

Objective 1C. Manage water annually to maintain water depths of at least 18 inches in the emergent plant zone of managed wetlands from April 1 through July 30 for nesting birds in the emergent strata breeding guild.

Objective 1D. By 2007, restore the natural hydrology of 250 acres of managed wetlands that occur in isolated watersheds and are not downstream from off refuge water sources.

Objective 1E. By 2017, restore the natural basin topography and historic wetland function of 29 wetlands that have been manipulated in the past to create deeper wetland habitat and waterfowl nesting islands.

Objective 1F. By 2000, develop and apply on an experimental basis management strategies to restore and maintain native plant communities of seasonal wetlands and wet meadows dominated by reed canarygrass.

Goal#2. Protect and restore water quality and quantity sufficient to maintain native wetland flora and fauna.

Objective 2A. By 1999, review the status of current adjudicated water rights and all claims for water rights and update to coincide with current water management objectives.

Objective 2B. Annually monitor wetland recharge and water losses for the 22 managed wetlands to quantify water usage and the status of local groundwater resources.

Objective 2C. Restore and maintain the natural water yield of refuge watersheds through restoration of open forest conditions and riparian habitats within the annual forest treatment areas.

Objective 2D. By 2000, identify properties adjacent to the refuge that contain large portions of the four major drainage systems that enter the refuge and their watersheds, and coordinate with federal, state, and local agencies to identify and reduce non-point sources of pollution and to protect water quantity.

Goal #3. Restore refuge forest to a natural distribution of stand structural and successional stages to benefit forest dependent wildlife.

Objective 3A. Restore and manage refuge ponderosa pine forest through the annual treatment of a minimum of 400 acres to improve forest health, restore diverse native understory plant communities and maintain natural tree densities and distribution and diversity of stand conditions necessary to sustain native forest-dependent wildlife(Figure 3 and Figure 4).

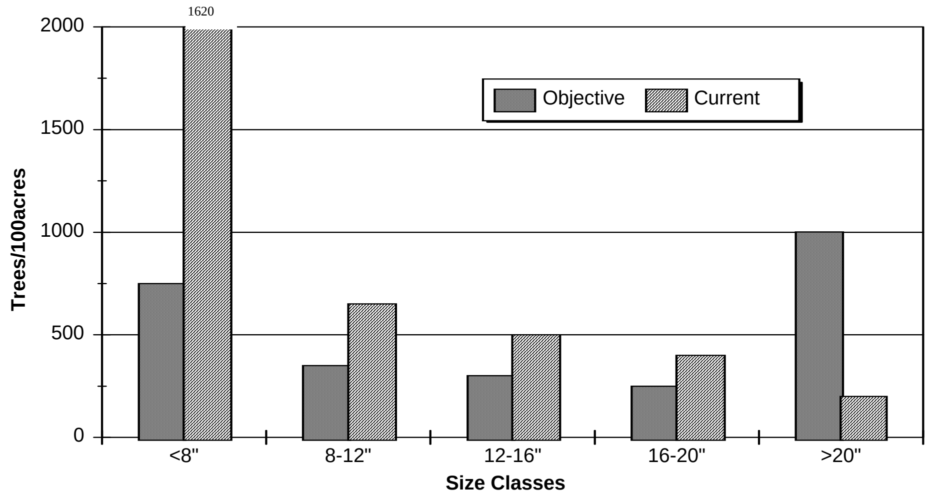

Figure 3 . Comparison of objective and current mean tree densities by size class.

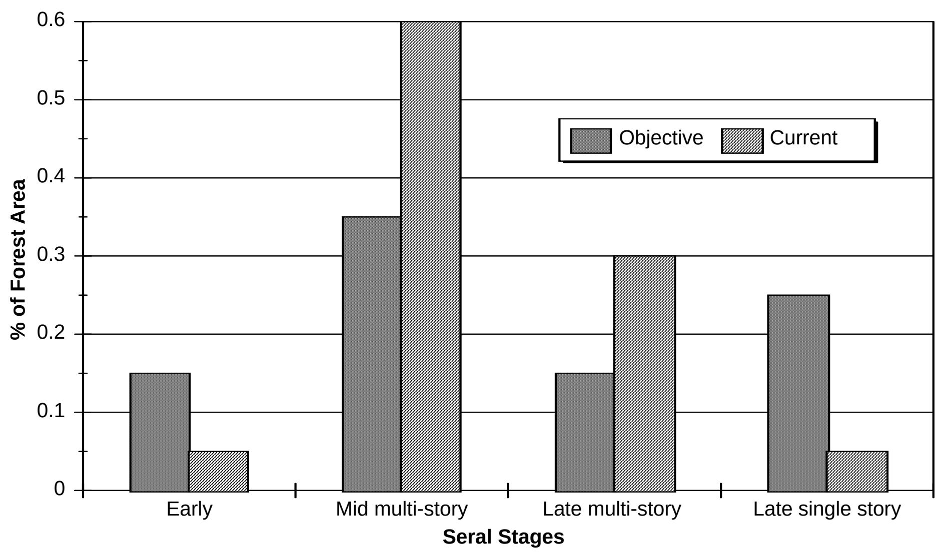

Figure 4. Comparison of objective and current distribution of forest seral stages.

Objective 3B. During annual forest treatments, provide conditions in refuge ponderosa pine and aspen stands that result in recruitment of the density and distribution of snags necessary to sustain 40% of the maximum potential breeding populations of cavity excavating wildlife species (Table 3).

Table 3. Objective and current snag densities (snags/100acres) in ponderosa pine and aspen stands of Turnbull National Wildlife Refuge.

	Ponderosa Pine		Aspen	
Size Class	Objective	Current	Objective	Current
> 12 inches	309	74	144	1862

Objective 3C. Within annual forest treatment units, restore the natural diversity of stand conditions and the dominance of aspen and native deciduous shrub species in riparian habitat now dominated by Ponderosa Pine to increase the number and size of habitat patches to support members of the tree canopy and shrub strata breeding and foraging guilds.

Objective 3D. Annual forest management activities will provide at least 4 downed trees per acre, 15 to 17 inches in diameter at the large end and 20 feet or more in length to support the members of the terrestrial covered surface breeding guild requiring this habitat feature.

Goal # 4. Protect and restore the natural distribution and diversity of grassland and shrub steppe habitats to benefit indigenous wildlife.

Objective 4A. Annually, maintain at least 75% of grassland and steppe habitats as nesting cover for resident and migratory birds as indicated by at least 50% ground cover of litter and a visual obstruction measurement greater than 8 inches taken prior to any spring growth.

Objective 4B. Restore and maintain the open grassland aspect to at least 50 acres of steppe habitat annually through removal of encroaching ponderosa pine trees.

Objective 4C. Control exotic plant species on between 25 and 50 acres of upland grassland and steppe habitats annually and by 1999 initiate an experimental program to investigate strategies to reduce the dominance of cheatgrass and restore native plant communities.

Objective 4D. By 2000, identify areas of intact native upland grasslands and meadow steppe habitat adjacent to the refuge and through cooperation and coordination with private landowners, local, state and federal agencies, and private organizations maintain these lands as native plant communities.

Goal #5. Maintain the biodiversity of the refuge through support of the conservation of threatened and endangered species in their natural ecosystems

Objective 5A. By 1999, conduct research and monitoring to answer critical questions about habitat requirements and species biology in order to design sound management plans for restoring and maintaining natural occurrences of water howellia.

Objective 5B. Assure that annual management activities adjacent to known occurrences of water howellia do no create habitat conditions that fall outside the range of suitability for this species and may jeopardize its continued existence.

Objective 5C. By 2000, identify and apply on an experimental basis management strategies that may reduce the impact of reed canarygrass on the survival of water howellia.

Objective 5D. By 2001, form partnerships with local, state, and federal agencies, and private organizations and individuals to develop and initiate an educational program concerning conservation of water howellia on private land.

Objective 5E. By 2001, explore options to protect additional water howellia habitat off refuge.

Goal #6. Support the maintenance of biologically effective landscape linkages and corridors between the refuge and other intact areas of vegetation zones representative of this ecoregion.

Objective 6A. On a continuing basis, provide input into growth management planning of the counties and local municipalities surrounding the refuge to assure the maintenance of lands with natural vegetative cover between the refuge and other large intact natural areas.

Objective 6B. Through coordination and cooperation with private landowners, local, state, and federal agencies, and private organizations identify opportunities to maintain the native land cover on properties within undeveloped areas contiguous with the refuge that support the goal of maintaining landscape linkages and corridors.

B. Habitat Management Strategies

Strategies used to restore, protect and enhance habitat to meet refuge goals and objectives fall into two basic categories, manipulative and administrative. Manipulative strategies involve the use of tools that physically alter habitats. Manipulative strategies that have been employed by the refuge either singly or in combination include fire suppression, prescribed burning, commercial timber harvest, non-commercial thinning, grazing, haying, farming, biological and chemical noxious plant control, earth moving, water management and use of artificial nest structures. Administrative strategies are primarily protective and include establishing regulations that restrict activities that alter the suitability of habitat, water rights applications and adjudication, landowner incentives programs, fee title acquisition of important habitats, and conservation easements that prevent development of wildlife habitat. In addition, refuge staff has worked with federal, state and local government agencies to assure land use planning takes into consideration the refuge and important regional wildlife habitats.

The following is a brief description of the management strategies developed to achieve refuge objectives. A discussion of each of the major land cover types on the refuge, their pre-settlement condition, past and present alterations and potential management strategies is provided in Appendix E.

1. Water management

The 22 wetlands that will have water control structures will be managed to achieve objectives for wetland strata(Table 4). Until contour maps can be developed for each of the managed wetlands, peak water levels will be based on existing operating levels (Table 5). Operating levels of buffer wetlands will be set, where possible, at 6 inches below the top of the control structure. Water levels in all managed wetlands should be stabilized by April 1. Interim adjustments to operating levels will be made if monitoring indicates that objectives for wetland strata are not being met. Contour maps of the 22 managed wetland basins will be developed through contract surveying or by refuge staff using a geographic positioning system and measurement of water depths relative to the water control structure. Because the bottom of the control structure is often higher than the lowest point in the basin, a piezometer well is required near the structure of each managed wetland to measure the level of the water table and water use to support existing water rights and claims. Piezometer wells are currently in place at Kepple Lake, Upper Turnbull, Lower Turnbull and Long Lake. The topography of these four wetlands will be surveyed and mapped first. Eighteen more piezometer wells will be placed at the remaining managed wetlands.

2. Restoration of natural hydrology

There are 29 wetland basins that have been manipulated through ditching, excavation of emergent plant beds and/or construction of nesting islands(Table 6 and Figure 5). Primary restoration activities will involve the removal of the 427 islands and berms that do not meet minimum requirements (see terrestrial covered surface guild guidelines, Appendix D) for secure nesting islands. The material from both islands and berms will be pushed back into the borrow areas and recontoured to the original slope of the wetland basin. Because of the large quantity of work, only 3 small wetlands or a single large managed wetland will be restored per year. To avoid creating artificial recharge deficits, large, managed wetlands should not be drawn down to gain access for restoration work . The larger permanent wetlands may not be accessible until a year or two of below average recharge. The shallower more seasonal wetlands can generally be accessed during the late summer and fall of most years. All manipulated wetlands will be surveyed for the presence of water howellia prior to treatment. If howellia is located, this area of the wetland will

Table 4. Size and objective ranges (acres) for emergent and open water strata in managed wetlands.

KaegleDitch/Kepple System		Objective Range (acres)			
		Emergents		Open Water	
Wetland Name	Size (acres)	Low	High	Low	High
Reeves Lake	158	40.2	71.8	36.2	67.8
Kepple Lake	115	16.5	39.5	37.5	60.5
Upper Blackhorse	30	4.0	10.0	5.0	11.0
Blackhorse	28	5.2	10.8	13.2	18.8
Swan Pond	12	2.8	5.2	1.8	4.2
Subtotal	343	68.7	137.3	93.7	162.3
Phillips Ditch/Pine Creek System					
Windmill Pond	3	0.0	0.3	1.7	2.3
Headquarters Pond	7	0.3	1.7	0.3	1.7
Ice Pond	2	0.5	1.3	0.5	0.8
Winslow Pond	13	0.7	3.3	4.7	7.3
Middle Pine Lake	16	0.0	1.6	11.4	14.6
Lower Pine Lake	81	1.9	18.1	43.9	60.1
Subtotal	122	3.4	26.3	62.5	86.8
Philleo Ditch System					
Stubblefield Lake	49	0.1	9.9	0.0	0.0
LongLake/Turnbull Slough System					
Helm's Marsh	80	12.0	28.0	2.0	18.0
Long Lake	229	53.1	98.9	72.1	117.9
Cossalman Lake	49	11.1	20.9	20.1	29.9
West Tritt	139	36.1	63.9	27.1	54.9
East Tritt	18	6.2	9.8	4.2	7.8
Upper Turnbull	285	26.5	83.5	159.5	216.5

Lower Turnbull	332	49.8	116.2	80.8	147.2
Campbell/Lasher Lake	91	17.9	36.1	6.9	25.1
Ballinger 1					
Ballinger 2		see Ballinger 4 for total			
Ballinger 3					
Ballinger 4	59	7.1	18.9	0.0	7.9
Subtotal	1282	219.8	476.2	372.7	625.2
Total	1845	292.1	659.6	528.9	874.3

Table 5. Interim water levels for water control structures at managed wetlands.

Kaegle Ditch/Kepple Lake

Wetland Name	Water Level
Reeves Lake	4.7
Kepple Lake	5.8
Upper Blackhorse	4.6
East Blackhorse	8.5
West Blackhorse	4.8
Swan Pond	7

Phillips Ditch/Pine Creek

Windmill Pond	7.5
Headquarters Pond	3.5
Ice Pond	7.5
Winslow Pond	4.7
Middle Pine Lake	4
Lower Pine Lake	6.5

Long Lake/Turnbull Slough

Helm's Marsh	
Long Lake	9.5
Cossalman Lake	4.8
West Tritt	5.8
East Tritt	4
Upper Turnbull	6.8
Lower Turnbull	5.2
Campbell/Lasher Lake	3.7
Ballinger 1	7.5
Ballinger 2	4.5
Ballinger 3	5.5
Ballinger 4	4

Table 6. The number, average size, and total acres of artificial islands and berms per wetland that need to be removed.

		Islands			Berms		
Wetland name	Wet ID #	No.	Ave. size	Total acres	No.	Ave. size	Total acres
Lower Turnbull	95	75	0.07	5.11	4	0.27	1.07
Reeves Lake	25	68	0.08	5.62	23	0.19	4.31
Ballinger	107	43	0.12	5.26	16	0.4	6.44
East Tritt	71	29	0.02	0.68	0	0	0
	69	26	0.1	2.55	8	0.15	1.21
Hale Meadow	97	20	0.21	4.17	1	0.49	0.49
Hale Lake	99	20	0.1	2	2	0.08	0.16
Upper Turnbull	64	18	0.06	1.08	2	0.33	0.66
	94	18	0.02	0.3	0	0	0
	82	13	0.14	1.91	3	0.1	0.29
Palmer Meadow	99a	13	0.08	1.07	1	0.66	0.66
	68	11	0.08	0.86	3	0.05	0.15
Wheeler Pond	35	11	0.11	1.17	2	0.28	0.55
Schafer Meadow	101a	8	0.08	0.69	0	0	0
Campbell/Lasher	112	7	0.11	0.79	8	0.47	3.74
	18	7	0.06	0.39	0	0	0
Swan Pond	34	6	0.24	1.43	1	0.59	0.59
	30	6	0.2	0.59	1	0.39	0.39
	110	5	0.04	0.2	0	0	0

McDowell Lake	60	4	0.08	0.34	2	0.14	0.27
Winslow Pond	5	4	0.51	1.38	0	0	0
	63a	4	0.13	0.52	0	0	0
	108a	3	0.07	0.2	0	0	0
McDowell Meadow	63b	3	0.07	0.22	0	0	0
	108	3	0.04	0.12	0	0	0
	40	1	0.1	0.41	4	0.16	0.66
	109	1	0.06	0.06	0	0	0
Cossalman Lake	93	0	0	0	6	0.37	2.2
	98	0	0	0	1	0.31	0.31
		427		39.12	88		24.15

Figure 5. Locations of manipulated wetlands.

be avoided during restoration activities.

In addition to island and berm removal, all unnecessary drainage ditches will be back-filled and recontoured to the original basin morphology. Water control structures in East and West Issacson, Hale Lake, McDowell Lake, 30 Acre Lake and Palmer Meadow will be removed and replaced with a earth fill plug set at or above the elevation of the natural outlet. In order to restore the natural hydrology of Beaver Pond, the outlet ditch will be filled to the level of the natural outlet. To achieve water level objectives in Reeves Lake and Upper Blackhorse Lake, the dike and control structure at their outlets will be rehabilitated and elevated to allow for deeper flooding and to reduce leakage.

Specific actions to remedy water retention problems in Stubblefield Lake, include compacting the wetland basin using a sheeps foot roller and initiating a study of the ground and surface hydrology of this basin.

3. Control of reed canarygrass

There are 4 wetland basins (Helms Meadow, Schaefer Meadow, Palmer Meadow, and McDowell Meadow that have large enough stands of reed canarygrass to warrant the use of replacement control strategies (Figure 6). Experimental plots will be established in these areas to test various restoration strategies involving the use of deep flooding, prescribed fire, high intensity short duration grazing, herbicides, discing and seeding. Although these sites are not typical water howellia habitat, a survey will be conducted prior to any treatment. A discing and seeding treatment following application of herbicides has already been completed on the Helm's Marsh. Red top(*Agrostis alba*) was used to seed the shallow wet meadow zone. No seeding was done in the deeper portions of the basin. It was felt that the greater water depth and an existing seed bank of native emergents will limit invasion by reed canarygrass. This site and future experimental treatments will be monitored to determine their success in restoring native plant communities.

Because of the potential for reed canarygrass to negatively impact the federally threatened plant species, *Howellia aquatilis,* a research effort will be initiated to investigate this relationship and potential control treatments that will not jeopardize howellia.

Figure 6. Wetlands where reed canarygrass control is feasible.

4. Silvicultural treatments

Management actions for uplands will be applied on a management unit basis(Table 7 and Figure 7). Management units will be treated on a priority basis determined by the condition of forest stands and the threat to private lands posed by a continuous fuel bed that extends across refuge boundaries. In addition,treatment of management units will be timed to maximize the distance between recently treated areas.

When possible silvicultural treatments will be performed by a commercial operator working under a Special Use Permit. Permits will be issued using a competitive process. All heavy equipment operation will be conducted at times when the ground is frozen or dry. The butt end of all felled will be raised off the ground during skidding operations. Where possible harvester loaders will be utilized to reduce damage from skidding. Landing areas will be dispersed to shorten the length of skid trails. All disturbed areas including skid trails, landings and temporary access roads will be rehabilitated by replacing topsoil and reseeding with native species. Non-commercial thinning, fuels management, road rehabilitation and restoration skid trails and log landing will be conditions of the Special Use Permit.

In order to reduce the potential for soils erosion and sediment transport to wetlands, no harvest equipment will be allowed within 25 yards of the wetland edge. Any trees harvested in this zone will be felled away from the wetland and skidded out of the zone by cable.

Small wood management

Cutting of trees less than 8 inch dbh will be completed on at least 100 acres annually for the next 15 years. Average densities in this size class range from 64 - 305 trees per acre with maximum densities above 1000 trees/acre. Stems will be removed for the small wood market, fuelwood or piled and broadcast for later burning. No slash burning will occur within 25 yards of a wetland to prevent loss of ground cover that could promote erosion and invasion of exotic plan species.

Commercial harvest

Single tree selection harvest will be conducted on at least 400 acres of ponderosa pine forests annually for the next 15 years to remove up to 60 percent of the trees between 8 and 24 inch diameter. This amounts to between 8 and 24 trees per acre. In

Table 7. Upland management units of Turnbull NWR in order of management priority.

Unit Name	Wetlands	Aspen/shrub	Pine forest	Steppe	Unit Total
Issacson	66.7	10.4	256.6	121.2	454.9
North Boundary	64.2	2.3	277.4	146.1	490.0
Long Lake	294.8	29.4	183.6	386.4	894.2
Pine Creek RNA	13.8	3.7	132.9	13.8	164.2
Campbell/Lasher	182.3	14.3	420.8	215.3	832.7
Aspen Meadows	35.3	5.6	215.0	126.4	382.3
Railroad Butte	42.3	8.9	294.9	148.3	494.4
Upper Turnbull	338.1	1.6	414.2	310.9	1064.8
Reeves Lake	237.6	14.5	301.7	438.6	992.4
Hale	87.6	5.7	339.5	191.9	624.7
Pine Creek	132.1	7.2	95.7	298.8	533.8
West Tritt	221.5	7.4	358.9	278.3	866.1
Howellia	34.6	9.7	343.8	217.7	605.8
Lower Turnbull	390.5	5.8	424.1	356.2	1176.6
Blackhorse Butte	23.3	11.8	203.8	197.0	435.9
Camas Canyon	82.7	16.3	304.1	194.1	597.2
Kepple	125.7	0.3	198.6	104.5	429.1
Palmer	143.0	8.1	449.2	309.4	909.7
Helm's	117.5	14.0	192.3	234.1	557.9
McDowell	141.4	7.9	370.2	101.7	621.2
Stubblefield	128.3	18.1	234.8	1358.7	1739.9
TLES	0.8	0.4	6.3	18.4	25.9
Refuge Total	2904.1	203.4	6018.4	5767.8	14893.7

Figure 7. Upland Management Units

mixed stands of pine and aspen, up to 100% of the ponderosa pine less than 24 inches in diameter will be removed from approximately 10 acres annually. Group selection cuts less than .25 acres in size will be completed on approximatley 25 acres annually.

Riparian restoration

Planting of native deciduous trees and shrubs will continue along Pine Creek from Headquarters Pond to Winslow Pond. Additional riparian restoration sites include Pine Creek below Middle Pine Lake and the drainage from Reeves Lake to Upper Blackhorse. Planting of aspen and other decicous trees and shrubs will also be necessary adjacent to wetlands, where aspen has been lost as a result of sucession to ponderosa pine climax forest.

5. Prescribed burning

All prescribed burning will take place within management unit boundaries. Because of the interspersion and juxtaposition of plant associations on the refuge, most prescribed burns will incorporate a diversity of plant communities and fuel types. Prescribed burn procedures and smoke management considerations will follow strategies outlined in the refuge fire management plan.

Slash and Pile Burning (100 acres annually)

As a part of non-commercial thinning operations there will be non-mechantable smallwood that will be piled or broadcast on site. These piles or broadcast fuel will be burned when fuel mositure and smoke dispersal conditions allow.

High Moisture Burns (400-800 acres annually)

Late winter and early spring prescribed burning, if needed will be conducted on management units one year following silvicutural treatments. These high moisture burns will involve broadcast burns to remove slash and a portion of the hazardous fuels around the base of large reserve trees. In addition to the steppe habitats treated within burn units, an experimental program will be established to study the potential of spring burning to suppress seed production of cheatgrass and increase vigor of native perennial grasses.

Low Fuel Moisture Burns (400 - 800 acres annually)

Late summer and fall burns will be conducted on management units that receive silvicultural treatments at least one year follwing treatment or two growing seasons following high moisture, spring burns. These burns will further reduce hazardous fuels in forest stands, regenerate overmature and decadent aspen, and decrease the extent of low shrub cover in forest plant associations. Heavy accumulations of organic debris, tall shrubs and reproduction will be cleared from the base of trees greater than 24 inches in diameter at breast height and snags greater than 15 inches in diameter at breast height to reduce either mortality of live trees or falling of snags. Because of lower tree densities and fuel loading in portions of some management units, burning during this time of year can be accomplished without any pretreatment. For logistics reasons, individual burns may be broken up into smaller units ranging in size from 50 to 200 acres.

Once all management units have received the restoration treatment, burns will be conducted in the late summer and fall at return intervals ranging between 10 and 25 years and averaging 15 years(Arno 1988 and Kinateder and Stein 1998).

6. Noxious plant control

The primary strategy for controlling the expansion of introduced plant species will be maintenance of vigorous native plant communities. Soil disturbance will be kept to a minimum during habitat and facility management activities. Where soil disturbance does occur, disturbed sites will be replanted with native species.

The control strategies for 6 herbaceous noxious plant species will include mowing of roadsides, manual pulling, discing and reseeding with native species, release of biological control agents, and use of herbicides (Table 8).

An experimental program will be initiated to determine the feasibility of using late winter and early spring burning followed by seeding of native plant species to control cheatgrass in steppe and forested habitats.

Table 8. Noxious plant control strategies, locations and areas treated.

Species	Control Strategy	Location	Acres
All species	Cultural	Refuge-wide	N/A
	Maintenance of native plant communities		
	Minimizing soil disturbance		
	Rehabilitation of disturbed areas		
Canada thistle	Biological	Cossalman Lake	N/A
	stem mining weevil		
	stem gall fly		
	Chemical	Stubblefield	30
	Aquatic 2,4-D	Islands	10
		Palmer Food Plot	10
	Mechanical		
	Cultivation and seeding	Palmer food plot	
Knapweed spp.	Chemical	TLES	2
	Curtail(Transline and 2,4-D)	Cheney/Plaza	1
	Mechanical		
	Cultivation/hydroseeding	TLES	2
	Biological	Old Highway	N/A
	seed head gall fly		
	seed eating moth		
Leafy spurge	Chemical		
	2,4-D Amine	Campbell/Lasher	0.05
		Old Highway	0.05
	Manual removal		
Dalmatian toadflax	Biological		
	leaf and flower eating moth	State trail ROW	N/A
	defoliating beetle		
	Manual removal	Public use area	
St. John's wort	Biological	refuge-wide	N/A
	defoliating beetle		
Tansy ragwort	Annual mowing	Cheever Lake Dam	2.0
		Entrance road	0.05

7. Off refuge land issues

Refuge staff will work with state and local regulatory agencies through their permitting process, use landowner incentive programs, and possibly acquire lands within priority areas(Figure 8). Improved coordination and communication will be fostered between refuge staff and regulatory agencies to assure input on all permits changing land use in areas adjacent to refuge. Refuge staff will continue to work with these regulatory agencies to assure that zoning and land and water protection ordinances minimize impacts to water quality and quantity and landscape connectivity.

Beyond local permitting processes and zoning laws, minimizing the impact of private land activities on water quality and quantity and landscape linkage will be accomplished through better outreach and education, landowner incentive programs, acquisition of easements or fee title purchase.

The U.S Fish and Wildlife Service through the Division of Ecological Services administers the Washington State Ecosystem Conservation Program which provides technical and financial assistance to private landowners to facilitate the protection, enhancement, restoration, and creation of wetlands. Financial assistance is provided on a cost-sharing basis with the landowner and other potential project partners. In exchange for federal assistance landowners must agree, through a wildlife extension agreement, to leave the project in place for a specified time period. The length of the agreement affects the level of federal assistance for the project.

There are also federal programs under the 1996 Farm Bill that provide incentives to landowners to restore, protect, and maintain wetlands and upland wildlife habitat on their lands. The Wetland Reserve Program (WRP) centers on wetland restoration but allows inclusion of up to 50 percent of the adjacent upland. This program offers three options involving purchases of easements of different lengths of time. The purchase price is based on the percentage of agricultural value foregone which varies depending on the length of the easement. Purchase of a perpetual easement is based on 100% of the agricultural value. A 30 year easement option is also available with a purchase price of 75% of the agricultural value. The last option involves restoration of wetlands for a ten year period through direct habitat work. This option requires a 75 % federal to 24% non-federal match for completion of habitat work. The Wildlife Habitat Incentives Program (WHIP)is a cost share program, where a 75 percent federal

Figure 8

match 25% non-federal match will support wildlife habitat restoration in both uplands and wetlands. The focus of this program is restoration and enhancement of larger, contiguous areas which contain diverse habitats. The third program is the Environmental Quality Incentives Program (EQIP). Water quality, non-point pollution, and wildlife are the focus of this program. At least 50% of the funding under this program must address livestock concerns. It is a bid-based cost-share program with up to 75% federal to 25% non-federal match required. These programs are administered by the Natural Resource Conservation Service. A key element in all these programs is partnerships between agencies and non-governmental organizations. These partnerships would enhance the priority of submitted projects for funding.

Grants are also available under authority of the North American Wetlands Conservation Act to enhance, restore or acquire wetlands. Proposals that represent the efforts of partnerships between public and private entities receive higher priority.

Where these programs are ineffective or the current landowners are contemplating significant changes in land use that could negatively affect the integrity of the refuge ecosystem, the only option available may be fee title purchase or acquisition of development rights. All acquisitions will be on a willing seller basis.

8. Outreach and Education

An integral part of the proposed actions to protect the quality and quantity of water entering the refuge and to prevent the biological isolation of the refuge is an outreach and education program that informs the general public of the refuge mission and its importance, current and potential threats to its viability and strategies to minimize these threats. The refuge currently has an outreach and environmental education program directed at school-age children. This program needs to be extended to the community-at-large including refuge neighbors, local government agencies, and private groups and individuals. This can be accomplished by development of outreach media including pamphlets, posters, video programs, communtity service projects and presentations by refuge staff to local business and service groups. Without an informed public, it will be difficult to accomplish objectives that involve the development of partnerships to minimize the impacts of private land use activities on wildlife habitat and the refuge.

C. Economic Costs of Actions

Proposed costs to implement this plan will involve the following; placement of piezometer wells, wetland survey, removal of islands and berms, backfilling ditches, removal of water control structures, additional prescribed burn personnel, additional personnel for forest management planning and monitoring, research on reed canarygrass and howellia, outreach and education activities and materials. Costs for forest management planning and wetland restoration reflect annual expenditures for personnel and equipment

Table 9. Annual personnel needs in addition to current staffing levels and annual and total implementation costs for habitat management activities.

Item	FTE	Cost
Piezometer wells		$ 35,000
Wetland basin survey		$165,000
Wetland restoration (0.5 Fte)	0.5	$ 50,000/year
Island and berm removal ditch filling water control structure removal reed canarygrass control		
Forest management	3.0	$240,000/year
Planning (1.0 FTE) Monitoring (1.0 FTE) Prescribed burning (1.0 FTE)		
Riparian restoration		$ 5,000/year
Native plant materials Fencing and mulch materials		
Stubblefield Hydrology Study		
Howellia research		$ 30,000
Outreach and Education	0.5	$ 50,000

IV. Habitat Monitoring

Habitat monitoring is important in an adaptive management approach to insure that assumptions made in developing strategies are correct. If objectives are not being met then corrections can be made. Monitoring procedures have been developed for breeding and foraging strata and howellia (Table 10). Detailed descriptions for each procedure are provided in the refuge Habitat Inventory and Monitoring Plan.

Table 10. Habitat monitoring procedures and habitat variables monitored by habitat strata

Strata	Monitoring procedure	Habitat variables
Aquatic strata		
Water column	Water level monitoring Annual aerial photography Annual aquatic plant surveys	Acreage of 1 foot water depth zones May - July Pond Counts Species composition by volume
Water surface	Water level monitoring Annual aerial photography	Acreage of 1 foot water depth zones Acreage of July open water habitat
Emergent plants	Water level monitoring	Acreage of 1 foot water depth zones Water depth in emergent plant zones
	Annual aerial photography	Acreage of emergent plant beds Interspersion of open water
	Permanent Wetland transects	Interspersion of open water Stem densities of emergent plants
Terrestrial strata		
Bare surface	Upland vegetation transects	Percent ground cover
Covered surface	Upland vegetation transects	Percent ground cover Visual obstruction
	Forest condition classification	Refuge wide inventory of forest fuels
	Forest treatment monitoring	Pre- and post- treatment amounts of downed woody material by size and decay class
Terrestrial sub-surface	Upland vegetation transects	Successional stage on deep soil

		Plant species cover

Table 10. Habitat monitoring procedures by habitat strata (continued).

Strata	Monitoring procedure	Habitat variable
Shrub	Habitat monitoring at bird point count stations	Shrub cover and canopy volume Stem densities
Tree bole/ Snag	Forest condition classification	Tree and snag densities by size class
	Forest treatment monitoring	Pre- and post- treatment densities of trees and snags by size and decay class.
Tree canopy	Habitat monitoring at bird point count stations	Tree cover and canopy volume
	Forest treatment monitoring	Pre- and post- treatment densities of trees and snags by size and decay class.
Water Howellia Monitoring		
	Annual monitoring	Presence or absence, estimated population size, site characteristics
	Pre-treatment monitoring	Presence or absence, population locations

V. Literature Cited

Includes citations for the plan and all attached apendices.

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VI. Glossary

aboriginal burning - the use of fire in the past by native people to clear land, drive game, improve forage, etc.

animal unit month - a measure of the quantity of livestock forage. Equivalent to the amount of forage needed to support a 1,000 pound animal for 1 month.

aquifer - subsurface rock formations (often sand, gravel, sandstone or limestone) that contain or carry groundwater and act as water reservoirs.

basal area - the cross sectional area(square feet) of a tree trunk measured at breast height (4.5). Basal area density is the amount of tree basal area per unit area (sq. feet/acre)

basalt - a finely grained, dark, dense volcanic rock.

biodiversity - the variety and variability among living organisms and the ecological complexes in which they occur.

biological control - the use of organisms or viruses to control weeds or other pests.

board foot - the amount of timber equivalent to a piece 1 by 1 foot and 1 inch thick(=1/12ft^3)

broadcast burn - burning forest fuels as they are with no piling or windrowing.

catastrophic wildfire - a wildfire that burns with high intensity over a large area causing greater than 90% tree mortality in all age classes.

Class A Noxious Weed - those noxious weeds not native to the state that are of limited distribution or are unrecorded in the state and that pose a serious threat to the state.

Class B Noxious Weed - those noxious weeds not native to the state that are of limited distribution or are unrecorded in a region of the state and that pose a serious threat to that region.

Class B designate - means those Class B noxious weeds whose populations in a region or area are such that all seed production can be prevented within a calender year.

Class C Noxious Weed - any other noxious weed.

commercial thinning - any type of thinning that produces merchantable material at least equal to the value of the direct costs of harvesting.

cover type - the present vegetation of an area.

crown fire - a forest fire that burns in the crowns of trees.

cryptogamic soil crusts - a thin layer on or just below the soil surface that is composed of organisms such as lichens, mosses, algae, fungi, cyanobacteria, and bacteria (also referred to as microbiotic soil crusts).

cultural resources - remains of sites, structues, or objects used by people in the past.

decay class - any of five stages of decomposition of snags or logs, ranges from essentially sound to completely decomposed.

deciduous - pertaining to any plant organ or group of organs that is shed annually; perrennial plants that are leafless for sometime during the year.

depredation - damage inflicted on agricultural crops or ornamental plants by wildlife.

diameter at breast height (DBH) - the diameter of a tree measured at a height of approximately 4.5 feet.

disturbance - refers to events that alter the structure, composititon, or function of terrestrial or aquatic habitats. Natural disturbances include, among others, drought, flood, wind, fire, wildlife grazing and browsing, and insects and pathogens. Human-caused disturbances include actions such as timber harvest, livestock grazing, roads, and the introduction of exotic species.

down woody material - all woody material, from whatever source, that is dead and lying on the forest floor.

drilling - a method of mechanical seeding where seed coverage is accomplished by dropping a seed in front of a heavy metal disk that forces the seed into the top surface of the soil.

ecological integrity - In general, ecological or biological integrity refers to the elements of biodiversity and the functions that link them together and sustain the entire system; the quality of being complete; a sense of wholeness.

ecosystem - dynamic and interrelating complex of plant and animal communities and their associated non-living environment.

ecosystem management - management of natural resources using system wide concepts to ensure that all plants and animal in ecosystems are maintained at viable levels in native habitats and basic ecocytme processes are perpetuated indefinitely (Clark and Zaunbrecher 1987).

ecological processes - The flow and cycling of energy, materials, and organisms in an ecosystem.

endangered species(federal) - A plant or animal species listed under the Endangered Species Act that is in danger of extinction throughout all or a significant portion of its range.

endangered species(state) - a plant or animal species in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. Populations of these speceis are at critically low levels or their habitats have been degraded or depeleted to a significant degree.

endemic species - Plants or animals that occur naturally in a certain region and whose distribution is relatively limited to a particular locality.

eutrophicaton - changes that occur in a body of water due to excessive supplies of nitrients such as nitrates and phosphorus.

evapotranspiration - the actual total loss of water by evaporation from soil, water bodies, and transpiration from vegetation over a given time.

even-aged - refers to a group of trees of approximatley the same age.

fauna - all the vertebrate and invertebrate animals of an area.

federal trust species - all species where the federal government has primary jurisdiction including federally endangered or threatened species, migratory birds, anadromous fish, and marine mammals.

flora - all the plant specise of an area

fire-dependent system - forests grasslands, and other ecosystems historically composed of plants that evolved with and are maintained by fire regimes.

fire return interval - The number of years between two successive fire events in a given area.

forest health - the condition in which forest ecosystems sustain their complexity, diversity, resiliency, and productivity. It is a useful way to communicate about the current condition of the forest, especially with regard to resiliency, a part of forest health that describes the ability of the ecosystem to respond to disturbance.

fuel continuity - the spatial distribution of fuels that allows for horizontal fire spread.

fuel ladder - vegetative structures or conditions such as low growing tree branches, shrubs, or smaller trees that allow fire to move vertically from a surface fire to a crown fire.

fuel loading - The amount of combustible material present per unit area.

groundwater - water that sinks into the soil and is stored in slowly flowing and slowly renewed underground reservoirs called aquifers.

group selection cut or harvest - Method of harvest where all trees regardless of size are removed from a given area creating an opening in the forest.

hard snag - a snag composed primarily of sound wood, particularly sound sapwood, generally merchantable.

hard snag equivalent - the number of hard snags required to produce a single soft snag; a percentage of snags will fall before becoming soft and suitable for most cavity excavators.

high intensity/short duration grazing - A grazing system that uses a high density of livestock over a short period of time on an area to avoid repeated grazing of more palatable plant species.

hydric soils - soil that is wet long enough to periodically produce anaerobic(without oxygen) conditions, thereby influencing the growth of plants.

hydrologic regime - see water regime

hydrophytic plants - any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of exceessive water content.

hydroseeding - a mechanical seeding method where a slurry of mulch, seed, and a fertilizer agent is applied to the ground surface.

indicator species - a species of plant or animal that is assumed to be sensitive to habitat changes and represents the needs of a larger group of species. Also referred to as a key species.

initial attack forces - the first fire suppression crews dispatched to a wildfire and actively attempt to contain the fire. The leader of the initial attack crews may request additional crews after sizing up the fire.

integrated weed management - a management approach for noxious weeds that includes: 1)education; 2)prevention; 3) physical or mechanical methods of control; 4) biological control; 5)responsible herbicide use; and 6) cultural methods.

landscape connectivity - the arrangement of habitats that allows organisms and ecological processes to move across tha landscape; patches of similar habitats are either close together or linked by corridors of appropriate vegetation. The opposite of fragmentation.

landscape linkage - a landscape feature linking areas set aside for conservation functions. The complete range of community and ecosystem processes continue to operate within these features through time. Plants and smaller animals are able to move between larger landscape blocks over a period of generations.

lithosols - a shallow soil without zonation and consisting of imperfectly weathered rock fragments.

litter - the uppermost layer of organic debris on the soil surface, which is essentially the freshly fallen or slightly decomposed vegetation material.

loess soils - soils that are the result of wind deposition.

maximum potential breeding population - the greatest number of breeding individuals of a wildlife species that can occur if the constraints of food, cover, and water are removed.

mitigation - measures designed to counteract environmental impacts or to make impacts less severe.

monitoring - a process of collecting information to evaluate whether or not objectives of a project and its mitigation plan are being realized.

mulch - any loose covering on the surface of the soil, such as litter or deliberately applied organic material.

multi-storied stand - a forest stand with two or more distinct tree layers in the canopy.

native species - Species that normally live and thrive in a particular ecosystem.

National Ambient Air Quality Standards(NAAQSs) - standards set by the Federal Environmental Protection Agency for the maximum levels of air pollutants that can exist in the outdoor air without unacceptable effects on human health or the public welfare.

neotropical migratory landbird - a bird species that is not dependent on aquatic habitats for its existence and breeds north of the U.S.- Mexican border and winters primarily south of this border.

nitrification - the conversion of ammonium salts and nitrites through oxidation to chemical forms more readily utilized by plants.

non-attainment area - a geographic area that is not in compliance with the National Ambient Air Quality Standards for a particular pollutant.

non-commercial thinning - the removal of trees before they reach a size or conditon to make it of sufficient value to meet the costs of the activity.

non-point source pollution - pollution whose source is not specific in location; the sources of the pollutant discharge are dispersed, not well defined or constant. Examples include sediments from logging activities and run off of livestock waste.

noxious weed - a plant species designated by federal or state law as generally possessing one or more of the following characteristics: aggressive and difficult to manage; parasitic; a carrier or host of serious insects or disease; or non-native, new, or not common to the United States, According to the Federal Noxious Weed Act (PL 93-639), a noxious weed is one that causes disease or has adverse effects on man or his environment and therefore is detrimental to the agriculture and commerce of the United States and to the public health.

outreach - the process of providing information to the public on a specific issue through the use of the media, printed materials, and presentations.

Partners for Flight(PIF) -

peat - partially carbonized organic matter formed by partial decomposition in water of various plants.

peizometer well - a hollow tube placed in the ground that allows measurement of the height of the water table. Often times fitted with an automated depth recorder.

permanent wetland - a wetland basin or portion of a basin that is covered with water throughout the year in all years except extreme drought. Typically the basin bottom is vegetated with submerged aquatic plant species including milfoil, coontail, pondweeds, and naiads.

plant association - a classification of plant communities based on the similarity in dominant vascular plant species of all layers in a climax community.

plant communtity - an assemblage of plant species unique in its composition; occurs in particular locations under particular influences; a reflection or integration of the environmental influences on the site - such as soils, temperature, elevation, solar radiation, slope, aspect, and rainfall; denotes a general kind of climax plant community ie ponderosa pine or bunchgrass.

PM_{10} - Particulate matter that measure 10 micrometers in diameter or less, a size considered small enough to invade the alveolar regions of the lung. PM_{10} is one of the six pollutants for which there is a National Ambient Air Quality Standard.

prescribed burning - skillful application of fire to natural fuels under conditions of weather, fuel mositure, soil moisture, etc. that allows confinement of the fire to a predetermined areaand produces the intensity of heat and rate of spread to accomplish planned benefits to one or more onjectives of silviculture, wildlife managment or hazard reduction.

prescribed fire - fire used as managment tool under specified conditions to achieve specific management objectives.

***q*-ration** - the ratio between numbers of trees in successive size classes. Size clasess used are either 2 or 4 inch size intervals.

replacement control - A method for the control of undesirable plant species that involves removal of the exisiting plant community through the use of cultivation and/or herbicides and re-seeding of the site with desirable plant species.

restoration - Actions taken to modify an ecosystem to achieve desired, healthy, and functioning conditions and processes. Generally refers to the process of enabling the system to resume its resilency to disturbance.

riparian - refers to an area or habitat that is a transition from terrestrial to aquatic ecosystems; includes streams, lakes, wet areas, and adjacent plant communities and their associated soils which have free water at or near the surface; an area whose components are directly or indirectly attributed to the influence of water.

seasonal wetland - a wetland basin or portion of a basin where surface water is present in the early part of the growing season but is absent by the end of the season in most years. Typically vegetated with sedges, rushes, spikerushes or burreed. This wetland type is prone to invasion by reed canarygrass.

seral stage - a developmental stage of ecological succession, characterized by a group of species or plant community that will eventually be replaced by a different group of species or plant community.

semi-permanent wetland - a wetland basin or portion of a basin where surface water persist throughout the growing season of most years. Typical vegetation is composed of cattails and bulrushes.

silviculture - the practice of manipulatiing the establishment, composition, structure, growth, and rate of succession of forests to accomplish specific objectives.

single-storied stand - a stand of trees in which the canopy is contained in one layer.

single tree selection cut or harvest - the periodic removal of individual trees of a selected size or condition. Trees are usually saw timber sized.

snag - a standing dead tree from which the leaves and most of the limbs have fallen.

soft snag - a snag composed primarily of wood in advanced stages of decay and deterioration, particularly in the sapwood portion.

stand - a group of trees in a specific area that are sufficiently alike in composition, age, arrangement, and conditions as to be distinguishable from forest in adjoining areas.

stand density - the number of trees growing in a given area, usually expressed in terms of trees per acre.

stand diversity - The distribution and juxtapositon of forest stands of different seral and structural stages(see stand structure).

stand-replacing fire - a fire in which less than 20% of the basal area or 10% of the canopy cover remains.

stand structure - the mix and distribution of tree sizes, layers, and ages in a forest. Some stands are all one size(single story), some are two story, and some are a mix of trees of different ages and sizes (multi-story)

state sensitive species - a plant or animal species is labelled sensitive when it is vulnerable or declining and could become endangered or threatened in the state without active managment or removal of threats.

state monitor species - a plant or animal species of potential concern in the state, but for which no status is currently assigned. The monitor list consists of three groups:

1) species in need of additional field work before a status can be assigned.

2) species with unresolved taxonomic questions

3) species more abundant and/or less threatened in the state than previousily assumed.

steppe - arid land dominated by shrubs and grasses where soil and moisture limit the growth of trees.

surface water - standing or running water that is visible on the surface of the ground.

threatened species (federal) - species listed under the Endangered Species Act that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

threatened species (state) - a plant or animal species likely to become endangered in Washington within the near future if factors contributing to its population decline or habitat degradation or loss continue.

transpiration - water loss from plants during the course of photosynthesis.

underburn - a burn by a surface fire that can consume ground vegetation and ladder fuels.

undesirable plant - either a noxious weed species or a species that is limiting the ability of the refuge to achieve its objectives. Generally a non-native plant species.

uneven aged - refers to a group or stand of trees in which there are considerable differences in the ages of individual trees.

urbanization - conversion of a unit of land from either natural plant cover or agricultural crops to land use dominated by man-made structures such as roads, buildings, pavement, etc.

visual obstruction measurement - A measure of vegetation density recorded as the height at which a 6 foot pole (Robel pole) viewed from a distance of 13 feet is completely obscured by vegetation.

water management - the control of the depth, timing, and length of flooding or drawdown to accomplish specific wetland habitat objectives.

water regime - The depth, duration and season of flooding in a wetland basin.

watershed - the region draining into a river, river system or body of water.

water yield - the water available to recharge aquifers or to wetlands after losses by evaporation and transpiration.

wetland basin - a depressional area in the landscape that is sufficiently deep to collect and hold water for a long enough period of time to develope hydric soils and support hydrophytic plant species.

wetland complex - an aggregation of wetlands of different sizes and types.

wildlife corridor - a landscape feature that facilitates the biologically effective transport of animals between larger patches of habitat dedicated to conservation functions. Such corridors may facilitate several kinds of traffic, including frequent foraging movements, seasonal migrations, or the once in a lifetime dispersal of juvenile animals. These are transitional habitats and need not contain all the habitat elements required for long-term survival or reproduction of its migrants.

wildlife guild - an aggregation of species that tend to utilize resources for both feeding and reproduction in a similar manner. For this plan resources are defined as habitat strata.

VII. Appendices

Appendix A. Data fields and codes used in refuge wildlife-habitat relationships database.

Breeding Guilds(BGUILD)

WC	Water Column Breeder
WS	Water surface breeder
EM	Emergent vegetation breeder
SS	Sub-surface breeder
SB	Bare surface breeder
SC	Covered surface breeder
SH	Shrub breeder
TB	Tree bole breeder
TC	Tree canopy breeder
CC	Cave/crevice breeder

Foraging Guilds(FGUILD)

WC	Water column feeder
WS	Water surface feeder
EM	Emergent vegetation feeder
SS	Sub-surface feeder
SB	Bare surface feeder
SC	Covered surface feeder
SH	Shrub feeder
TB	Tree bole feeder
TC	Tree canopy feeder
AF	Aerial feeder

Breeding Status(BREED)

B Known to breed on the refuge

O Occasional breeder on refuge or breeds in the vicinity and forages on the refuge.

P Distribution includes refuge, extirpated or breeding not yet verified

M Migrant - Uses refuge during spring and/or fall migration periods.

Importance of Area(IA)

0 Exotic

1 Found in a variety of habitats nationwide.

2 Found nationwide in structurally similar habitats.

3 Found principally west of the Rocky Mountains in various habitats.

4 Found mostly west of the Rocky Mountains in structurally similar habitats.

5 Found primarily in the interior NW or in a distinct western plant community found on the refuge.

Appendix A. continued

Neotropical Migratory Bird Status (NTMB)

A Long distance migrant - winters primarily in south of the U.S. Border with Mexico.

B Short distant migrant - winter primarily within the U.S.

C Resident

Washington State Partner in Flight Management Index (PIF)

Based on a species continent-wide breeding distribution, evidence of decline, threat to habitats, and habitat specialization.

Evidence of Decline (ED)

This field was developed by Oregon/Washington Partners in Flight (Andelman and Stock 1994) and provides an index of how compelling the evidence of decline is for a species in Washington State. Trend information is based primarily on Breeding Bird Survey Data.

0 Trends indicate increasing or stable populations.

3 No statistically significant trend information is available for this species.

5 There is a statistically significant declining population trend.

Legal Status(STATUS)

EX Exotic Species not provided federal protection.

NO No special status. May be a state trust species(gamebird, furbearer, etc.)

SM State Monitor Species

SC State Candidate - species that are under review for possible listing as a State endangered, threatened or sensitive.

ST State threatened

SE State endangered

TR Federal trust resource (migratory bird and anadromous fish)

SS Federal Sensitive species

FC3 Federal Candidate Category 3

FC2 Federal Candidate Category 2

FC Federal Candidate Category 1

FP Federal Proposed

FT Federal threatened

Appendix A continued.

FE Federal endangered

State Habitat Specialization(SHS) - Index derived by OR/WA PIF for neotropical migratory birds and based on the number of habitats statewide used for nesting and foraging.

0 Uses 4 or more habitats for nesting and/or foraging.

1 Uses 3 habitats for nesting and/or foraging.

3 Uses 2 habitats for nesting and/or foraging.

5 Uses 1 habitat for nesting and foraging.

Refuge Vegetative Cover Type Specialization(RHS) - Index based on the number of vegetative cover types used by all species for breeding and foraging. Cover types are based on refuge classification system (see Appendix D).

0 Uses all four primary types for breeding and/or foraging.

1 Uses 3 primary types and most secondary types for breeding and/or foraging.

2 Uses 2 primary types and most secondary types for breeding and/or foraging.

3 Uses 2 primary types and three or less secondary types for breeding and/or foraging.

4 Uses 1 primary type for either breeding and/or foraging.

5 Uses 2 or less secondary types in the same primary type for either breeding and/or foraging.

Vegetative Strata Specialization(SS) - Index based on the number of strata utilized by al refuge species for breeding and foraging (see Appendix F for strata)

0 Uses 4 or more secondary terrestrial strata for breeding and/or foraging.

1 Uses 3 secondary terrestrial strata for either breeding or foraging.

2 Uses 3 secondary terrestrial strata for breeding and foraging combined and 2 strata for either breeding or foraging.

3 Uses 3 three secondary terrestrial strata for breeding and foraging combined but only a single stratum for either breeding or foraging or 2 secondary terrestrial combined and at least 1 aquatic stratum for breeding or foraging.

4 Uses 2 secondary terrestrial strata combined but only 1 strata for either breeding or foraging or 1 secondary terrestrial and at least 1 aquatic strata for breeding and/or foraging.

5 Uses a single secondary terrestrial strata or at least one aquatic strata for both breeding and foraging.

Appendix B. Key indicator species by breeding guild (Column descriptions at end of table)

Species name	CLASS	FGUILD	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
Breeding Guild: CC Cave/crevice breeder											
Yuma myotis	MAMMAL	AF	B	4				NO		3	4.
long-eared myotis	MAMMAL	AF	B	3				SM		3	4.
Breeding Guild: EM Emergent Breeder											
Virginia rail	AVES	EM	B	2	A			TR		4	4
yellow-headed blackbird	AVES	EM	B	3		12	1	TR	5	5	4
redhead	AVES	WC	B	4	B			TR,SS		5	5
muskrat	MAMMAL	EM	B	2				NO		5	5
Breeding Guild: SB Bare surface breeder											
common nighthawk	AVES	A	B	2	A	5.25	1	TR	0	0	4
spotted sandpiper	AVES	SB	B	2	A			TR		5	4
Breeding Guild: SC Covered surface breeder											
mallard	AVES	WC	B	2	B			TR,S		3	3
gadwall	AVES	WS	B	2	B			TR		3	3
cinnamon teal	AVES	WC	B	3	B			TR		4	4
grasshopper sparrow	AVES	SC	B	2	A	11	1	SM,TR	3	5	5
sharp-tailed grouse	AVES	SC	P	4				FC2,SC	5	4	4
Townsend's solitaire	AVES	AF	B	3	A	5	1	TR	0	2	3
vesper sparrow	AVES	SC	B	2	A	10	0	SM	3	4	4
vagrant shrew	MAMMAL	SC	B	4				NO		3	4
rubber boa	REPTILIA	SC	B	4				NO		3	3

Appendix B. Continued

Species name	CLASS	FGUILD	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
Breeding Guild: SH Shrub breeder											
yellow warbler	AVES	SH	B	2	A	11	5	TR,SS	3	5	4
willow flycatcher	AVES	AF	B	2	A	8.	0	TR,SS	3	5	5
MacGillivray's warbler	AVES	SH	P	4	A	9	1	TR	3	3	5
black-chinned hummingbird	AVES	SH	B	3	B	9	1	TR	3	3	2
Breeding Guild: SS Sub-surface breeder											
Columbian ground squirrel	MAMMAL	SS	B	4				NO		4	4
yellow pine chipmunk	MAMMAL	TC	B	5				NO		5	3
badger	MAMMAL	SS	B	2				NO		3	4
montane vole	MAMMAL	SC	B	2				NO		1	4
northern pocket gopher	MAMMAL	SS	B	3				N0		3	4
Breeding Guild: TB Tree bole breeder											
red-napped sapsucker	AVES	TB	B	4	A	7	0	TR	0	4	4
Lewis' woodpecker	AVES	AF	P	4	B	9	1	SC,SS	1	4	3
western bluebird	AVES	SC	B	4	C	6.6	1	SC,SS	0	4	3
pygmy nuthatch	AVES	TB	B	5	C			NO		5	3
northern flicker	AVES	TB	B	3	C	5	1	NO	0	3	4
California myotis	MAMMAL	AF	B	3.				NO		4	2
big brown bat	MAMMAL	AF	B	2				NO		2	3
Breeding Guild: TC Tree canopy breeder											
western wood-pewee	AVES	AF	B	4	A	5	0	TR	0	2	4

Appendix B. Continued

Species name	CLASS	FGUILD	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
black-headed grosbeak	AVES	SH	B	3	A	8	1	TR	1	4	2
chipping sparrow	AVES	SC	B	1	A	9	5	TR	0	2	3
red-tailed hawk	AVES	SC	B	2	B			TR	0	3	3
red crossbill	AVES	TC	B	4	C			NO		5	5
Breeding Guild: WC Water column breeder											
Columbian spotted frog	AMPHIBIA	WS	B	4				FC2,SC	5	5	
blotched tiger salamander	AMPHIBIA	SS	B	3				SM		3	4
Breeding Guild: WS Water surface breeder											
eared grebe	AVES	WC	B	3	A			T		5	5
black tern	AVES	W	B	3				FC2,SM	5	5	5

Expalantion of codes in Appendix A

Appendix C. Refuge Vertebrate Species List By Foraging Guild (Field descriptions at end of appendix)

Appendix C. continued

Species name	CLASS	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
Foraging Guild: AF	**Aerial feeder**									
Hammond's flycatcher	AVES	M	3.	A	8.	1.	TR	0.	4.	1.
dusky's flycatcher	AVES	M	3.	A	7.	0.	TR	0.	4.	3.
olive-sided flycatcher	AVES	M	2.	A	7.	1.	TR	0.	2.	1.
northern goshawk	AVES	M	2.	A	11.	1.	FC2,SC	5.	5.	3.
loggerhead shrike	AVES	M	1.	B	13.	1.	FC2,SC,SS	5.	1.	1.
Foraging Guild: SB	**Bare surface feeder**									
marbled godwit	AVES	M	2.	C			TR		5.	4.
least sandpiper	AVES	M	2.	A			TR		5.	5.
pectoral sandpiper	AVES	M	2.	A			TR		5.	5.
long-billed dowitcher	AVES	M	2.	A			TR		5.	5.
Baird's sandpiper	AVES	M	2.	A			TR		5.	5.
semipalmated sandpiper	AVES	M	2.	B			TR		5.	5.
semipalmated plover	AVES	M	2.	A			TR		5.	5.
greater yellowlegs	AVES	M	2.	A			TR		5.	4.
lesser yellowlegs	AVES	M	2.	A			TR		5.	4.
solitary sandpiper	AVES	M	2.	A			TR		5.	4.
dunlin	AVES	M	2.	B			TR		5.	5.
lesser golden plover	AVES	M	2.	A			TR		5.	5.
sanderling	AVES	M	2.	A			TR		5.	5.
water pipit	AVES	M	2.	A	12.	1.	TR	5.	5.	5.

Appendix C. continued

Species name	CLASS	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
Bonaparte's gull	AVES	M	1.	B			TR		1.	4.
great white-fronted goose	AVES	M	1.	B			TR		4.	4.
white-throated sparrow	AVES	M	1.	C			TR		2.	2.
white-crowned sparrow	AVES	M	1.	C	4.	1.	TR	0.	2.	2.
rosy finch	AVES	M	1.	C			TR		1.	2.
turkey vulture	AVES	M	1.	B	3.	1.	TR,SM	0.	0.	2.
Foraging Guild: SH	**Shrub feeder**									
rufous hummingbird	AVES	M	3.	A	12.	5.	TR	0.	3.	2.
evening grosbeak	AVES	M	2.	C			TR		2.	1.
winter wren	AVES	M	2.	C			TR		3.	2.
golden-crowned kinglet	AVES	M	2.	C	12.	5.	TR	1.	4.	4.
Foraging Guild: SU										
merlin	AVES	M	1.	A	6.	1.	TR,SM	0.	5.	5.
Foraging Guild: TC	**Tree canopy feeder**									
Townsend's warbler	AVES	M	3.	A	11.	1.	TR	3.	4.	4.
Clark's nutcracker	AVES	M	3.	C			NO		2.	3.
Cooper's hawk	AVES	M	2.	A	6.	1.	TR	1.	3.	0.
Nashville warbler	AVES	M	2.	A	8.	1.	TR	1.	2.	4.
sharp-shinned hawk	AVES	M	2.	A	6.	1.	TR	1.	1.	0.
Bohemian waxwing	AVES	M	2.	C			TR		3.	1.
orange-crowned warbler	AVES	M	2.	A	9.	5.	TR	0.	2.	4.
Foraging Guild: WC	**Water column feeder**									
western grebe	AVES	M	3.	B			TR,SM		5.	5.

Appendix C. continued

Species name	CLASS	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
western sandpiper	AVES	M	2.				TR		5.	5.
black-bellied plover	AVES	M	2.	A			TR		5.	5.
Foraging Guild: SC	**Covered surface feeder**									
Franklin's gull	AVES	M	4.	A			TR		1.	4.
varied thrush	AVES	M	3.	C			TR		0.	2.
prairie falcon	AVES	M	3.	A	10.	1.	TR,SM	1.	1.	2.
ferruginous hawk	AVES	M	3.	B	14.	5.	FC3,ST,SS	1.	3.	2.
California gull	AVES	M	3.	B			TR		0.	4.
Steller's jay	AVES	M	3.	C			NO		2.	1.
Swainson's hawk	AVES	M	3.	A	7.	0.	TR,SS,SC	0.	2.	2.
ring-billed gull	AVES	M	3.	B			TR		0.	4.
common redpoll	AVES	M	2.	C			TR		2.	2.
sandhill crane	AVES	M	2.	C			SE,SS,TR		2.	2.
fox sparrow	AVES	M	2.	C	5.	1.	TR	1.	1.	2.
canyon wren	AVES	M	2.	C			TR		3.	5.
hermit thrush	AVES	M	2.	A	5.	0.	TR	0.	5.	2.
pine grosbeak	AVES	M	2.	C			TR		4.	5.
long-billed curlew	AVES	M	2.	B	15.	1.	FC3,SM	5.	3.	5.
Lincoln's sparrow	AVES	M	2.	B	8.	1.	TR	1.	4.	2.
snow goose	AVES	M	1.	B			TR		3.	4.
American tree sparrow	AVES	M	1.	C			TR		3.	2.
northern mockingbird	AVES	M	1.	C			TR		1.	1.
northern shrike	AVES	M	1.	C			TR		2.	0.
rough-legged hawk	AVES	M	1.	C			TR		1.	2.
golden eagle	AVES	M	1.	B	8.	5.	SC	0.	0.	2.

Appendix C. continued

Species name	CLASS	BREED	IA	NTMB	PIF	ED	STATUS	SHS	RHS	SS
red-breasted merganser	AVES	M	2.	B			TR		5.	5.
Barrow's goldeneye	AVES	M	2.	C			TR		5.	5.
great egret	AVES	M	2.	A			TR,SM		5.	4.
tundra swan	AVES	M	2.	C			TR		5.	5.
common merganser	AVES	M	2.	B			TR		5.	5.
common goldeneye	AVES	M	2.	C			TR		5.	5.
common loon	AVES	M	1.	A			TR		5.	5.
white-winged scoter	AVES	M	1.	C			TR		5.	5.
Foraging Guild: WS	**Water surface feeder**									
Forster's tern	AVES	M	4.	A			TR,SM		5.	5.
bald eagle	AVES	M	2.	B			FT,ST		4.	4.
black-necked stilt	AVES	M	2.	A			TR,SM		5.	5.
red-necked phalarope	AVES	M	2.	A			TR		5.	5.
American avocet	AVES	M	2.	B			TR		5.	5.
peregrine falcon	AVES	M	1.	A	6.	1.	FE,SE	1.	1.	5.

Field Descriptions

BREED = Breeding status on refuge   IA = Importance of area   NTMB = Neotropical migratory bird status

PIF = WA State Partners in Flight management index   ED = Evidence of decline in WA State

Status = Legal Status   SHS = Statewide habitat specialization   RHS = Refuge habitat specialization

RSS = Refuge vegegation strata specialization

Explanation of codes found in Appendix A.

Appendix D. Habitat Management Guidelines

1. Wildlife Guilds

The following are guild management guidelines that were developed using information summarized in the Guild Management Document. These guidelines represent optimum conditions for each guild and are not limited by actual refuge resources. These guidelines and the natural capability of the refuge were taken into consideration in the development of habitat objectives to reach refuge goals.

a. Breeding Guilds

i. Water column breeders

This breeding guild consists entirely of amphibian species who breed and deposit their eggs within the water column. There are five species that have been confirmed as breeders on the refuge. Three species, the spotted frog, the blotched tiger salamander and the long-toed salamander have been chosen as indicator species based on either a limited distribution in the west, more restrictive habitat requirements, or their current population status.

-Successful reproduction of spotted frogs and tiger salamanders requires a permanent or intermittently exposed water regime to allow for adequate foraging habitat for adults and larvae through metamorphosis. Water management strategies should attempt to provide at least 1 permanent wetland greater than or equal to 10 acres per 247 acres of refuge habitat.

- Semi-permanent wetlands should contain a peripheral band of emergents at least 33 feet wide.

- Natural basin topography should be maintained or restored to a 10:1 slope to provide the necessary shallow, warmwater areas needed for maintenance of this guild under a variety of water conditions.

- Optimally, seasonal wetlands should be flooded from February 15 - May 15th.

- Introductions of exotic aquatic species that are potential predators or competitors should be prohibited. Environmental education programs should stress the dangers of introductions of non-native species. The presence of exotic aquatic species, especially the bullfrog, should be monitored and any individuals encountered immediately removed.

ii. Water surface breeders

There are four species known to breed on the refuge whose reproductive efforts are primarily undertaken on the water surface. All four are avian and build a floating platform of submerged aquatic plants or litter. Nest may be in the open or attached to sparse emergent vegetation. The eared grebe and black tern were selected as indicator species for this guild.

- For every 1000 acres of habitat, maintain at least one large wetland, greater than 100 acres, with deep water and beds of dense submerged aquatic plants available from March 15th to August 30th.

- Maintain a zone of emergent vegetation, primarily hardstem bulrush, approximately 33 feet wide near deep permanent or intermittently exposed water with abundant submerged aquatic plants.

iii. Emergent plant breeders

There are fourteen species in this guild including the redhead duck, yellow-headed blackbird, yellow rail, and muskrat. All but one are avian species. All the birds build either open or domed nest supported by upright stems of persistent emergent vegetation such as hardstem bulrush and common cattail. The muskrat, in addition to being a terrestrial subsurface breeder, utilizes emergent vegetation especially cattail to build a lodge that is at least partially supported by stems of emergent plants.

General

- A diversity of wetland types and sizes are required to meet all wetland associated needs of this guild seasonally and annually.

- Fluctuating water levels seasonally and between years promotes both a temporal and spatial diversity of conditions in emergent stands. Under these conditions, suitable habitat is provided for all guild members over the longterm.

Semi-permanent wetlands

- The ratio of open water areas to emergent plant beds should be near 1:1. At least half of the emergent plant beds should be at least 100 feet in width to provide adequate area for the establishment of territories and security for nesting.

- Water depths in hardstem bulrush stands should not drop below 18 inches (45 cm) from April 1 to July 30.

- Stem densities should be greater than 14 stems per square foot in at least 50% of the emergent stands.

Permanent Wetlands

- Permanent wetlands should be maintained at a density of 2 ponds larger than 50 acres per square mile.

- Between 30 and 50% of a permanent wetland basin should be managed as open water in blocks of at least 25 acres in size.

- Open water areas should contain interspersed patches of dense, submerged aquatic plant beds. Submerged aquatic plants provide a substrate for invertebrate production. Aquatic invertebrates are critical to egg production, the maintenance of incubating females and growth and survival of broods.

iv. Terrestrial bare surface breeders

This guild consists of 5 bird species including the killdeer, spotted sandpiper, and common nighthawk whose nest are placed on exposed soil surfaces. Nest are generally little more than a scrap. These birds utilize cryptically colored eggs instead of cover to camouflage their nests. All 5 species are known to breed on the refuge.

- The presence of areas of exposed soil and rock interspersed in open habitats and near wetlands should be maintained in a natural distribution and quantity.

- Disturbance of these areas by livestock and human activity should be avoided during the nesting season

(April 1 to July 1).

v. Terrestrial cover surfaced breeders

All members of this guild reproduce on the ground and utilize some form of security cover ranging from grass to fallen logs. Membership includes 30 species and such diverse species as cinnamon teal, vesper sparrow, rubber boa, vagrant shrew, and Rocky Mountain elk. Twenty-seven species are confirmed refuge breeders. The Columbian sharp-tailed grouse, upland sandpiper and western jumping mouse are species whose range includes the refuge and are known to use land cover types found here, but have either not been confirmed as breeders on the refuge or have been extirpated as is the case of the sharp-tailed grouse and upland sandpiper. Two thirds of the guild members are found primarily in landcover types with a grassland aspect. Eight species breed primarily in forested types and two in shrub cover types.

- For upland nesting waterfowl and other waterbirds, areas of grass and low shrub cover within 200 yards of brood-rearing wetlands is of critical importance.

- A residual vegetation component should be maintained in at least 75% of the wet meadow and grass and low shrub dominated upland plant communities. As a rule, the maintenance of a visual obstruction reading of 10 inches or greater taken prior to initiation of current years growth will provide the best nesting cover. Visual obstruction is measured by estimating the height a pole is completing hidden from view by an individual 13.4 feet away.

- Litter is an important component of the terrestrial covered surface stratum and should be present but not in excess of 50% ground cover or a depth of 1 inch.

- Islands can be excellent predator free breeding habitat for waterfowl members of this guild when they are located in the right environment. Critical features include a distance from shore of at least 160 feet, maintenance of water depths in excess of 50 inches around islands throughout the breeding season, a spacing of at least 60 feet between islands, and no more than two islands per 20 acres of wetland area.

- Several guild members require large dead and down material as cover above the soil surface. At least 4 logs, 15 to 17 inches in diameter at the large end and

20 feet or more in length should be maintained per acre.

vi. Terrestrial sub-surface breeders

Members of this guild may nest, birth young, or rear offspring below the surface of the ground. They either construct their own burrows or utilize natural subterranean cavities or burrows constructed by others. There are 24 species known to breed on the refuge that belong to this guild including the Columbian ground squirrel, northern pocket gopher and badger. Four species are potential breeders. Eighteen mammal species constitute the largest percentage of the membership.

- Highest densities of fossorial guild members are found in areas of deep soils with a minimum of rock.

- Successional stage and structure of the overlying plant community and the proximity to water are important determinants of habitat suitability.

- Deep soil habitat with open or early successional plant cover with an abundance of herbaceous forb species is important to both key indicator species, the northern pocket gopher and Columbian ground squirrel.

- Maintenance of the natural distribution and diversity of successional stages and structural classes on these deep soil sites should meet the needs of this guild.

vii. Shrub breeders

Members of this guild either build nest above the ground in deciduous or evergreen shrubs or rely specifically on shrubs for cover. Guild membership totals fourteen species and include the yellow warbler, willow flycatcher, black-billed magpie, and black-chinned hummingbird. Two species, the yellow-breasted chat and MacGillivray's warbler have been recorded on the refuge but have not been confirmed as breeders.

- Patches of shrub habitat greater than the average reported territory size of shrub nesting passerines (0.83 acres) should be maintained.

- The greater the number of patches, the larger the patch size, and the closer patches are to each other the greater occupancy rate and productivity of guild members.

- Greater volume of shrub foliage in habitat patches provides better security cover by impeding the movement of predators and shielding the nest and/or activities of parents and neonates that can alert a predator.

viii. Tree canopy breeders

All twenty-six members of this guild including the red-tailed hawk, western wood peewee, and red crossbill build nest on the limbs of live or dead trees. All but one species, the red squirrel, are avian. All species have been confirmed as breeders on the refuge.

- In general, higher breeding densities of individual guild members are associated with greater height to the bottom of the tree canopy and greater volume of individual tree canopies.

- The majority of the guild membership are found more frequently and in greater abundance in open forest that provide access to open air spaces and surface and shrub strata for foraging.

- Guild members native to the refuge that require coniferous tree canopies do not have strong area requirements. The size and patchy nature of refuge pine stands are not limiting.

- For guild members that require deciduous tree cover, greater habitat occupancy is found in larger habitat patches in close proximity to other suitable patches in the landscape.

ix. Tree bole and Snag breeders

One of the largest guilds on the refuge, members either excavate their own cavities in the bole or large limbs of a snag or live tree or utilize natural cavities and those excavated by others. There are twenty-nine species in this guild including the red-napped sapsucker, northern flicker, western bluebird, and the big brown bat. All but five members are avian.

- The larger the tree or snag diameter the better. As a rule, most guild members use snags or trees greater than 15 inches in diameter at breast height.

- Snags are more valuable in clumps than individually.
- Trees with large diameter dead tops are important snag resources because of their height and greater longevity
- Forest stand conditions should provide a density of snags necessary to maintain at least 40% of the maximum breeding population of cavity excavators. A good rule of thumb is a density of approximately 3 hard snag equivalents per acre.

x. Cave/Crevice breeders

Members of this guild breed primarily in caves and crevices of rock formations including the Yuma myotis and long-eared myotis, two bat species. All seven species in this guild are confirmed breeders on the refuge.

- Habitats of this guild (caves and crevices in rocks and cliffs) are unique features that are fixed in the landscape and cannot easily be created or enhanced.
- The plant community and the structural or successional stage in which these features occur and the proximity of preferred foraging strata may be important determinants of suitability. Management of the refuge for a natural distribution and diversity of plant communities and structural and successional stages should met the needs of all guild members.

b.Foraging Guilds

The following guidelines are for wildlife guilds that utilize the refuge primarily during migration.

i. Water column and water surface feeders

Members of these guilds are mostly migratory waterfowl and there is a good deal of overlap with habitat utilized by shorebirds in the bare surface feeding guild especially in the near shore areas. The largest difference between the two groups is the timing of migration and the foods being sought. For most waterfowl there is a significantly greater number of spring migrants than fall migrants. Although many spring migrant waterfowl are seeking invertebrate food resources, most fall migrants and swans and diving ducks are seeking preferred plant foods primarily the seeds, roots and tubers of submerged and emergent aquatic plant species.

- Without full water management capability, maintenance of a complex of natural wetlands with dynamic hydrologic cycles will provide the greatest diversity of foraging opportunities during spring and fall migration periods.

- Whenever possible large wetlands with gentle shoreline slopes should be flooded in the winter and spring to a depth that maximizes the amount of shallow flooded shoreline areas. These wetlands should be allowed to drawdown naturally through the spring and summer. These large wetlands have the highest potential for providing a sustained diversity of foraging strata for this guild overtime.

ii. Bare surface feeders

This guild includes all species that utilize the unconsolidated shoreline of wetlands and the wetland edge up to a depth of 8 inches. Members of this guild utilize refuge habitats during both spring and fall migration periods. The largest number of individuals and species is observed during the fall. The primary food resource sought in this stratum during both periods is invertebrates.

- Availability of exposed mudflats and an adjacent, shallow wetland zone with less than 25% vegetative cover from mid-June to the end of September is key to the maintenance of this guild during migration.

- Wetlands with a gradual sloping bottom provide a greater diversity of water depths and shoreline edge resulting in greater invertebrate diversity. As food diversity increases so does the diversity of species using different foraging strategies.

- A complex of wetlands with a different hydrologic regimes, will provide the diversity of habitats required by all waterbird species in a localized area.

iii. Covered surface feeders

The membership of this guild includes migrant ground gleaning passerines, raptors, and geese.

- In general, maintenance of a natural distribution and diversity of plant communities and successional stages will provide the habitats necessary to sustain this guild during migration and wintering periods.

- For raptors such as the rough-legged, red-tailed hawk, northern harrier, and short-eared owl, maintenance of rodent prey populations in open habitats is key to good winter maintenance habitat. Rodent populations are dependent on the availability of grass and forb cover and the presence of litter (see management guidelines for the terrestrial covered surface breeders).

- Canada geese feed primarily in uplands and temporary and seasonal wetlands. Availability of fall plant regrowth is a key determinant of habitat use by geese. Winter wheat fields in surrounding agricultural fields provide this resource in abundance.

Shrub and Tree Canopy feeders

This guild is comprised entirely of passerine species that either feed on the fruit and seeds of shrubs and trees or glean insects from the foliage of these strata.

- Management for these guilds parallels the breeding guilds in these strata.

2. Howellia Management Guidelines

Water howellia is an annual aquatic plant of a monotypic genus in the family Campanulaceae. It is globally rare and a native of the Pacific Northwest. It is known historically from northern California, western Oregon, western and eastern Washington, northern Idaho and northwestern Montana (Shelley and Mosely 1988). Many of these populations are thought to be extirpated. The Refuge contains many of the extant populations of this species. Water howellia was listed as a threatened species under the Federal Endangered Species Act by the U.S. Fish and Wildlife Service in July 1994. A recovery plan is being drafted for the species. The recovery objective in the draft plan is " ... to provide an adequate level of protection for the species and its habitats so that there will be self-sustaining populations distributed throughout its range." Developement and implementation of habitat management plans to sustain water howellia on federal lands is a Priority 1 recovery action.

The habitat of water howellia consists of seasonal wetlands or the margins of semi-permananet wetlands that experience annual fluctuations in water depths. Water howellia germinates in the late summer or fall on the portion of the pond bottom that is exposed when water recedes (Shelley and Moseley 1989). The pond bottoms usually consist of firm, consolidated clay and organic sediments. In order for the plant to grow, flower and produce seeds, these germination sites most be inundated the following spring. Howellia is generally found in water depths less than 3 feet but has been found in depths up to 6 feet. Wetlands are generally small(<3 acres in size), occur in a forested matrix and are frequently bordered by broad-leaved decidouos trees.

Management guidelines

- In a semi-arid region with highly variable climate, maintenance of a complex of wetlands with different basin configurations and hydrologic regimes is essential to the longterm persistence of this species.

- Management activities that increase the slope of a wetland basin will probably reduce the area of suitable habitat.

- Land use activities that significantly alter the basin bottom through mechanical excavation, combustion or sedimentation may displace the seedbed or cause direct mortality of seeds and jeopardize sub-populations of this species.

- Land use activities that significantly alter the hydrologic regime of a wetland resulting in prolonged flooding, increased drought, or changes in the macrophyte community could jeopardize the existence of this species at that location.

- Evasive exotic species capable of invading water howellia habitat, such as reed canarygrass, may through competition for light and space reduce or eliminate the area of suitable habitat in a wetland basin.

- Changes in water chemistry or temperature can result in changes in macrophyte and algal communities that may adversely affect the survival of indivudual populations through competition for light and space.

Appendix E. Habitat Descriptions and Potential Management Strategies

The following discussion covers each of the major habitat types on the refuge(Figure 1), their pre-settlement condition, past and present alterations and potential management strategies.
In addition, the landscape setting of the refuge is described and strategies discussed to maintain connectivity of the refuge to other natural areas.

1. Wetlands

A. Description and Pre-settlement Conditions

Channeled scabland wetlands receive water primarily from spring rains and snowmelt. Runoff is intermittent, localized and generally ceases by late April. At this time wetlands begin to lose water through ground water seepage and evapotranspiration. Because of climatic variations, wetlands go through wet and dry cycles resulting in fluctuations in both the quantity and distribution of different wetland vegetation zones (Figure 2). Populations of wetland dependent wildlife also cycle depending on their life history requirements for different habitat strata within these vegetation zones.

Prior to settlement by individuals of European descent, nearly all surface waters in the channeled scablands were isolated in individual wetland basins except at peak levels in spring of above average water years. Maximum wetland depths were dictated by the elevation of the topographic low separating wetland basins from each other and the natural drainage of the region. The natural drainage pattern for the majority of the refuge is from the northeast to the south west through the Rock Creek and Damage Creek/Cow Creek drainage to the Palouse River. The drainage from Long Lake in the northwest portion of the refuge, historically flowed to the northeast and the Spokane River.
The ground water system underlying the refuge consists of a deep aquifer (Grande Ronde Basalts), a shallow aquifer (Wanapum Basalts), and a confining bed (Wanapum-Grande Ronde Interbed) that impedes movement between the shallow and deep aquifer. Vertical recharge to the system is in the order of 1 to 2 inches per year and occurs in the upper most aquifer layer, which in this area is Wanapum Basalts. Although perched wetlands occur in this area, the majority in this portion of the channeled scablands are a surface expression of water levels in Wanapum Basalts. Any decline in water levels in Wanapum Basalts has an immediate impact on the wetlands complex.

Figure 1. All land cover types

Figure 2. Wetland Dynamics

Fire was an integral part of the refuge landscape. Late summer and fall wildfires initiating in forest uplands burned into wetland basins when water levels were low and wetland vegetation was dry and combustible. Two types of fires, cover and peat burns, occurred in wetland basins. The type of burn was dictated by either the presence or absence of surface water or moist soil conditions.

A cover burn resulted when water or moist soil exist restricting fire to aboveground fuels of residual stems and accumulated litter. Cover burns did not result in individual plant mortality and actually resulted in increased plant biomass and live stem densities for at least two growing season following the burn (Young 1985) Increased growth was probably caused by increased light, soil or water temperature, and nutrients as result of the combustion of residual stems and litter. This increased growth is often higher in protein resulting in increased herbivory by waterfowl and aquatic mammals that may alter the structure and composition of the emergent plant community(Smith and Kadlec 1985). Patchy burns in dense emergent vegetation that reduced litter and residual stems provided improved access to denser, unburned portions for nesting. Removing accumulated dead biomass may have resulted in early hatching and emergence of invertebrates by increasing solar insolation and warming of the water column. This increased food resource undoubtedly benefitted wetland dependent foragers.

Peat burns, occurred when a marsh was drawndown and adequately dried peat soils were present. Under this condition, fire could consume accumulated organic material in the marsh bottom, and cause mortality to below ground plant structures such as roots, tubers and rhizomes. Destruction of these plant organs would alter the structure of the plant community producing a greater amount of open water habitat and improving interspersion and horizontal diversity or patchiness. Peat burns could remove the entire emergent plant community, organic soils, and the associated seed bank resulting in a sterile basin that would take years to reestablish aquatic vegetation.

B. Human Alterations and Current Conditions

By the early part of this century many of the large wetland basins in the channeled scablands area were connected to a man-made drainage system to provide additional acreage for farming. When the refuge was established, drained wetlands within its boundary were restored. Restoration was accomplished by plugging the drainage ditches in smaller wetlands and construction of a dike and water control structure at the outlet of larger sloughs and lakes. Because of the regional nature of the drainage system, surface water from several, drained wetland basins on private land flow through a chain of refuge wetlands to the south and the Palouse River drainage (Figure 3). As a result, some refuge wetlands received supplemental water from these off refuge sources and control structures allow limited management of water levels. Other wetlands that were drained occur at the head of a drainage system and do not receive supplemental water from other wetlands.

The maximum depths of drained wetlands after restoration were often different from the pre-drainage period. The elevation of water control structures were sometimes higher or lower than the natural outlet. Those wetlands that could be held deeper than normal had the potential to become more lake-like with a greater proportion of open water and less shoreline emergent vegetation. The wetlands that could no longer be flooded as deeply became more shallow and seasonal with less open water and a greater proportion of emergent vegetation. Reed canarygrass was planted in restored wetland basins in an attempt to speed recovery of wetland plant communities. This aggressive exotic species quickly dominated the shallow, seasonal wetlands or the shallow zone of the larger permanent wetlands displacing native plant communities. All wetland basins on the refuge now contain reed canarygrass.

Past wetland management strategies involved both the manipulation of water levels in managed wetlands and the mechanical alteration of both managed and natural wetland basins to increase their depth and improve interspersion of wetland vegetation zones. Objective levels for managed wetlands were set to achieve an average depth in the basin of three feet. It was believed that this average depth would provide the quantity and proportion of wetland vegetation zones beneficial to migratory waterfowl. Wetlands were drawn down when aquatic plant surveys indicated decreased productivity and changes in species composition to less desirable plant species. Additional drawdowns were initiated to allow alteration of basin topography to create more open water, construct nesting islands, and replace water control structures.

Figure 3 Refuge wetlands and drainage system

Prescribed fire has also been used to remove accumulated dead biomass of emergent plants in order to set-back succession and improve the interspersion of open water. Past wetland burns were cover burns and provided temporary openings and reductions in the quantity of dead emergent vegetation.

C. Management Strategies

i. Restoration and Water management

a. Managed wetlands with supplemental surface water

Because of the availability of supplemental water, these wetlands can be managed to provide breeding habitat for the water surface, water column and emergent plant breeding guilds on a less cyclic basis then occurred previously. Supplemental runoff can be stored in larger wetlands provide deep water marshes in all but the severest drought years. When these wetlands occur at the head of a drainage system, stored water can also be used to help meet water level objectives in downstream managed wetlands.

Buffer wetlands

Four wetlands(Long Lake, Upper Turnbull Slough, Reeves Lake, and Kepple Lake) can act as potential buffer wetlands during years of below average recharge. These wetlands have been selected because of their greater overall depth and water holding capacity. The control structures on these wetlands allow holding a peak water volume approximately 15% higher than the natural peak volume of the wetland basin. With the exception of Kepple Lake, supplemental water can be used to fill these wetlands to the maximum capability of their respective water control structures during successive years of average or above average recharge. The greater volume of water in these wetlands should allow maintenance of permanent water in most years. Long Lake because of its position in the drainage system and the availability of supplemental water from off refuge sources can act as a reservoir. Stored water can be passed to downstream wetlands to help meet habitat management objectives.

Other managed wetlands

There are 22 wetlands with water control structures where water levels can be established that will meet habitat objectives for a range of values for open water, emergent vegetation and water depths. Meeting these objectives will provide the strata necessary to support wetland breeding and foraging guilds. Water levels can be established using both vegetation simulation models and empirical data. Supplemental water can be used to augment local runoff to reach these water levels. It is important to note that even with supplemental water it will not be possible or desirable to maintain stable quantities or distributions of different vegetation zones and water depths within a wetland basin overtime. Long-term stability of wetlands is often associated with declining productivity in terms of the interspersion of wetland vegetation zones, productivity and composition of submerged aquatic plant communities, and the diversity and abundance of aquatic invertebrates. Use of supplemental water can, however, reduce the extremes of natural cycles and maintain objective levels of wetland strata for longer periods of time.

The following are some general rules that will be used to establish a peak operating level for each managed wetland basin that will have the greatest probability of meeting objectives for wetland strata. They have been empirically derived for prairie pothole wetlands to predict changes in wetland vegetation zones as a result of different hydrologic inputs (van der Valk 1981). The rules predict conversion from one vegetation type to another as a result of different drawdown and flooding scenarios. These rules have been incorporated into spatial simulation models to predict potential effects of global warming on prairie wetlands (Poiani and Johnson 1991). Recently this model with some modifications was applied to a wetland basin on the refuge with good predictive ability (Mahrer 1995).

Establishing emergent deep water marsh

Emergent plant species can establish in a wetland basin either by germination of seeds on exposed mud flats or through spread of rhizomes from established stands of emergent vegetation. Mudflat establishment occurs during drawdown of an open water zone to a depth of less than 1 inch by May or June resulting in the germination of annual and perennial emergent plant species on the exposed seed bed. If the seed bed stays dry or has a water depth less than 1.5 inches following germination, a mixed plant zone will develop. A water depth between -22 and 22 inches the following spring will allow development of an emergent plant zone. Maintaining an emergent marsh requires a water depth between 1 and 20 inches for greater than 4 growing season months. This water regime in any vegetation zone adjacent to an emergent marsh will result in the spread of emergent vegetation at a rate of approximately 10 feet per year.

Conversion to open water

Flooding any vegetation zone at a depth greater than 22 inches for more than 12 growing season months or two years will convert that zone to open water.

A mixed plant zone will revert to open water if standing water is deeper than 1.5 inches for more than 17 growing season months or approximately three years.

Conversion to shallow marsh/wet meadow

If the depth to the water table is more than 22 inches in May a mixed plant zone will convert to meadow/shallow marsh. Maintaining the water table between 4 and 22 inches below the soil surface for 15 growing season months will result in the spread of the wet meadow/shallow marsh into that area at a rate of 3 meters per year.

Establishing or maintaining wet meadow/shallow marsh habitat

Drawdown of an open water area to less than a 1 inch depth will allow germination of both annual and perennial emergent plants. A water depth the following May of more than 20 inches below the soil surface will result in establishment of shallow marsh/wet meadow vegetation. Water depths between 20 and 2 inches below the soil surface for 12 months out of the year will maintain this vegetation zone.

Establishing an operating level

Because recharge is seasonal, meeting objectives will require setting a peak operating level that will meet water depth requirements and duration of flooding given evapotranspiration and seepage losses.

As an example, given an average total annual water loss of 3 feet, meeting the objective of 50% open water, 30% deep water emergent marsh and 20% shallow marsh/wet meadow in a 200 acre wetland basin that currently has 20% open water, 50% deep emergent marsh, and 30% shallow marsh/wet meadow will require the following hydrologic regime;

-Fifty percent or 100 acres of the basin will have to have a peak water depth of no less than 5.0 feet at the beginning of the water year to maintain a minimum depth of 22 inches over the entire growing season. This flooding scenario is necessary for at least two years to convert 60 acres of emergent marsh to open water and maintain the existing 40 acres of permanent open water marsh.

-Sixty acres (30%) of the basin will have to have a peak water depth in April between 4.5 and 3.0 feet to maintain the remaining 40 acres of emergent marsh and convert 20 acres of shallow marsh/wet meadow zone to deep water emergent marsh.

-The remaining 20 acres of the basin should have a peak depth in April between 3.0 and 1.5 feet to maintain it as shallow marsh/ wet meadow.

In order to provide shallow flooded shoreline areas for water strata feeders during migration, water levels can initially be held higher than the operating level when excess water is available. This strategy would work best in wetlands with gradually sloping shorelines. Water levels can be dropped slowly through the migration season to reach objective levels by the beginning of the growing season.

Determining the objective water level at the control structure of each managed wetland will require information on evapotranspiration and seepage losses and the topography of the wetland basin relative to the control structure. Evapotranspiration and seepage losses can be determined empirically through analysis of past water level monitoring records or by the climatic water-budget method (Thornthwaite and Mather 1957). Topographic information needs require a .5 foot contour map of each managed wetland basin. This can be accomplished by surveying managed wetland basins with traditional surveying methods or the use of a geographic positioning system and measurement of basin depth relative to the water control structure. Until this work is completed, interim objective levels can be set through the review of water management records and analysis of the quantity and distribution of wetland vegetation zones in past aerial photography.

b. Managed wetlands with no supplemental water.

Because supplemental water is not available to recover from drawdown or maintain water depths over extended periods of time in these wetlands, active water management is not generally feasible. Based on overall depth, wetlands in this category can be separated into two types. The deeper wetland type with greater than 20% permanent open water has little need for a water control structure because drawdowns can result in artificial deficits that may be difficult to overcome in all but the wettest years without supplemental water. The long-term strategy should be to maximize water retention in these basins. Existing water control structures (McDowell Lake, 30-Acre Lake, and Hale Lakes) can be replaced by a spillway set at a desired maximum level. Drainage ditches can be back-filled and the wetland basin returned to its natural configuration by removal of near shore islands and recontouring.

The remaining wetlands in this category are more shallow and seasonal in nature and have no permanent open water. This may be the result of either a shallower natural basin or the placement of a water control structure below the elevation of the natural outlet. These wetlands often contain extensive alterations to deepen the basin and create nesting islands. Restoration of natural hydrology will involve back filling ditches and recontouring the wetland basin. As a result of the shallowness of these wetlands, they are often dominated by reed canarygrass. Control of reed canarygrass in these managed wetlands can be accomplished in part by deep flooding. This is a possible option in wetlands where the maximum elevation of the current outlet is lower than the pre-drainage outlet such as Palmer Meadow. Raising the elevation of the outlet will allow deeper flooding. Where the outlet is already at the level of the natural outlet, native plant restoration may require using a combination of treatments including the use of grazing, prescribed fire, chemical treatment, discing and seeding. An adaptive management approach can be implemented that utilizes replicated small experimental units that are extensively monitored. Treatment strategies that achieve management objectives can then be applied on a larger scale. Since periodic treatment may be necessary to maintain restored native communities, water control structures that allow drawdown will be needed to provide access to the entire basin for treatment.

c. Natural potholes

These wetlands have not been drained either because of their smaller size or the length of ditch required to connect them to the regional drainage system. Some, however, have been altered through the use of heavy equipment to deepen the basin and create nesting islands. The hydrologic regime of many of these small wetlands has also been altered through changes in the density of coniferous forest cover in local water sheds. Reduction of coniferous forest cover and restoration of deciduous riparian vegetation should increase water yields through decreased transpiration and interception of precipitation (Gifford et al.

1984). Coniferous trees transpire for a longer period of the year than either deciduous woody vegetation or grass and forbs. The presence of tree foliage throughout the year in coniferous forest results in the interception of a greater amount of snowfall by the tree canopy. This results in less snowpack and potentially less runoff to wetland basins. It is likely that intercepted snow evaporates more readily than snow on the ground because of the greater surface area exposed to solar radiation and wind(Debyle 1985). Management emphasis should be the restoration of natural hydrology and both riparian and wetland plant communities through removal of physical alterations and watershed management (see Upland Pine Forest and Aspen Management Strategies).

Water howellia habitat restoration and protection is a primary concern in these wetlands. Restoration of riparian deciduous vegetation and increasing water yield in refuge watersheds will increase the amount of available Howellia habitat by restoring the natural hydrology of refuge wetlands. Control of reed canarygrass invasion in these small isolated wetlands will require more selective treatments that will have minimal adverse effect on Howellia. Little work has been done on developing tools that can control reed canarygrass in this manner. Most work has involved broadcast application of non-selective herbicides and/or mechanical discing. Both of these treatments could have a detrimental effect on howellia. Potential treatment strategies need to be more selective in application or applied during a period of time when water howellia is less susceptible. One possible treatment strategy is the wick application of the glyphosphate chemical, Rodeo. This type of application could potentially reduce the density of reed canarygrass decreasing competition with Howellia. Further study of the impact of reed canarygrass on Howellia and possible canarygrass control strategies is needed.

ii. Fire in wetlands

Because of the interspersion of wetlands in the refuge landscape, reintroduction of fire into upland plant communities will result in the burning of wetlands. As previouisly mentioned, fire is a naturally occurring disturbance in refuge wetlands that performs important ecosystem functions that benefit wetland dependent guilds. Fire periodically removes accumulated litter and standing dead vegetation resulting in increased growth of emergent plants, higher protein content of aquatic plants and earlier emergence of aquatic invertebrates. Combustion of dense accumulations of dead vegetation can also improve access to emergent cover for nesting.

If burns are too extensive, the loss of residual stems of emergent vegetation will decrease the availability of nesting habitat for many emergent plant stratum breeders such as the redhead, ruddy duck, and marsh wren. Fire in wetlands seldom results in the creation of long-term openings in emergent plant beds. Mortality of emergent plants only results from a peat fire (Linde 1969 and Beule 1979) or when wetland recharge is sufficient to cover the burnt stems of emergent plants with 18 inches of water the next growing season (Nelson and Dietz 1966).

The intensity of fire activity in wetlands depends on the presence of water and the moisture content of accumulated litter and standing dead vegetation. During late summer and early fall, the period of natural fire occurrence, the presence of green emergent vegetation and high moisture content of dead vegetation often prevents fire from entering the semi-permanent and permanent wetland basins. These wetlands can in most years act as natural fire barriers. A period of 2 -3 years of drought is often required before fire can carry into emergent plant beds during this season of the year. Seasonal wetlands that dry up by mid-summer will carry a fire during most years. The presence of reed canarygrass which remains green longer than most native species further reduces the years in which fire will burn into wetland basins. Cover burns can be accomplished in most years after heavy frosts have killed and dried emergent plant tops in late fall.

iii. Water quality and quantity protection strategies

Any strategy to protect both quantity and quality of water entering refuge wetlands must deal with both surface and ground water resources.

a. Ground water

Quantity

Most refuge wetlands are directly linked to the shallow Wanapum aquifer. This aquifer is also the primary source of domestic water for rural and semi-rural homeowners around the refuge. Use of the Wanapum aquifer more than its recharge, will result in a lowering of the water table. With increased development outside the city limits of Cheney, overuse is a real possibility. If extensive enough, there would be a direct impact on refuge wetlands.

Another potential threat to the refuge wetlands is the over use of the deeper aquifer in the Grand Ronde Basalts. This aquifer is currently the source of water for the city of Cheney. Although the shallow Wanapum basalts and the Grande Ronde aquifer are separated by a confining bed (Wanapum-Grande Ronde Interbed) that impedes vertical movement of water between the two aquifer systems, this confining bed is not present in all areas.

The major source of recharge for the deep aquifer is laterally from the north. Recharge is limited by a pinching out of these basalts against basement rocks. Ground water divides exist to the east and less prominently to the west within Grande Ronde Basalts. Ground water divides are analogous to surface water divides in that on each side of the divide, water will flow in a different direction with no flow occurring across the divide. One affect of a divide is to limit lateral recharge from direction of the divide.

Long-term pumping in such situations will likely result in wide spread, ground water declines within Grande Ronde Basalts. Such declines will increase potential for flow from Wanapum Basalts, the shallow aquifer, to Grande Ronde Basalts. The hydraulic separation of two aquifer units varies greatly on a regional scale. However, possible lack of an interbed within the local area increases likelihood of an impact on Wanapum water levels due to declines in the Grande Ronde aquifer.

Application of the United States Geological Survey regional model for this area has demonstrated that Wanapum Basalts will be impacted by pumping from Grande Ronde Basalts, even at rates less than those utilized by the City of Cheney (personal communications, Viccaro 1993). Additionally, at these pumping rates the model demonstrated that the radius of influence could extend as much as 11 miles from the pumping center. This radius encompasses the entire refuge.

Any decline in water levels in Wanapum Basalts will have an immediate impact on the wetlands complex. Annual run-off would go more toward meeting ground water deficits resulting in shallower wetlands more susceptible to drought and the encroachment of reed canarygrass and common cattail. This would negatively affect the production of waterfowl and other waterbirds through declining acres of the open water stratum and a lack of adequate brood rearing habitat in late summer.

Ground water deficits may be currently effecting Stubblefield Lake in the southeast portion of the refuge. Prior to 1987, this lake would often hold water well into fall making it an important stopover habitat for migrating waterfowl and shorebirds. In recent years, Stubblefield Lake has gone completely dry as early as mid-June. Although this early drying may have been in part the result of recent drought, early drying has also been evident during recent high run-off years. Investigation of this phenomena is warranted to identify causal factors that may be corrected.

Quality

All homes outside the Cheney city limits are on septic systems. The majority of residential development within a mile of the refuge will be using septic systems. There is a strong possibility these systems could contaminate the Wanapum Aquifer resulting in nutrient enrichment and eutrophication of refuge wetlands.

b. Surface water

Quantity

There are four major man-made drainage systems, Kaegle Ditch, Philleo Ditch, Phillips Ditch and Company Ditch, that flow onto the refuge from private land. These systems drain an extensive area of private land. These off refuge sources are critical to meeting late season brood water objectives in years of below normal precipitation. Any change in these drainage system could seriously affect the quantity and timing of water we receive. This would in turn affect the ability of the refuge to provide habitat for wetland-dependent wildlife.

The Philleo Ditch which diverts Rock Creek from Philleo Lake to Stubblefield Lake is almost entirely on private land. Maintenance of this ditch is necessary to meet refuge water rights. The existing landowner has indicated that he will not be maintaining this ditch in the future. Access to this ditch to do maintenance is not guaranteed. Future landowners may not complete maintenance or allow access. The result would be that Rock Creek water would revert to Philleo Lake, and Stubblefield lake, important migration habitat for waterfowl and shorebirds, would only function as an ephemeral wetland. In addition, there is a current application on file for a junior water right by the Philleo Lake Duck Club that could reduce the recharge necessary to maintain water through the fall migration season.

Quality

Grazing and mechanical disturbance of soil associated with the use of heavy equipment during habitat improvement work on the refuge can potentially affect water quality through increased erosion and sediment transport to wetlands. Heavy concentrations of livestock can deposit nitrogenous waste into wetlands resulting in eutrophication. Drained wetland basins on private lands are currently used as pasture and hay for livestock. Many of these basins are drained by the four major ditches that enter the refuge. A study of water quality completed on the refuge in 1992 by Eastern Washington University (Whalen et. al. 1992) found high concentrations of nitrogen and phosphorus entering the refuge in drainwater from both the Kaegle and Phillips Ditch. The private pastures drained by these two ditches are used as pasture in late summer and fall and during the winter as feedlots. Spring thaw and rain transports the accumulated animal waste into the drainage ditch and onto the refuge. The result is nutrient enrichment of affected wetlands resulting in extensive algal blooms.

In 1992, a potential landowner applied for a permit from the county to allow placement of an auto wrecking yard adjacent to Philleo Ditch. During a public hearing, the refuge manager and several private citizens testified to the importance of Stubblefield Lake to wildlife and the inadequacy of the applicant's environmental checklist as required by the State Environmental Protection Act. The hearing officer found the checklist inadequate and denied the permit until the applicant completed a more thorough review. The applicant has not yet reapplied. As the area around the refuge becomes increasingly urbanized there will be other applications of this sort and a real potential for contamination of surface and ground waters entering the refuge.

c. Protection strategies

All strategies employed to protect, restore, and maintain water quality and quantity will need to assure that activities on the refuge and private lands do not adversely affect both surface and ground water resources important to the refuge. Water quality should be maintained through limiting non-point sources of pollution including sediment from erosion and animal, domestic, and industrial waste. Direct action can be taken on refuge lands to discontinue or modify activities that can contribute to poor water quality or affect the quantity of water reaching refuge wetlands. Water rights applications need to be made to reflect proposed water usage. Water usage needs to be closely monitored to assure maintenance of water rights following adjudication. Minimizing the effects of private land uses will require work with state and local regulatory agencies through their permitting process, landowner incentive programs, and acquisition of sensitive lands.

Exposure of mineral soils and erosional processes are the primary source of sediment to refuge wetlands. Activities that expose mineral soil can be minimized by decreasing intensity of activity, restriction of activities to sites that are not easily eroded, or conducting activities during periods of time when the soil is more resistant to disturbance. Use of heavy equipment during habitat restoration and enhancement is one of the potential disturbing factors. To minimize soil compaction and rutting from tracked or wheeled vehicles, wide flotation tires or tracks that distribute vehicle weight over a larger area can be utilized. Loaders can be used instead of skidding during forest restoration work to avoid removal of ground cover. Maintenance of a buffer of undisturbed vegetation around wetlands can prevent sediment transport from uplands. Restricting activities to periods of time when the soil is either frozen or very dry can also reduce soil disturbance. Many of these measures are currently required of applicants for State Forest Practices Permits and State Hydraulic Project approval. Livestock grazing should not be allowed on highly erodible soils. Activities such as placement of mineral licks or supplemental water points can concentrate livestock activity and can be used as an alternative to redistribute livestock.

Nutrient enrichment of refuge wetlands is primarily the result of livestock waste(Whalen et al. 1992). Direct deposition of animal waste in refuge wetlands has a greater effect on water quality when it occurs over an extended period of time. Annual grazing programs with high numbers of livestock that concentrate use in the same wetlands should be avoided. Other potential sources of nutrient enrichment or contamination include seepage from domestic septic systems and run-off from commercial enterprises. Regulation of point and non-point sources of pollution on private lands that drain onto the refuge is currently the responsibility of state and local agencies. Better coordination and communication is needed between refuge staff and regulatory agencies to assure input on all permits changing land use in areas adjacent to refuge. Refuge staff should continue work with these regulatory agencies to assure that zoning and land and water protection ordinances minimize impacts to water quality.

Beyond local permitting processes and zoning laws, minimizing the impact of private land activities on water quality and quantity can be accomplished through better outreach and education, landowner incentive programs, acquisition of easements or fee title purchase.

The U.S. Fish and Wildlife Service administers the Washington State Ecosystem Conservation Program that provides technical and financial assistance to private landowners to facilitate the protection, enhancement, restoration, and creation of wetlands, Financial assistance is provided on a cost-sharing basis with the landowner and other potential project partners. In exchange for federal assistance landowners must agree, through a wildlife extension agreement, to leave the project in place for a specified time period. The length of the agreement affects the level of federal assistance for the project.

There are also federal programs under the 1996 Farm Bill that provide incentives to landowners to restore, protect, and maintain wetlands and upland wildlife habitat on their lands. The Wetland Reserve Program (WRP) centers on wetland restoration but allows inclusion of up to 50 percent of the adjacent upland. This program offers three options involving purchases of easements of different lengths of time. The purchase price is based on the percentage of agricultural value foregone which varies depending on the length of the easement. Purchase of a perpetual easement is based on 100% of the agricultural value. A 30 year easement option is also available with a purchase price of 75% of the agricultural value. The last option involves restoration of wetlands for a ten year period through direct habitat work. This option requires a 75 % federal to 24% non-federal match for completion of habitat work. The Wildlife Habitat Incentives Program (WHIP)is a cost share program, where a 75 percent federal match 25% non-federal match will support wildlife habitat restoration in both uplands and wetlands. The focus of this program is restoration and enhancement of larger, contiguous areas which contain diverse habitats. The third program is the Environmental Quality Incentives Program (EQIP). Water quality, non-point pollution, and wildlife are the focus of this program. At least 50% of the funding under this program must address livestock concerns. It is a bid-based cost-share program with up to 75% federal to 25% non-federal match required. These programs are administered by the Natural Resource Conservation Service. A key element in all these programs is partnerships between agencies and non-governmental organizations. These partnerships will enhance the priority of submitted projects for funding.

Grants are available under authority of the North American Wetlands Conservation Act for federal agencies or non-federal individuals or groups to enhance, restore or acquire wetlands.

Proposals that represent the efforts of partnerships between public and private entities receive higher priority.

Where these programs are ineffective or the current landowners are contemplating significant changes in land use that could potentially affect the quality and quantity of water entering the refuge the only option available may be fee title purchase or acquisition of development rights on a willing seller basis.

2. Steppe

A. Description and Presettlement Conditions

The open grassland habitats of the refuge fall into a broad category of plant associations referred to as meadow steppe by Daubenmire (1970). Meadow steppe plant associations form a chain around the periphery of the Columbia Basin between areas of extensive forests to the north and east and the more xeric shrub steppe habitats of the lower basin. In contrast to the uniform soil and landscapes of the Palouse prairie, steppe plant associations in the flood tracts of the channeled scablands are intermixed in a mosaic of small remnant loessal mounds and swales comprised of shallow lithosols. This unique patterned ground is often referred to as biscuit and swale topography. The Idaho fescue (*Festuca idahoensis)/*common snowberry (*Symphoricarpus albus*) association is the predominant association on the mound areas. Scabland sage (*Artemesia rigida)/* Sandberg's bluegrass *(Poa sandbergii* and Snow buckwheat *(Eriogonum niveum)/* Sandberg's bluegrass associations are edaphic climaxes and dominate the intermound areas. The three-tipped sage *(Artemesia tripartita)/*Idaho fescue association is a shrub-steppe association and is found on shallow stony soils associated with low ridges that penetrate this landscape.

All associations can support a diverse community of native plant species. The Idaho fescue/snowberry and three-tipped sage/Idaho fescue associations have a well developed herbaceous layer consisting of the perennial grasses; Idaho fescue, bluebunch wheatgrass *(Agropyron spicatum*), and Sandberg's bluegrass, low shrubs such as *Eriogunum spp.* and Wood's rose(*Rosa woodsii)* and numerous herbaceous forbs, including arrowleaf balsamroot (*Balsamorhiza sagittata),* old man's whiskers *(Geum triflorum),* yarrow *(Achillea millefolium),* Silky lupine *(Lupinus sericeus),* and fringecup (*Lithophragma bulbifera)*. The two plant associations found on the stony soils of the intermound area appear to be less diverse because of the sparse nature of the vegetation. Species diversity is however quite high. Sandberg's bluegrass is the predominant grass species with squirreltail (*Sitanion hystrix)* occurring on the mound edges. The primary forb species found in these associations are *Lomatium spp.,* wild onions *(Allium spp),* bitteroot *(Lewisia rediviva)*, and fringecup. These swales or intermound areas maybe intermittently flooded creating vernal pools with a distinct plant community that receives use by waterfowl, shorebirds, amphibians, and invertebrates in the spring. Camas (*Camassia quamash*) and spike rush species (*Eleocharis spp*) often occur in these areas.

Cryptogamic soil crusts comprised of numerous moss and lichen species are prevalent in all plant associations and may play a critical role in nutrient cycling, germination and survival of native plant species, and providing soil structure that retards erosion (Ladyman and Muldavin 1996). These biotic crust are very fragile and susceptible to loss through trampling, frequent fire, and excessive accumulation of litter.

The presence of a well developed cryptogamic soil crusts, the dominance of bunchgrass species that are not well adapted to grazing pressure, the absence of dung beetle species, and the paucity of buffalo and other large native herbivores in the recent archaeological record all indicate that large mammal grazers were not a significant component of the steppe and grassland ecosystems of the Columbia Plateau since the Pleistocene(Mack and Thompson 1982).

The primary natural disturbance in these plant communities is the activity of burrowing rodents. This is especially true in the mound areas. These fragments of meadow steppe provide the only stone free substrate for burrowing rodents and their primary predator, the badger. The soil of these mound areas are frequently disturbed providing a substrate for germination of native annuals and perennials. The presence of basin wildrye (*Elymus cinereus)* on mound areas is often a result of this soil churning. In recent years, this soil disturbance and removal of soil cover by domestic livestock has also provided a substrate for invasion of exotic species introduced through livestock grazing and other agricultural practices.

Although fire occurs in the steppe habitats of the channeled scablands, several lines of evidence indicate that it did not occur as frequently as it does in the pine forests (Daubenmire 1970). The dominance of shrub and grass plant communities and absence of tall woody vegetation in these associations is primarily the result of soil and climatic differences rather than the action of frequent fire. The discontinuous fuel bed associated with bunchgrass communities with biscuit and swale topography are not conducive to fire spread. Although not frequent, fire likely played a role in long-term nutrient cycling and maintaining the vigor of native perennials. A more visible effect that fire may have had on steppe habitats in forest openings and areas bordering established forest stands of the scablands area is the suppression of encroachment by pines. Periodic fire originating in the pine forest may have removed the few seedlings that established on mound areas along the forest edge.

B. Human Alterations and Current Conditions

The main limitation to achieving objectives for refuge steppe and grassland areas is the presence of exotic plant species. Exotic species were established in this community during past agricultural practices that involved farming and livestock grazing. These practices introduced the seeds of exotic species and disturbed the soil surface allowing invasion of native plant associations. The primary exotic species in these stands include cheatgrass brome (*Bromus tectorum*), ventanata (*Ventanata dubius*), St. Johns Wort , dalmatian toadflax, diffuse and spotted knapweed, and leafy spurge. Many of the mound areas in refuge steppe habitats are dominated by cheatgrass and ventanata with few remaining native species. Cheatgrass decreases the survival of native perennial seedlings by rapidly exploiting available soil water and nutrients (Harris 1967). Cheatgrass germinates earlier and over a longer period of time and continues root growth during cooler temperatures than native perennial species. The productivity and density of cheatgrass on the mounds and its early senescence also create a thick layer of thatch that further decreases survival of native plant seedings, reduces the vigor of native forb species, reduces the cover of cryptogamic soil crust and may increase the frequency and intensity of fires(Mack 1981 and Tausch et al. 1994). Increased fire frequency and intensity further modifies steppe plant communities favoring cheatgrass.

Encroachment of ponderosa pine into steppe areas in forest openings and along the forest edge has also occurred(Figure 4). Currently 1000 acres of steppe habitat now have a forest component. Establishment of pine in these areas may be the result of both past grazing that created a mineral seed bed and suppression of fire.

Figure 4. Pine encroachment

C. Management Strategies

i. Exotic Plant Species

Current refuge control strategy for exotic plants relies on minimizing activities that create sites for invasion, biological control and herbicides. Focus is on the control of a few of the more noxious exotic forb species (Diffuse and spotted knapweed, Canada thistle, St. Johns' wort, dalmatian toadflax, and leafy spurge). Herbicides are used where small, isolated populations occur and provide a potential seed source for invasion. Biological controls are used when available for widespread species or in sites where herbicide usage is not advisable. A summary of current control strategies for noxious weeds that will be included in the refuge Integrated Pest Management Plan is provided in Table 1.

The tools outlined Table 1 will remain the primary strategy for the control of these species. Management strategies for the control of cheatgrass need to be developed. Because of the ability of cheatgrass as a competitor, there are few known strategies that are effective in its control outside the agricultural environment (Vallentine and Stevens 1994). The primary strategy in agricultural fields or rangelands dominated by cheatgrass is replacement control (Hironaka 1989). This requires preparation of a suitable seed bed by control of target weed species for a 1 to 2 year period. The primary mode of control is the use of herbicides. Seed bed preparation is followed by seeding of desired plant species. Because cheatgrass seed is still present in the soil and it can germinate over a longer period of time and continue root growth under cooler temperatures it is important to utilize species that have high seedling vigor (Frasier 1994 and Johnson and Asay 1994). Native species often do not have this characteristic. This may require utilizing a less desirable intermediate species that will improve the soil moisture depletion regime for later establishment of native perennial species. Seed coverage is an important aspect of seed placement. Perennial grass seedlings cannot establish unless the seed is covered to ensure anchorage and prevention of root desiccation. Drilling is one of the best ways to ensure adequate seed coverage. Under most range conditions, drilling is not physically or economically feasible. The broken distribution of the mound areas and the presence of rock out crops and stone nets in the channeled scablands will make drilling difficult. Other methods of seed coverage will be necessary.

Table 1. Existing and potential control strategies for six principal noxious weed species.

Species	Control Strategy
Canada thistle	Biological
	Stem mining weevil *(Ceutorhynchus* litura)
	Stem gall fly (*Urophora cardui*)
	Mechanical)
	Mowing and weed eater prior to seed ripening
	Chemical
	Aquatic 2,4-D
Spotted and diffuse knapweed	
	Chemical
	Curtail(Transline and 2,4-D)
	Mechanical(Turnbull Lab site)
	Cultivation and hydroseeding with native plants
	Biological
	Seed head gall fly (*Urophora affinis*)
	Seed eating moth (*Metzeneria paucipunctella*)
Leafy spurge	
	Chemical
	Weedar 64 (2.4-D Amine)
	Biological
	Short-tip gall midge (*Spurgia esulae*)
	Root mining flea beetle (*Apthona spp.*)
	Manual removal
Dalmatian toadflax	
	Biological
	Leaf and flower eating moth (*Calophasia lunula*)
	Defoliating beetle (*Brachypterolus pulicarius*)
	Manual removal
St. John's wort	
	Biological
	Defoliating beetle (*Chrysolina quadrigemina*)

On the refuge, cheatgrass is mostly present in mixed stands of native perennials where replacement control is not warranted. Cheatgrass and other exotic annuals do not normally displace native species in these stands without disturbance. The best strategy for mixed stands is the maintenance of native plant vigor and minimizing disturbances that expose a mineral soil seedbed. Most native steppe communities because of the dominance of widely spaced bunchgrasses maintain vigor without frequent disturbance. However, the presence of cheatgrass in these communities increases the rate at which a heavy litter layer builds up increasing the need for treatment.

Because livestock will graze cheatgrass in the spring prior to senescence, their use in preventing the build up of excessive litter and the control of cheatgrass has been advocated. Precise timing is necessary because native perennials are also susceptible to spring grazing. Grazing heavy enough to reduce seed production and leaf elongation in cheatgrass often impacts native grasses (Vallentine and Stevens 1994). Grazing can also break up cryptogamic soil crusts exposing mineral soil increasing sites for cheatgrass establishment (West 1990). The negative impacts of cheatgrass control by grazing often outweigh the benefits.

Prescribed fire is another tool that can be used to reduce and prevent excessive cover of litter associated with cheatgrass dominance. Fire has an advantage over grazing in that existing litter is consumed. There are, however, some constraints to its use. In areas where fuel loading is unnaturally high, fire intensity will be high resulting in a severe disturbance that may increase cheatgrass density (Whisenant 1990). Perennial bunchgrasses can be susceptible to damage by fires during the growing season when a large accumulation of dead leaves and stems can promote a hot intense fire that damages the root crown (Wright and Klemmendson 1965). Cheatgrass can successfully compete against re-sprouting perennials by rapidly exploiting available soil water and nutrients(Melgoza et al. 1990). Fires timed for the early boot stage of cheatgrass have been shown to retard growth and prevent seed production that year (Rasmussen 1994). If conducted when native perennial grasses are dormant and not actively growing, little or no damage will occur (Countryman and Cornelius 1957, Conrad-Poulton 1966, Daubenmire 1968). Burning during the late winter or early spring may provide enough of a window the following year to allow establishment of native perennial seedlings. Reducing cheatgrass densities with fire is only temporary because of the presence of seeds in the soil and seed sources in untreated areas. When native perennials are few, seeding to speed recovery and maintain reductions of cheatgrass is often warranted.

ii. Pine encroachment

Selective harvest, non-commercial thinning, and prescribed fire are all tools that can be utilized in a strategy to remove encroaching pines. The presence of exotic species must also be taken into consideration when applying these tools. Disturbance of soils or impacts to native species must be minimized. Prescribed fire if properly timed has the lowest risk and the highest probability of meeting objectives for the removal of ponderosa pine from these areas.

iii. Protection of additional steppe habitat

Because meadow steppe habitat in Washington state is primarily in private ownership much of which has been converted to agricultural land (Grue et al. 1995), the refuge should seek to acquire protection of additional meadow steppe habitat adjacent to the refuge. The majority of this undeveloped habitat is south and east of the refuge.

3. Ponderosa Pine Forest

A. Description and Presettlement Conditions

Ponderosa pine zonal associations are intermixed on refuge uplands with both steppe and edaphic climax plant associations. The two major pine associations are Ponderosa pine/Idaho fescue and Ponderosa pine/snowberry (Daubenmire 1952 and Franklin and Dyrness 1973)(Figure 5). The distribution of these associations is influenced primarily by soil moisture regime.

The ponderosa pine/fescue association occurs on more xeric sites and has a convex topography with shallow rocky soils. These stands are often found on flat to gently sloping terrain and low ridges between wetland drainage. The understory is comprised of an abundance of other grasses and perennial forbs including bluebunch wheatgrass, Sandberg's bluegrass, prairie junegrass *(Koeleria cristata),* arrowleaf balsamroot, grass widow *(Sisyrinchium inflatum),* deer vetch *(Lotus nevadensis),* and fringecup. Trees are uneven aged and tree canopy cover is typically less than 50%.

The ponderosa pine/snowberry association is found mostly in shallow depressions, at the bottom of slopes near wetlands, and on the north aspects of basalt bluffs. Soils are deeper, less well drained and consist primarily of silt loams of the Hesseltine complex. The understory of this association can consist of a dense growth of common snowberry, Wood's rose, bearberry *(Arctostaphylous uva-ursi*), and Oregon grape *(Berberis repens)* with a suppressed herbaceous layer consisting of *bluebunch wheatgrass*, several *Poa* species, pinegrass (*Calamagrostis rubescens*) and starry Solomon-plume(*Smilacina stellata*). In more mesic sites, pinegrass can assume dominance of the herbaceous layer. Associated herbaceous species may include rhizomatous bluebunch wheatgrass, starry Solomon-plume, cinquefoil *(Potentilla gracilis)*, and strawberry *(Fragaria vesca*).

At the edge of wetlands and in deeper depressions a tall deciduous shrub layer may occur comprised of such species as *Spiraea sp.,* serviceberry *(Amelanchier alnifolia),* chokecherry *(Prunus virgiana),* golden currant *(Ribes cereum),* and Wood's rose. Quaking aspen, mountain alder (*Alnus incana),* and water birch *(Betula occidentalis)* may also be represented in the understory. Trees establish on these sites more readily, grow quickly and tend to be more densely stocked due to the uniform nature of the soil and higher moisture conditions. Canopy cover

Figure 5 Forest types of Turnbull NWR

on these sites often exceeds 50%.

Ponderosa pine is also found in the steppe associations of the biscuit and swale topography found on higher ridges and near the edge of the Palouse - Cheney flood tract. Groups of trees or individuals are often found on the mound areas. Density of trees is limited by the distribution of the mounds. The extent of pine encroachment into these areas depends on the distance from established pine stands. In general, pine trees are not found much further than 1200 feet from the edge of more contiguous forest stands.

Refuge forest types were mapped from aerial photography by canopy cover class. These cover classes can overlap forest associations. Table 2 correlates the canopy cover class with forest or steppe associations. This map will be refined through field reconnaissance.

Table 2. Forest Canopy cover classes and associated forest types.

Land Cover Type	Canopy Cover	Plant Associations
2240 - 2140	> 75%	Ponderosa pine/snowberry Ponderosa pine/pinegrass
2130	50-75%	Ponderosa pine/snowberry, Ponderosa pine/Idaho fescue
2120	25-50%	Ponderosa pine/Idaho fescue
2110	< 25%	Idaho fescue/snowberry

Based on studies in ponderosa pine communities in the Southwest, pre-settlement stocking densities of ponderosa pine stands ranged from 19 - 47 trees per acre (Covington and Moore 1994). Trees were often found in relatively even-aged clumps approximately 0.07 acres in size (Cooper 1961, West 1969, White 1985). Although a diversity of different age and tree densities were present in the landscape, the overall aspect of the forest was open and park-like, with predominately large diameter trees in single-storied stands(Quigley and Arbelbide 1996). The bottom of the tree canopy was higher as result of frequent pruning by ground fires. This higher canopy resulted in less needle scorch and needle fall. These higher canopies and more open understories favored many canopy breeders and aerial feeders. Stand replacing fires were uncommon. Stand initiation occurred when individual trees or groups of trees died from lightning, disease, insects or fire. Subsequent fires created a mineral seed bed for pine seedling establishment.

Since trees near the end of their physiological life were present in many stands, there were probably a fair number of large dbh snags. These larger snags were more resistant to rot and windfall and probably persisted for decades providing an adequate habitat base for cavity nesting birds requiring more open habitat. Keen (1961) reported average snag densities of 4 snags per acre in ponderosa pine forest in the early part of this century. Densities ranged from 1.1 to 7.9 snags per acre. This range of densities correspond with the recommendations of several researchers studying the needs of cavity using wildlife (Balda 1975, Cunningham et al. 1980, Scott and Oldemeyer 1983, Raphael and White 1984).

The presettlement understory consisted of a dense ground cover of bunchgrasses or low shrubs that favored ground breeding and foraging species. Common snowberry and Wood's rose, although common, were probably less abundant and represented by a higher proportion of live stems as a result of frequent low intensity ground fires. Excessive accumulations of needles and other organic debris would have been reduced by these fires promoting the development of cryptogamic soil crusts on bare soils between the low shrubs and bunchgrasses. These soil crusts are made up cyanobacteria and numerous moss and lichen species(Cooke 1955). Cyanobacteria are capable of nitrification and soil crust can contribute as much as 22.7 lbs of nitrogen/acre/year in semi-arid terrestrial systems (Loftin and White 1996). Through their suspected role in the overall nitrogen budget they may also improve the nutrient content of wildlife forage species. As previously mentioned, these soil crust may have additional benefits associated with increased soil stability and survivorship of native perennial plant species. The presence of a well developed cryptogamic crust can also limit the invasion of exotic plant species by reducing favorable sites for seed germination (West 1990).

B. Human Alterations and Current Conditions

Post-settlement stands of pines in many areas of the West have tree densities in excess of 300 trees per acre. Dense thickets of stagnated pine reproduction are the rule rather than the exception. A thick layer of pine needles has replaced the once dense understory of bunchgrasses. The quantity of downed woody material is greater than ten times that once present in pre-settlement pine forest (Covington and Moore 1994).

Recent inventory of refuge stands show that on the average post-settlement tree densities are not as high as those reported for other areas of the West (Table 3). The highest fuel loading recorded in refuge stands was less than 4 times the acceptable level. There are, however, stands in the higher canopy cover classes that exceed reported densities. The largest difference between existing pine stands on the refuge and pre-settlement conditions is the uniform age structure and tree densities in refuge pine stands over fairly large areas and the conspicuous lack of larger DBH trees (> 24.0 inches)(Figures 7 an 8). Over 90 percent of the trees in refuge stands are less than 20 inches in diameter.

Table 3. Mean stocking densities (trees per acre) of different size classes trees by forest plant association.

Forest type	**<8in**	**8-11.9**	**12-15.9**	**16-19.9**	**>=20in**	**Total**
pine/fescue	64.0	2.1	2.4	1.7	1.2	71.7
pine/snowberry	162.0	6.5	5.0	4.2	1.8	179.5
pine/pinegrass	305.0	15.5	12.7	8.8	6.0	348.0

Some if not all the trees and snags in the largest size class (>=24in) represent pre-settlement trees. Density of these trees in existing refuge stands averages 0.89 per acre. A recent inventory found an average of 0.03 snags/acre with a DBH greater than 24 inches. If refuge pre-settlement pine densities approached the ranges reported in the literature, this represents a loss within the past 100 years of between 2-6 trees per acre. If all this loss was the result of natural mortality, tree deaths would range between .2 and .6 trees per acre per decade. These values are three to five times the mortality rates (Covington and Moore 1994). Undoubtedly some of this loss was due to natural mortality, as evidenced by snags and some large logs, but many of the large pre-settlement trees were removed through logging between 1890 and 1920. Several small sawmills were in operation in the area during this time period providing saw logs and milled lumber to the local municipalities and the railroad(Holstine et al. 1992).

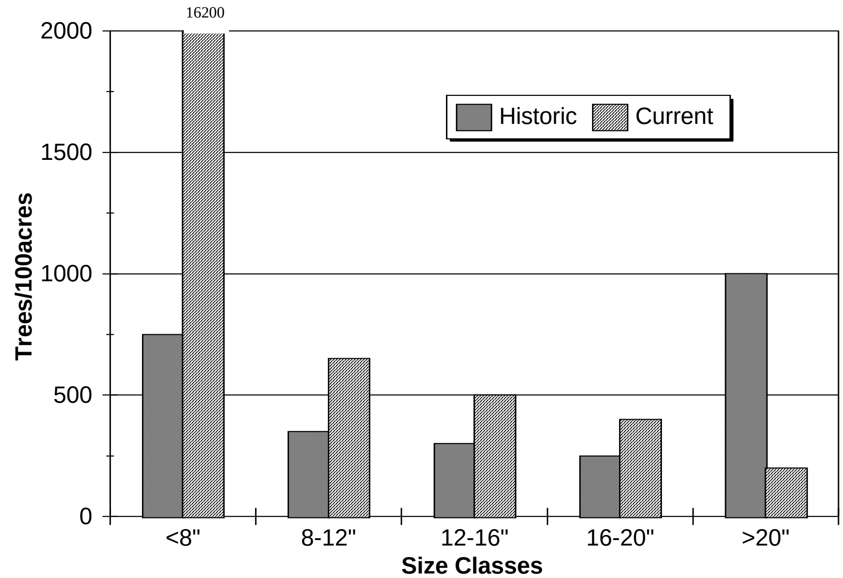


Figure 6 . Comparison of historical and current mean tree densities by size class.

Overall refuge snag densities average 3.2 snags per acre and range between 0.0 and 9.6 snags per acre (Table 4). Densities of snags suitable for wildlife (greater than 15 inches in diameter) are considerably lower (0.7 snags per acre) and do not provide the amount necessary to meet population objectives for cavity using wildlife. Because of the older age structure in aspen communities and shorter life span of aspen, snag densities

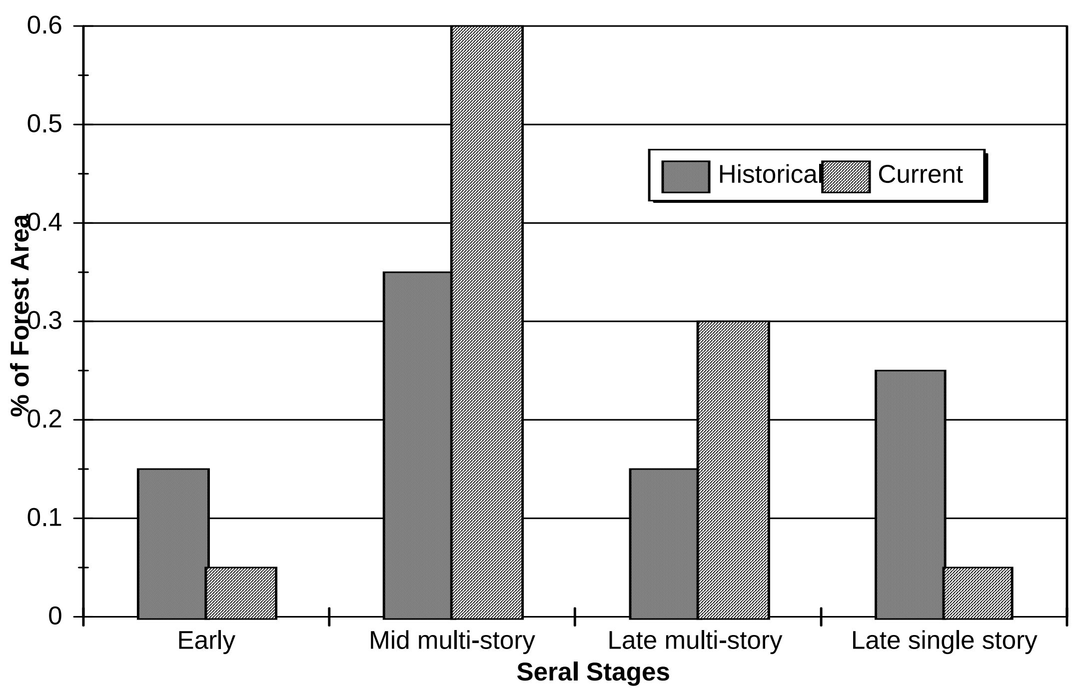


Figure 9. Comparison of historic and current distribution of forest seral stages

(19 snags/acre) are significantly greater than in pine. The 112 acres of aspen dispersed throughout the refuge may be compensating for low snag densities in adjacent pine stands.

Table 4. Mean, minimum, and maximum snag densities (snags per acre) of different size classes for ponderosa pine(n = 20) with greater than 50% canopy cover.

	<5in.	**5-11.9**	**12-17.9**	**18-23.9**	**>=24in.**	**Total**
Mean	0.4	1.7	0.5	0.2	0.04	3.2
Minimum	0.0	0.2	0.0	0.0	0.0	0.0
Maximum	2.9	6.0	4.4	0.7	0.3	9.6

Current recruitment of snags greater than 15 inches in diameter averages 0.1 snags per acre or approximately 1 percent of the live trees in this size class. Snag fall rates have not been calculated for the refuge, but Keen (1955) reported a 2 percent annual average fall rate of beetle-killed ponderosa pine snags in northern California. Assuming no change in these values in the

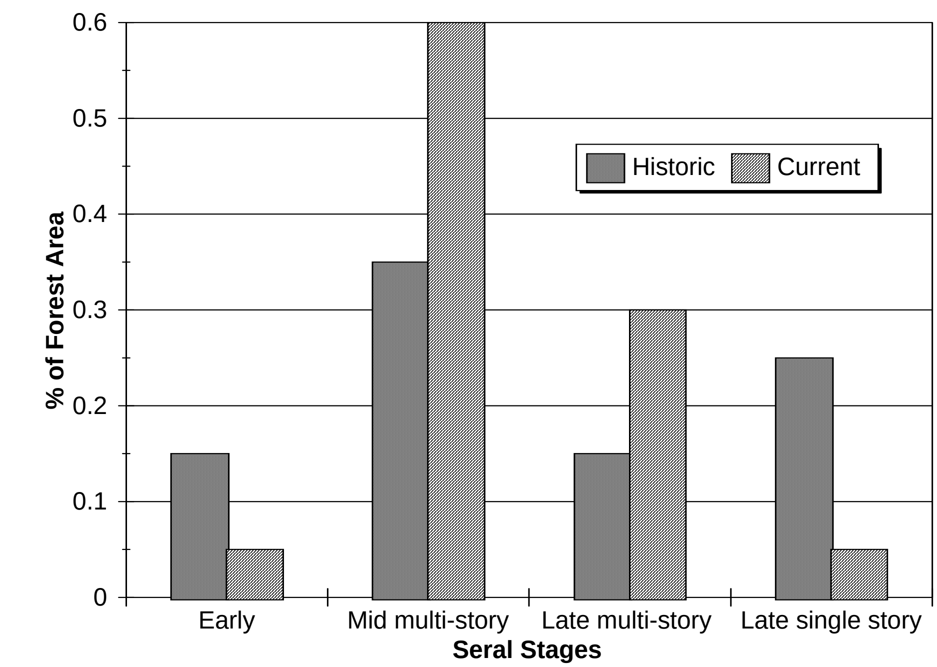


Figure 7. Comparison of historic and current distribution of forest seral stages

long-term , snag objectives will be met within the next 30 years (Figure 9). Based on personal observations, current fall rates may be substantially higher in refuge pine stands. Overstocked stands result in low tree vigor, weak root structure and more rapid decay of heartwood which increases breakage and windfall. Snag fall rates of 30% or greater will result in declining snag densities.

Past land use practices and fire suppression have significantly altered the understory pine stands, affecting the productivity and diversity of native flora. Common snowberry and Wood's rose now cover a much greater area than during pre-settlement times. Dense thickets occur throughout many stands inhibiting the growth of perennial bunchgrasses and herbaceous forbs with a canopy coverage greater than 50%. These thickets contain a large amount of dead stems that increase the crowning potential of ground fires. The expansion of these shrub species has probably been the result of fire suppression and past heavy grazing. Brayshaw (1965) reports that heavy grazing may extend the snowberry site into areas previously dominated by bluebunch wheatgrass. Past grazing pressure has also allowed the invasion of several exotic plant species. In some stands, the understory plant community has shifted to one dominated by exotic invaders such as cheatgrass, ventanata, Japanese brome *(Bromus japonicus),* dalmatian toadflax, and St. John's wort. These species are now
Figure 9. Snag Projections

present in nearly all forest stands. The drier ponderosa pine/Idaho fescue zone is particularly susceptible to this change. Increased canopy cover and greater accumulation of needles and other organic debris has also reduced the coverage and diversity of native understory species. This thick litter layer inhibits the formation of cryptogamic soil crust affecting the nitrogen budget of forest soils (Foxx 1996 and West 1990). Needle litter, high in monoterpenes, inhibits nitrification by cyanobacteria in the soil and the cryptogamic soil crusts (White 1996).

C. Management Strategies

Fire in ponderosa pine forest is a distinct ecosystem process. Without periodic fire, these forests will remain altered ecosystems. The long-term goal of forest restoration and management should be the reintroduction of fire at natural fire return intervals. Ultimately, fire alone should be the key management strategy for maintaining forest structure and ecosystem processes that produce the array of strata required by native wildlife species.

i. Stand Conditions

Before forest restoration can begin, a desired future condition must be established to guide management activities. The two parameters that are often used to describe the structure of uneven aged stands are the density (basal area ft^2/acre)and the *q*-ratio (the ratio between numbers of trees in successive size classes)(Fieldler et al 1996). Basal area reflects the utilization of forest resources by trees in a stand. The q ratio describes the size class structure of the stand. Establishing reference values for these parameters is difficult in highly altered systems and requires some prior knowledge of the historic range of these values. Where reference conditions are not available published values for similar areas in the west will have to be used.

Covington and Moore (1994) reported an average basal area of 65 ft^2/acre for pre-settlement ponderosa pine in 8 stands in their study area in Arizona. Cooper (1960) reported basal area densities of 66 and 86 ft^2/acre for two unmanaged stands in Arizona that represent pre-settlement conditions. Reserve basal area densities between 40 and 80 ft^2/acre were thought to be reasonable guidelines for forest restoration activities in ponderosa pine stands of western Montana (Fielder et al. 1995). The lower densities would be expected on drier sites. Fieldler et al. 1995 utilized a *q*-ratio of 1.2 to 1.4 for 4 inch diameter classes. Although lower than values recommended for uneven aged management, a greater proportion of the basal area is allocated to larger trees. This is consistent with accounts of presettlement forest.

Refuge forests consist of plant associations that probably spanned the range of conditions cited above. The ponderosa pine/Idaho fescue association, the driest forest association on the refuge, likely had basal area densities ranging between 15 and 20ft^2/acre. The Ponderosa pine/snowberry association would have had higher basal areas possibly ranging between 20 and 40ft^2/acre. The stands of this association where pinegrass dominates the understory could have had basal area densities as high as 60ft^2/acre. The q ratio for all associations would probably fall in the range of 1.2 to 1.4 reported by Fieldler et al. (1996). Using a basal area density of 20, 40 and 60ft^2/acre for the three refuge forest associations and a *q*-ratio of 1.2, the desired, post-treatment size class distribution was defined. Comparison of the desired size class distribution with both average and maximum current conditions illustrates the potential tree removal required (Figure 8, 9, and 10).

Forest restoration would require on the average removal of all trees below 8 inches in diameter and removal of between 0 and 60% of the 8 to 20 inch trees depending on current densities. In most cases, trees greater than 20 inches in diameter would be reserved to become the large tree cohort characteristic of pre-settlement forests. Because of the lack of larger diameter trees, the desired post-treatment size class distribution does not reflect the *q*-ratio in all cases. A greater number of trees will have to be removed in the smaller size classes to meet basal area density objectives. Removal of trees less than 8 inches in diameter is warranted because most of these trees established in the understory of a closed canopy stand and have been suppressed throughout their life. Once released they, may retain attributes that decrease their ability to survive in more open forest conditions with a disturbance regime of more frequent ground fires. By creating conditions that favor seed germination and establishment in restored forest these size classes will be replaced with trees better adapted to the natural frequency of fire and distribution of forest stand conditions.

Although fire was the principal means of thinning in pre-settlement forest, the current altered state of refuge forests will make meeting objectives with fire alone difficult. The current uniform structure of forest stands, high fuel loading and the high volume of trees that require removal, present challenges to the use of fire. The uniform density and size of

Figure 8. Current mean, current maximum, and post-treatment tree densities by size class for the Pipo/Feid forest association.

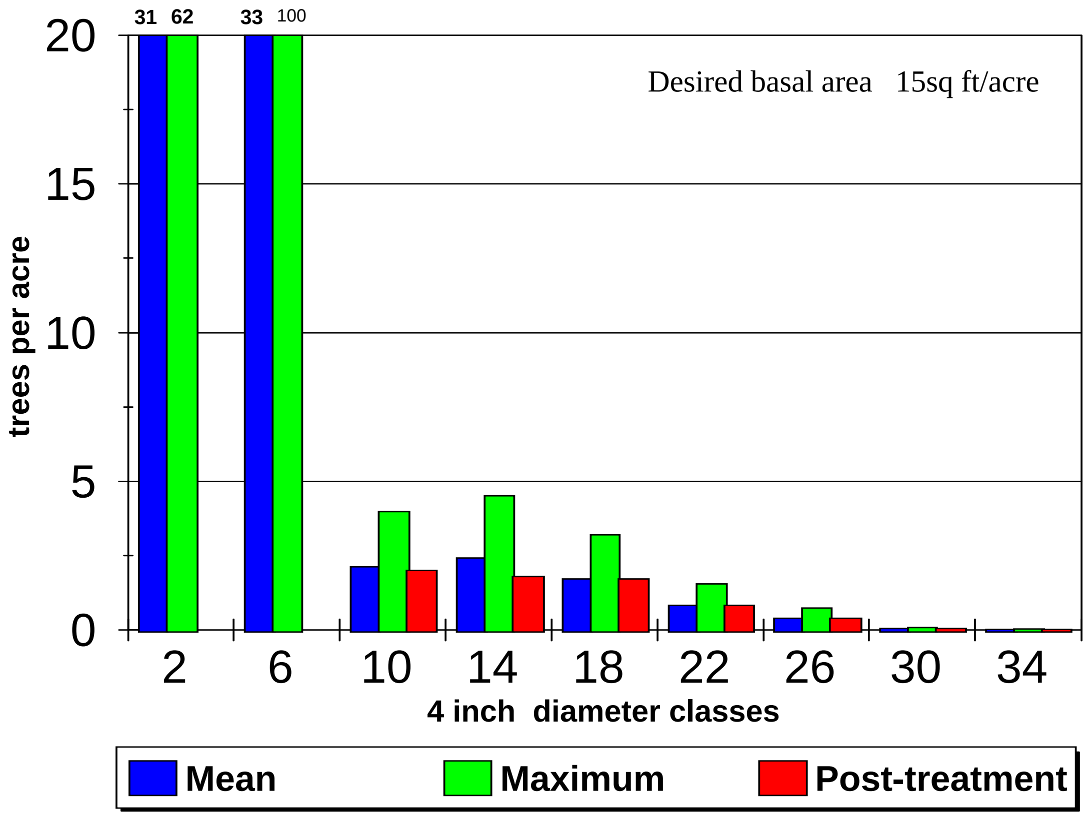


Figure 9. Current mean, current maximum and post-treatment tree densities by size class for the Pipo/Syal forest association.

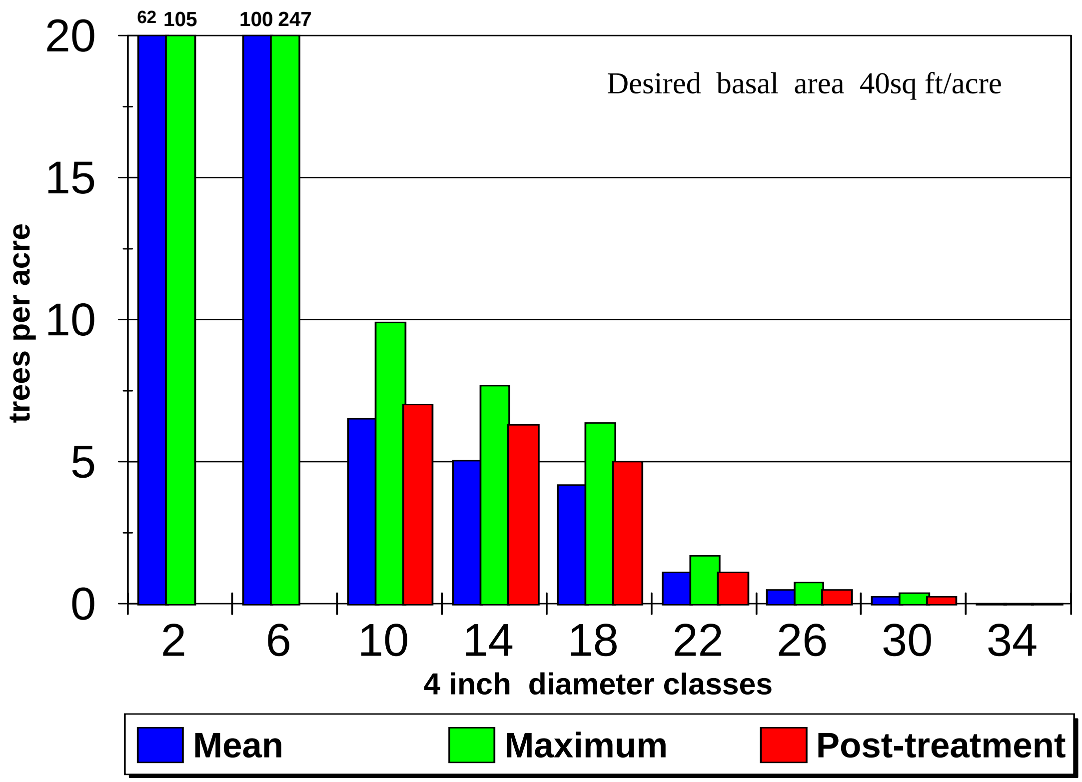
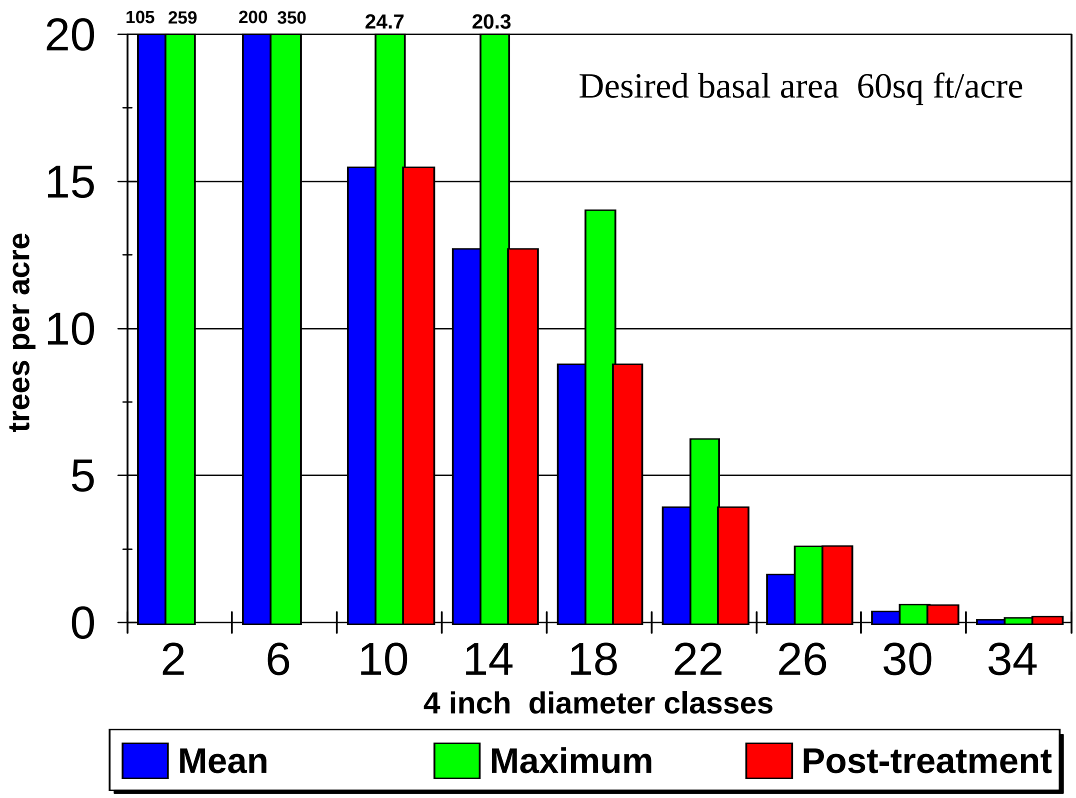


Figure 10. Current mean , current maximum, and post-treatment tree densities by size class for the Pipo/Syal-Caru forest association.



trees in some stands as a result of past logging require that density reductions be non-uniform to restore the clumped nature of forest stands. In many portions of the refuge, the natural patch structure is still apparent in the grouped nature of trees in the larger dbh classes. The average clump or patch size found in the southwest was approximately 0.07 acres in size (Cooper 1961 and White 1985). Where clumps of large dbh trees are still present in forest stands, these groupings can be used as a gauge for reconstructing the natural diversity of patch sizes and tree densities.

The presence of limbs close to the ground and the heavy accumulation of fuels at the base of large diameter trees can result in high mortality of these desired reserve trees when burning. Past forest restoration work utilizing prescribed fire alone found that ground fires at the base of large old growth trees with heavy fuel loading can result in 20 to 50 percent mortality through damage to the root bole and cambium (Harrington and Sackett 1992). Pruning of limbs close to the ground, removal of surface fuels by raking, and control of fire at the base of trees by application of foam or retardant is technically feasible but costly in both time and money. Conducting initial burn treatments in the spring or at night in the summer and fall when fuel moistures are higher, resulting in less intense fires are alternatives that have been utilized. Because these low intensity burns will only partially meet objectives for reducing tree densities or fuel reductions, it will be necessary to follow up with a late summer or early fall burn. The use of spring or night burning is constrained by the availability of fire personnel, weather conditions that promote good smoke dispersal, and safety concerns associated with working under conditions of low visibility.

Although excessive accumulation of fuels on the forest floor and the presence of ladder fuels create problems with high mortality in the larger size class pines, it is possible that unnatural distribution and quantities of fuel can result in too little tree mortality from fire in some stands. This condition often exists in dense pole and sapling thickets. The general lack of fine fuels and higher humidities in these dense thickets require that burns be performed under conditions that may result in less desirable fire effects in other portions of the burn area.

Because of the difficulty in achieving objectives with fire alone in these altered systems, a combination of prescribed burning and flexible silviculture including group selection cuts, single tree selection, patch clearcuts, and both commercial and non-commercial thinning will be necessary. It is important to remember that during any prescribed burn program, there will be some mortality in the larger tree classes. Tree harvest should be set at between 80 to 90 percent of the tree removal objectives to account for fire mortality.

b. Snags and Downed Woody Material

Meeting objectives for snags and downed woody material requires a balance between recruitment and loss of snags of the appropriate size. Snag recruitment occurs when live trees are killed by insects disease, fire, lightning, drought and flooding (Keen 1955, Dahms 1949, Harrington 1996). These mortality factors act both singly and in combination. Insects and many diseases attack trees that are stressed and of low vigor. These conditions occur due to old age, physical injury by fire, drought, flooding and overcrowding. In a healthy ponderosa pine forest with a diversity of stand conditions, tree mortality occurs at a relatively constant level and operates at the single tree or group level (Hessburg et al. 1994) Tree mortality seldom occurs over an entire landscape. Where ponderosa pine forests take on a uniform age structure over an entire landscape, stands are overcrowded, and fuel loadings are unnaturally high, insects, diseases, and fire can kill trees over a large area. Although this provides an abundance of snag resources in the short term, objectives for sustained density of snags will not be met.

Snag losses occur through natural processes of decomposition, consumption by fire, and windfall. Prevention of snag losses during prescribed fire activities can be achieved by the use of foam or retardants or physically removing fuel from the base of snags. Taking these actions would be important if current snag densities are below objective levels. The principal cause of snag fall, however, is decay of the sapwood and heartwood resulting from fungal infection (Keen 1955). Introduction of decay fungus is primarily the result of insect attack. Therefore, snag longevity is related to the ability of the tree once injured to defend against insect attack. The principal defense mechanism in ponderosa pine is the synthesis and translocation of resin that can flush out or isolate insect attackers. Higher resin concentration in the stem retards the spread of decay fungi increasing the time a tree will remain standing after death. Production of resin is energetically costly and allocating resources to its production and translocation is a lower priority then production of foliage, buds, roots, stem elongation, and storage reserves (Raffa and Berryman 1983). Trees that have been severely stressed or damaged may not have the additional resources needed to defend against insect attack and subsequent spread of fungi.

In a study of fall rates in fire-killed ponderosa pine, Harrington (1996) reported that trees with greater than 80% crown scorch died within one year post fire and had a 80% probability of falling within 10 years. In contrast, trees that received less than 80% crown scorch and survived 2 to 3 years post fire had only a 27% probability of falling within 10 years. He associated the greater longevity in the latter group to maintenance of photosynthetic processes for a period of time sufficient to support resin production. Crown scorch is more likely when tree limbs are close to the ground and high accumulations of surface fuels or ladder fuels occur beneath the tree canopy.

Tree size also appears to be a factor in snag retention. Dahms (1949) and Keen (1955) both found that larger ponderosa pine had as much as a 50% lower probability of falling than smaller size class trees. Presumably, larger trees have a greater surface area of decay-resistant heartwood. Larger trees with a large portion of their crowns well above surface fuels are also less likely to receive crown scorching that would limit a tree's response to subsequent insect attack.

Long-term strategy for meeting objectives for snags and downed woody material requires the restoration and maintenance of forest stand conditions that foster recruitment and retention of large diameter snags. Forest conditions should promote the growth of larger, older trees that are more resistant to decay and less susceptible to crown scorch. These conditions should also deter large scale disturbances that kill large numbers of trees and limit the ability of damaged trees to respond to insect attack.

Because of the current low numbers of snags in refuge pine stands, meeting snag density objectives in the short-term will require increasing snag recruitment and retention. Snags can be created in association with forest restoration activities through the use of fire, girdling, or blasting. Fire is the least selective tool for snag creation making it difficult to met specific size objectives. Application of fire must avoid crown scorch greater than 80% and trees should remain alive for at least two years post treatment. Girdling and blasting of individual trees are both selective tools. Of these two options girdling is the least effective because of low snag retention. Trees die immediately after treatment preventing resin production that resist decay. Blasting of tree tops has shown to create snags with lower fall rates. The shorter height reduces risk of blowdown and mortality is often delayed allowing adequate time for some defensive response to insect attack.

An alternative to snag creation is the use of artificial nest boxes until snag objectives are met through forest restoration. The refuge currently has a very successful bluebird nest box program that fledged on the average 400 birds annually. Several other species including the wood duck, hooded merganser, bufflehead, American kestrel, northern saw-whet owl, northern pygmy owl, tree swallow, and all three nuthatch species successfully utilize nest boxes. Nest boxes also provide an opportunity to monitor the productivity of cavity using species.

c. Forest Understory

Strategies for restoring the forest understory communities will involve opening the dense overstory canopy, reductions of excess litter and low shrub cover, controlling existing populations of exotic plant species and minimizing soil disturbances that promote further invasion of exotic plant species. A combination of spring fires of intermediate intensity to partially remove accumulated fuels followed by hotter summer and fall burns should result in increased production and density of native perennial grass and forb species. Summer and fall burns have a greater probability of reducing the density of both common snowberry and Wood's rose. These shrubs are both root sprouters. Hot fires that burn down into the forest floor have a greater probability of damaging their rhizomes. Cool spring fires can actually increase the densities of these plants by stimulating greater sprouting. One of the negative aspects of hot, intense understory burns is the complete loss of the native plant community(Sackett et al. 1996). This can occur where there is an extreme accumulation of fuel loading such as under the canopy of some of the larger pine trees, areas with large, downed woody material, or where logging slash has been piled. These disturbed areas can be invaded by exotic species including bull thistle (*Cirsium vulgare*), mullein (*Verbascum thlaspus*), and cheatgrass brome. These may eventually revert to native plant communities by emigration from adjacent areas. Reseeding can speed up this process. Heavy equipment use during silvicultural activities can also disturb the forest floor creating sites for exotic plant invasion. Conducting these activities at times when the soil is frozen or dry can minimize disturbance. The use of vehicles with wider tires that distribute the weight over a larger area can also reduce rutting and soil disturbance. Log landing areas should be well dispersed to reduce the length of skid trails and the butt-end of felled trees should be lifted off the ground during skidding to avoid soil disturbance. All disturbed areas should be rehabilitated by removing berms and replacing top soil. Seeding may be warranted to speed recovery.

Existing populations of exotic plant species in forested areas are similar to those found in steppe plant associations. Control strategies discussed for these associations will also apply to the forested associations as well.

Intense grazing by hooved herbivores was no more a part of the natural disturbance regime of forest associations of the Columbia Basin than the steppe associations. Although grazing by domestic livestock can be managed to minimize impacts to forest understory species, there are no wildlife management objectives that can be met by the use of livestock grazing. Grazing removes plant cover which decreases residual plant material and litter both important habitat components for terrestrial covered surface breeders. The hoof action of grazing livestock also disturbs the soil surface destroying the cryptogamic soil crusts and exposing mineral soil. This type of disturbance can increase soil erosion, create opportunities for invasion by exotic species and decrease the nitrogen fixing capability of soil crust. Grazing should be excluded from forested plant associations

d. General forest prescription

The following is a generic prescription for forest restoration based on the previous discussion;

- In general, trees greater than 24 inches should be reserved.

- If a deficit of snags and large woody debris occurs in the stand, they can be created from live trees larger than 15 inches dbh. Existing large diameter snags should be protected by removal of fuels around their base or the use of foam during burning operations

- Unless the lack of larger size class prevents meeting basal area density objectives, tree stems less than 8 inches in diameter should be cut and removed from the site. If left on site, they should be piled for later burning.

- Commercial harvest should be employed to remove excess trees in intermediate size classes. Single -tree selection and group-selection should be used to create a grouped spatial arrangement of different densities and size classes, including openings for future regeneration.

- All commercial harvest involving the use of heavy equipment should take place in the winter when soils are frozen and snow covered.

- Thinning and commercial harvest activities should be followed up with low intensity burn to remove a portion of the slash and piles. Another burn should be completed in the late summer or fall of the following year to complete fuel reductions and understory treatment.

- Treatment units should be burned again at approximately 10 to 25 year intervals to mimic natural fire return intervals (Arno 1988 and Kinateder and Stein 1998).

4. Aspen and Riparian Shrub

A. Description and Presettlement Conditions

Aspen dominated forest stands are a critical resource for species requiring both cavities and deciduous foliage in tree and shrub canopies for breeding and foraging. In the channeled scablands, aspen communities are often linear and occur along the margin of meadows and large sloughs, and as rings around the margins of pothole wetlands where soil and moisture conditions are favorable for aspen growth(Figure 11). The understory of these stands are often dominated by such deciduous shrubs as red-osier dogwood (*Cornus stolonifera*), Wood's rose, chokecherry (*Prunus virginiana*), and serviceberry (*Amelanchier alnifolia*). In the drier upland portion of these stands snowberry and rose are the dominant understory species. Along the upland edge of existing stands and in slight topographic depressions, aspen can be seral to ponderosa pine. Without periodic fire to remove pine regeneration and promote aspen suckering, these aspen stands will eventually become a climax pine community.

B. Human Alterations and Current Conditions

In many stands, the overstory is dominated by overmature aspen with little regeneration. These even age communities are probably the result of past heavy grazing by domestic livestock that removed aspen shoots(Debyle 1985a). Although these stands provide important habitat for snag and tree bole breeders and feeders, the lack of structural diversity decreases the availability of the shrub strata. The lack of regeneration will eventually result in loss of this resource. Fire can play a role in regenerating these overmature stands by removing the dominance of overstory trees and stimulating root sprouting. There is also the possibility that dense understory thickets of shrubs that occur in some of these overmature stands suppress the shade-intolerant aspen regeneration.

Approximately, 100 acres of aspen/tall shrub habitat are now dominated by a closed canopy overstory of Ponderosa pine. Because of the high site index, the majority of these pines are greater than 15 inches in diameter. Succession to a ponderosa pine climax community has occurred on the upland edge of riparian communities and in topographic lows with greater soil moisture resulting in a decrease in number and sizes of habitat patches. In most stands,

Figure 14. Aspen and deciduous shrub habitats Turnbull NWR.

some aspen still exist although suppressed and of low vigor. There are stands where stumps and decaying logs are the only evidence of aspen presence in the past.

There are four streamside riparian areas where deciduous tree and shrub cover has been removed as part of a past program to improve water delivery. Three of these sites occur along Pine Creek near refuge headquarters. Pine Creek, a spring-fed system, was altered through the construction of five dams to create ponds. The portions of creek between the ponds and at the spring sources were excavated and all riparian vegetation was removed to facilitate water movement. The fourth site is along the water delivery ditch between Reeves Lake and Upper Blackhorse Lake. This area was primarily a seep area that flooded at high water in the spring. It was cleared of riparian shrubs species for farming prior to excavation of the ditch and building a dike on the eastern edge of Reeves Lake.

C. Management Strategies

Meeting aspen/shrub riparian objectives will require strategies that can return dominance of aspen and deciduous shrubs to stands where ponderosa pine is climax, regenerate declining, even-aged stands, and restore degraded stream side riparian habitat. The periodic use of prescribed fire can remove advance regeneration of ponderosa pine and kill above ground aspen stems stimulating regeneration through root sprouting. Where mature pines are suppressing aspen growth and vigor, commercial harvest or non-commercial thinning can be used to remove trees. Pine trees greater than 24 inches in diameter at breast height can be killed and left as snag habitat. If these large diameter pines, represent the only old growth pine remaining in an area they should be maintained. In cases where fuel moistures are too high or fuels are inadequate to carry a fire through a stand, clearcutting of aspen or use of mechanical crushing can initiate suckering (Shepperd 1996 and Schier et al. 1985). Mechanical treatments are more effective if slash is removed from the site.

Restoration of degraded riparian habitats can be accomplished through the use of plantings. An excellent discussion of species and techniques related to plantings are provided by Monsen (1983) and in a symposium proceedings compiled by Clary et al. (1992). This strategy has already been employed on the reach of Pine Creek from Headquarter Pond to Winslow Pool using volunteers from the local Audubon chapter and scout groups. Rooted stock of thin-leafed alder (*Alnus incana*), black cottonwood (*Populus trichocarpa*), aspen, and red-osier dogwood have been used in these plantings. Because many of these areas are currently dominated by reed canarygrass, a planting area of approximately 16 ft^2 was cleared to reduce competition with shrub and tree plantings. A 4 X 4 ft^2 piece of used carpet was placed over the planting to retard reinvasion of reed canarygrass.

Domestic livestock and large native herbivores can significantly reduce the effectiveness of restoration strategies by overbrowsing aspen and shrub regeneration (Debyle 1985b). Once suckers reach a height of 6 feet impact is minimal. Fencing individual stands until this height is met is an effective means of reducing ungulate use but is costly and labor intensive. Reduced stocking densities or deferred grazing of burn units have also been successfully utilized to reduce impacts of domestic browsers. Dispersion of treatment sites throughout the landscape may be a more cost-effective method of reducing impacts by native browsers than fencing. A single treatment block in a given year has a tendency to concentrate animals attracted to higher quality forage.

5. Landscape Linkages

A. Description

The refuge is located on a narrow peninsula of the Ponderosa Pine zone of northeastern Washington that extends into the steppe associations of the Columbia Basin (Figure 12). Linkage of forested associations of the refuge to the large more contiguous forest areas to the north and east occur along Latah Creek to the Mica Peak/Dishman Hills area south of Spokane and north through the Medical Lake area to the Deep Creek Drainage.

B. Current Conditions

These corridors are already bisected by Interstate 90 and State Highway 195. Urban development along both these transportation corridors and in each of the drainages are further eroding the biological effectiveness of these corridors.

C. Management Strategies

The overall goal in these forested corridors is the maintenance of native cover. Achieving this goal will require working with state and local regulatory agencies through their permitting process, landowner incentive programs, and acquisition of sensitive lands to prevent the loss of forest cover.

Refuge staff should work closely with city and county planners during Comprehensive Planning required by the state Growth Management Act to assure that zoning laws maintain a low density development buffer within a mile of the existing refuge boundary and that biologically effective landscape linkages be maintained to the northern forest zones.

Many of the federal cost share programs identified under the wetland protection strategies provide for the protection of adjacent upland habitats. These programs should be utilized in conjunction with an outreach and education program to build partnerships with private landowners that will help minimize isolation of the refuge. The Eastside Ecosystem Project may provide a framework whereby these programs can be implemented. Refuge forest restoration activities can be used as demonstration of land management practices that maintain wildlife habitat in channeled scabland forests.

Figure 12 Landscape linkages