Chapter 6
Environmental Consequences

Chapter 6 Environmental Consequences

6.1 Summary of Effects

Chapter 6 provides an analysis of the environmental consequences of implementing the alternatives described in Chapter 2. Impacts are described for the main aspects of the environments described in Chapters 3 through 5, including physical, biological, cultural, and socioeconomic resources. The alternatives are compared "side by side" under each topic, and both the adverse and beneficial effects of implementing each alternative are described. The overall cumulative effect on the environment from implementing the various alternatives is summarized in Section 6.8. More detailed assessments of the Tualatin River National Wildlife Refuge's (the refuge's) cumulative effects for relevant impact topics are presented section by section. For additional reference, see Appendix P for maps of land status, hydrology, public use, and management alternatives.

Table 6-1 provides an overview of the effects under each alternative by indicator. Effects are described in terms of the change from current conditions. Although the analysis shows that none of the alternatives would be expected to result in significant effects, some positive (beneficial) or negative effects are expected. The terms intermediate, minor, and slight, are used to describe the magnitude of the effect. To interpret these terms, intermediate is a higher magnitude than minor, which is of a higher magnitude than slight. The word neutral is used to describe a negligible or unnoticeable effect compared to the current management plan as depicted in Alternative 1. For more detail, please refer to the remainder of Chapter 6.

The information used in this comprehensive conservation plan/environmental assessment (CCP/EA) was obtained from relevant scientific literature, existing databases and inventories, consultations with other professionals, and personal knowledge of resources based on field visits and experience.

The terms identified below were used to describe the scope, scale, and intensity of effects on natural, cultural, and recreational resources.

- **Neutral.** Resources would not be affected, or the effects to resources would be at or near the lowest level of detection.
- **Slight.** Resource condition changes would be so slight there would not be any measurable or perceptible consequence to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource.
- **Minor.** Effects would be detectable but localized, small, and of little consequence to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource. Mitigation, if needed to offset adverse effects, would be easily implemented and successful.
- **Intermediate.** Effects would be readily detectable and localized, with consequences to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource. Mitigation measures would be needed to offset adverse effects, and would be extensive, moderately complicated to implement, and probably successful.
- **Significant (major).** Effects would be obvious and would result in substantial positive or negative consequences to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource within the local area and region. Extensive mitigating measures may be needed to offset adverse effects and would be large scale in nature, very

complicated to implement, and may not have a guaranteed probability of success. In some instances, major effects would include the irretrievable loss of the resource.

Time and duration of effects have been defined as follows.

- **Short term or Temporary.** An effect that generally would last less than one year or season.
- **Long term.** A change in a resource or its condition that would last longer than a single year or season. All effects described below are long term unless otherwise indicated.

Table 6-1. Summary of Effects to Habitats, Major Wildlife Groups, and Public Use

	Alternative 1 (No Action)	Alternative 2 (Preferred)	Alternative 3 (Alternative Action)
Effects to the physical environment			
Effects to hydrology	Neutral effects as no changes would be made	Minor positive long-term effects as Rock and Chicken Creeks, and Wapato Lake would be restored	Minor positive long-term effects as Rock and Chicken Creeks, and Wapato Lake would be restored
Effects to water quality	Neutral or slightly positive long-term effects as streams are restored and croplands are converted to native habitat types	Neutral or slightly positive long-term effects as streams are restored and croplands are converted to native habitat types	Neutral or slightly positive long-term effects as streams are restored and croplands are converted to native habitat types
Effects to air quality	Neutral effects as restoration and maintenance of habitats continues	Slight short-term negative effects that would impact vegetation and may displace wildlife, but a slight long-term and beneficial effect as prescribed fire is introduced and restoration of native habitat types allows for increased carbon storage	Slight short-term effects that would impact vegetation and may displace wildlife, but a slight long-term and beneficial effect as prescribed fire is introduced and restoration of native habitat types allows for increased carbon storage
Effects to visual quality	Neutral effects as management activities continue	Neutral to slightly positive long-term effects as new infrastructure designed to enhance visitor viewing opportunities are constructed	Neutral effects as more closed canopy habitats are restored
Effects to habitats			
Effects to bottomland riparian forest and	Slight positive effects from maintaining and	Neutral effects as some bottomland riparian	Intermediate positive effects from expanding

Table 6-1. Summary of Effects to Habitats, Major Wildlife Groups, and Public Use

	Alternative 1 (No Action)	Alternative 2 (Preferred)	Alternative 3 (Alternative Action)
associated species	restoring bottomland riparian forest	forest is converted to other habitat type and new areas are restored to this habitat type	bottomland riparian forest
Effects to mixed coniferous/deciduous forest and associated species	Slight positive effects from maintaining mixed coniferous/deciduous forest	Slight positive effects from expanding mixed coniferous/deciduous forest	Minor positive effects from moderate expansion of mixed coniferous/deciduous forest
Effects to oak savanna and associated species	Slight positive effects from maintaining oak savanna	Slight short-term negative effects that would impact vegetation and may displace wildlife due to prescribed fire, but a slight long-term and beneficial effect as prescribed fire is introduced and restoration of native habitat types allows for increased carbon storage. Overall slight positive effects from restoration of oak savanna	Minor negative effects from conversion of oak savanna to other habitat types
Effects to wet prairie and associated species	Slight positive effects from maintaining wet prairie	Slight short-term negative effects that would impact vegetation and may displace wildlife, but a slight long-term positive and beneficial effect as prescribed fire is introduced and restoration of native habitat types allows for increased carbon storage. Overall, intermediate positive effects from expanding wet prairie from currently farmed areas	Neutral effects from expanding wet prairie in some areas while reducing this habitat type in other areas

Table 6-1. Summary of Effects to Habitats, Major Wildlife Groups, and Public Use

	Alternative 1 (No Action)	Alternative 2 (Preferred)	Alternative 3 (Alternative Action)
Effects to herbaceous and scrub-shrub wetlands and associated species	Neutral effects from maintaining wetlands	Slight positive effects to wetlands by reducing some wetlands in the Sherwood Units while restoring wetlands in the Wapato Lake Unit	Minor negative effects to wetlands by further reducing wetlands in the Sherwood Units while restoring wetlands in the Wapato Lake Unit
Effects to streams, rivers, and backwater sloughs and associated species	Slight positive effects from maintaining streams, rivers, and backwater sloughs	Intermediate positive effects from restoring streams and backwater sloughs	Intermediate positive effects from restoring streams and backwater sloughs
Effects to croplands and associated species	Neutral effects from maintaining croplands	Intermediate negative effects from converting croplands to native habitat types	Intermediate negative effects from converting croplands to native habitat types
Effects to ruderal lands and associated species	Intermediate long-term negative effects as these lands are restored to native habitat types	Intermediate long-term negative effects as these lands are restored to native habitat types	Intermediate long-term negative effects as these lands are restored to native habitat types
Effects to fish and wildlife			
Effects to state- and federally listed and special-status species	Minor long-term positive effects from continuing to introduce and maintain listed and special-status species	Minor long-term positive effects from continuing to introduce and maintain listed and special-status species	Minor long-term positive effects from continuing to introduce and maintain listed and special-status species
Effects to nonnative plant and animal species	Neutral effects from continued management to reduce nonnative plant and animal species	Minor long-term positive effects to native habitat types and native fish and wildlife by implementing measures to further reduce nonnative plant and animal species	Minor long-term positive effects to native habitat types and native fish and wildlife by implementing measures to further reduce nonnative plant and animal species
Effects to waterfowl	Neutral effects from maintaining current habitat types	Minor positive effects for waterfowl by reducing some wetlands in the Sherwood Units while restoring croplands to wetlands in the Wapato Lake Unit	Neutral effects for waterfowl by further reducing wetlands in the Sherwood Units while restoring croplands to wetlands in the Wapato Lake Unit

Table 6-1. Summary of Effects to Habitats, Major Wildlife Groups, and Public Use

	Alternative 1 (No Action)	Alternative 2 (Preferred)	Alternative 3 (Alternative Action)
Effects to songbirds	Slight positive effects as recently restored habitat matures	Intermediate positive effects as more bottomland riparian and mixed coniferous/deciduous forest, oak savanna, and wet prairie habitat types are expanded	Slight positive effects as more bottomland riparian and mixed coniferous/deciduous forest habitat types are expanded, but wetlands, oak savanna, and wet prairie are reduced
Effects to shorebirds	Neutral effects from maintaining current habitat types	Slight positive effects for shorebirds by reducing some wetlands in the Sherwood Units while restoring wetlands in the Wapato Lake Unit	Neutral effects for shorebirds by further reducing wetlands in the Sherwood Units while restoring wetlands in the Wapato Lake Unit
Effects to marshbirds and waders	Neutral effects from maintaining current habitat types	Intermediate positive effects for marshbirds and waders by reducing some wetlands in the Sherwood Units while restoring wetlands in the Onion Flats and Wapato Lake Units	Slight positive effects for marshbirds and waders by further reducing wetlands in the Sherwood Units while restoring wetlands in the Onion Flats and Wapato Lake Units
Effects to raptors	Neutral effects from maintaining current habitat types	Slight positive effects for raptors as a result of habitat conversions	Slight positive effects for raptors as a result of habitat conversions
Effects to mammals	Slight positive effects as current restoration of habitat matures	Minor positive effects for most mammals as native habitat types are restored	Minor positive effects for most mammals as native habitat types are restored
Effects to native fish	Slight positive effects for native fish as current restoration of habitat matures	Intermediate positive effects for native fish as streams and backwater sloughs, and other habitat types, are restored	Intermediate positive effects for native fish as streams and backwater sloughs, and other habitat types, are restored
Effects to reptiles	Slight positive effects as current restoration of habitat matures	Intermediate positive effects as habitats are restored, especially as cropland is taken out of production and streams and backwater sloughs are restored	Intermediate positive effects as habitats are restored, especially as cropland is taken out of production and streams and backwater sloughs are restored

Table 6-1. Summary of Effects to Habitats, Major Wildlife Groups, and Public Use

	Alternative 1 (No Action)	Alternative 2 (Preferred)	Alternative 3 (Alternative Action)
Effects to amphibians	Slight positive effects from maintaining current habitat types	Minor positive effects as cropland, especially in the Wapato Lake Unit, is restored to wetland habitat types	Slight positive effects as cropland, especially in the Wapato Lake Unit, is restored to wetland habitat types, but some negative effects at the Sherwood Units as wetland habitat is reduced
Effects to cultural and historic resources			
Effects to cultural and historic resources	Slight negative effect from lack of adequate protection and interpretation of cultural resources	Minor positive effect from stronger inventory, evaluation, and protection of, and education about, cultural resources	Minor positive effect from stronger inventory, evaluation, and protection of, and education about, cultural resources
Social effects			
Effects to wildlife observation and photography	Neutral effect	Minor positive effect from providing additional facilities and improved program quality	Minor positive effect from improved program quality
Effects to environmental education	Neutral effect	Intermediate positive effect by increasing participation in program, adding new program elements, and improving program quality	Minor positive effect from enhancing current program
Effects to interpretation	Neutral effect	Minor positive effect from improving program quality and building new partnerships	Minor positive effect from improving program quality and building new partnerships
Effects to hunting	Neutral effect	Intermediate positive effect due to establishing waterfowl hunt program(s)	Intermediate positive effect due to establishing waterfowl hunt program(s)
Effects to fishing	Neutral effect	Intermediate positive effect by establishing a fishing program	Neutral effect as no fishing would be established

Table 6-1. Summary of Effects to Habitats, Major Wildlife Groups, and Public Use

	Alternative 1 (No Action)	Alternative 2 (Preferred)	Alternative 3 (Alternative Action)
Effects to nonwildlife-dependent recreation	Neutral effect	Neutral effect as no nonwildlife-dependent uses are proposed	Neutral effect as no nonwildlife-dependent uses are proposed

6.2 Effects to the Physical Environment

Topics addressed under the physical environment section include direct and indirect effects to hydrology, water quality, air quality, visual quality, and geology/soils. Direct effects are generally caused by a particular action and occur at the same time and place as the action. Indirect effects are reasonably foreseeable effects caused by the proposed action, but occur later in time.

6.2.1 Effects to Hydrology

Under Alternative 1 (no action) there would be no change to hydrology as described in Section 3.2 of this CCP/EA.

Under Alternative 2 (preferred) and Alternative 3, intermediate, positive long-term effects would take place in the hydrology of Chicken and Rock Creeks in the Sherwood Units, and Ayers, Wapato, and Hill Creeks in the Wapato Lake Unit as these areas are restored. These positive effects include returning stream channels to a more natural meandering condition, reduced streambank erosion, increased groundwater recharge, and sediment and nutrient trapping by vegetation. Minor short-term negative effects would occur during restoration and include direct impacts such as disturbance to stream channels, erosion, sediment inputs, disturbance of habitat, release of stored nutrients from fertilizers, and displacement of fish and wildlife. Restoring croplands to wetlands and other habitat types in both the Sherwood and Wapato Lake Units would have similar short-term minor negative effects, but these would be offset by long-term intermediate positive effects to habitats, fish, and wildlife. Converting wetlands to wet prairie in the Sherwood Units would likely have a neutral effect on hydrology. Short-term minor negative effects of conducting this conversion would include some local erosion and siltation. Long-term minor positive effects are increased floodplain storage during flood events and trapping sediments and nutrients by vegetation.

6.2.1.1 Overall Effects to Hydrology

Overall, Alternative 1 would be expected to have a neutral effect to hydrology. Alternatives 2 and 3 would be expected to have minor long-term positive effects to hydrology in the vicinity of the refuge.

6.2.2 Effects to Water Quality

Under Alternative 1 (no action), restoration activities might cause a slight short-term negative effect on water quality as a result of heavy equipment operation necessary to conduct habitat restoration. There would be slight long-term positive effects as habitats mature and create shade for water cooling and water filtration as plants mature.

Under Alternative 2 (preferred), there would be short-term minor negative effects due to restoration of croplands to natural habitat types, conversion of wetlands to wet prairie, and restoration and construction of stream channels and backwater sloughs. These effects may include localized siltation and turbidity, and release of trapped nutrients into local waters. Long-term minor positive effects include trapping of sediments and nutrients by vegetation, and increased groundwater recharge. Restoration of vegetation along stream and river channels would have a minor positive effect by cooling water, thus increasing its capacity to hold dissolved oxygen.

Under Alternative 3, there would be short-term minor negative effects due to restoration of croplands to natural habitat types, conversion of wetlands to bottomland riparian forest, and restoration and construction of stream channels. These effects may include localized siltation and turbidity, and release of trapped nutrients into local waters. Long-term minor positive effects include trapping of sediments and nutrients by vegetation, and increased groundwater recharge. Restoration of vegetation along stream and river channels would have a minor positive effect by cooling water, thus increasing its capacity to hold dissolved oxygen.

Under all alternatives the refuge would continue to conduct habitat management that would include periodic discing of wetlands, which may cause short-term slight negative effects to water quality such as sedimentation and turbidity, and reduced trapping of sediments and nutrients. Also the refuge would apply herbicide in situations where other methods of invasive species control are ineffective. Application of U.S. Fish and Wildlife Service (Service; USFWS)-approved herbicide may have a slight short-term negative effect to local water quality as described in Appendix G, Integrated Pest Management (IPM).

6.2.2.1 Overall Effects to Water Quality

Overall, Alternatives 1, 2, and 3 would all be expected to have a neutral or slightly positive long-term effect to local water quality.

6.2.3 Effects to Air Quality

Under all alternatives, restoration activities might cause a slight short-term negative effect on air quality as a result of exhaust and dust from heavy equipment operation necessary to conduct habitat restoration. In addition, during the first few years following a restoration project, it is often necessary to mow or apply Service-approved herbicide to combat weeds until native plants can become established. Mowing and herbicide applications can be expected to produce slight negative short-term air quality impacts from gas- and diesel-powered equipment and possible herbicide drift. Restoration of native habitat types would have a slight long-term positive effect on air quality as plants grow by producing oxygen, and taking in carbon dioxide and storing it in plant fibers as carbon.

Under Alternative 1 (no action), no further effects to air quality would be expected.

Under Alternatives 2 (preferred) and 3, prescribed fire would be implemented as a tool for habitat management and would result in intermediate short-term negative effects on air quality in a localized area. Any prescribed burning would be conducted in accordance with all state, local, and Service policies and regulations. Wilhelm (2004) suggested that burning of wet prairies has a negligible effect on atmospheric carbon dioxide levels because plants store more carbon underground than is released as a result of burning their aboveground parts. With the conversion of croplands to native

habitat types under these two alternatives, there would likely be a slight positive long-term effect on air quality as a result of using less diesel fuel in farm equipment and applying less herbicide necessary for crops.

Under Alternative 3, there may be slight long-term positive effects to air quality as more land is converted into forested habitat types. The increase in forested habitat types would be expected to produce more atmospheric oxygen, take up carbon dioxide, and store carbon in plant materials. In addition, the conversion of wetlands to forest habitat types would negate the need for continued maintenance using heavy equipment, thus reducing the amount of diesel fuel expended.

6.2.3.1 Overall Effects to Air Quality

Overall, effects to air quality would be neutral under all alternatives.

6.2.4 Effects to Visual Quality

All alternatives would have neutral or slight positive effects to visual quality. A few minor developments, such as new photography blinds, kiosks, and hunting blinds, would be incorporated in Alternatives 2 and 3. These would be designed to enhance visitor appreciation of the natural and visual resources in that area, and would be constructed in the same architectural style as existing features. Short-term minor visual effects may occur during construction of new facilities.

Habitat actions proposed in Alternative 2 would enhance a variety of habitats and would therefore slightly improve visual quality, with more diverse wildlife and scenery. Alternative 3 would convert more of the refuge into contiguous forest habitats, resulting in less broad landscape views, less habitat diversity, and more closed canopy views.

6.2.4.1 Overall Effects to Air Quality

Overall, effects to visual quality would be neutral under all alternatives.

6.3 Effects to Habitats and Wildlife

6.3.1 General Effects

Under Alternative 1, most habitat types and fish and wildlife listed below would experience largely neutral or slightly positive long-term effects from continued current management actions. However, Alternative 2 and 3 show some changes to habitats and wildlife. Table 6-2 demonstrates the changes in habitat types across alternatives. As restored and enhanced habitat types continue to mature, slight positive long-term effects might be realized by some species or guilds, while others would remain unchanged. For example, mammals such as black-tailed deer and most songbirds would benefit as bottomland riparian forests mature. Black-tailed deer prefer the sanctuary of a closed forest rather than open habitat types, and many songbird species forage and nest in mid- to large-sized trees. Likewise, marshbirds and waders would see slight benefits as recently restored scrub-shrub wetlands continue to mature. Marshbirds and waders forage on a diversity of invertebrates and amphibians that would flourish in a mature scrub-shrub wetland. Guilds such as waterfowl and shorebirds would likely remain unchanged.

6.3.1.1 General Effects from Public Use Actions

Several general effects from public use apply refuge-wide and are not tied to specific habitats or wildlife guilds. With the proposed increase in public use opportunities, expanded outreach, new facilities, and current rising interest in the refuge, visitation is estimated to grow to 250,000 visitors per year. This could have an intermediate negative effect from wildlife disturbance, introduction of invasive species, and loss/fragmentation of habitat. Some examples of disturbance to wildlife and habitat from public use include flushing of birds, causing additional expenditure of energy to evade humans; disturbance to nest sites; and changes in animal behaviors or patterns of habitat use from off-trail use by refuge visitors. However, disturbance to wildlife and habitat from visitors would be minimized with the use of several techniques, including the use of screening vegetation; seasonal closures; limited use of photography and hunt blinds through reservation systems; establishing maximum group/class sizes; providing accurate regulatory information; and increasing law enforcement.

Construction of new facilities would include proper placement of facilities; constructing during a time of the year when the least amount of disturbance would be caused; using low-impact construction techniques and materials; planning minimal footprints; and timely rehabilitation from ground disturbance.

These techniques would cumulatively result in a minor overall negative effect to wildlife and habitat, and is balanced with an overall positive social effect. See remaining sections of Chapter 6 and Compatibility Determinations in Appendix B for detailed analysis of specific public use actions, where applicable.

Table 6-2. Current and Proposed Habitat Acreages

Habitat type	Current Acreage*	Alternative 1			Alternative 2			Alternative 3		
		Restored	Converted to Other Habitat	Net Gain/ Loss	Restored	Converted to Other Habitat	Net Gain/ Loss	Restored	Converted to Other Habitat	Net Gain/ Loss
Bottomland riparian forest	388	39	7	+32	90	39	+51	318	11	+307
Mixed coniferous/deciduous forest	49	47	0	+47	80	3	+77	129	0	+129
Oak savanna	149	0	0	0	79	33	+46	0	40	−40
Wet prairie	27	0	0	0	114	12	+102	30	12	+18
Herbaceous wetland	294	0	0	0	0	106	−106	0	229	−229
Scrub-shrub wetland	20	0	0	0	180	0	+180	176	0	+176
Cropland	942	0	0	0	0	942	−942	0	942	−942
Ruderal lands	249	0	246	−246	0	249	−249	0	249	−249

* Approximate values based on geographic information system (GIS).

6.3.2 Effects to Bottomland Riparian Forest

Under Alternative 1, bottomland riparian forest would experience slight long-term positive effects as plants mature in newly and previously restored areas, and as plants continue to flourish in maintained areas.

Under Alternative 2 (preferred), bottomland riparian forest would be expanded slightly from the current extent of approximately 388 acres and would experience neutral effects. In the Riverboat Unit, about 11 acres of bottomland riparian forest would be converted to wet prairie and scrub-shrub wetland. In the Tualatin River Unit, 13 acres of bottomland riparian forest would be restored from ruderal land. In the Atfálat'i Unit, about 25 acres of bottomland riparian forest would be restored from ruderal lands. An unknown part of the Wapato Lake Unit might also be restored to bottomland riparian forest.

Under Alternative 3, bottomland riparian forest would experience intermediate positive effects as bottomland riparian forest would be expanded from about 388 to 707 acres. In the Riverboat Unit, about 11 acres of bottomland riparian forest would be converted to wet prairie and scrub-shrub wetland. In the Tualatin River Unit, 13 acres of bottomland riparian forest would be restored from ruderal land, and an additional 28 acres of herbaceous wetland would be converted to riparian forest. In the Atfálat'i Unit, about 248 acres would be converted to bottomland riparian forest from wetlands, ruderal lands, and other habitat types. An unknown part of the Wapato Lake Unit might also be restored to bottomland riparian forest.

Bottomland riparian forest on refuge lands exists as mature forest with large trees creating a relatively closed canopy over a diverse understory of smaller trees, shrubs, and herbaceous layer, and as young restored areas from 2 to10 years old with saplings and shrubby understory. Maintenance of these areas includes protecting young trees in older stands with tree tubes, clearing nonnative invasive plants such as Himalayan blackberry, English ivy, English holly, and English hawthorn using mechanical, cultural, chemical, and/or biological means (as described in Appendix G, IPM).

6.3.2.1 Effects from Public Use Actions

The possibility for one boat access is considered under Alternatives 2 and 3. The location is undetermined, but would be considered if implementation would result in minimal disturbance to vegetation. Implementation would require a shallow slope that could be accessible for wheelchairs, safe parking area, and little to no impact to the floodplain. In these circumstances, a boat access would create the potential for minor amounts of increased erosion and additional visitors within bottomland riparian and riverine habitats.

The 2-acre environmental education off-trail study area proposed in Alternative 2 would likely result in trampling of bottomland riparian forest vegetation and may increase disturbance to forest wildlife species. However, these impacts would not result in displacement of unique habitats, resulting in a minor negative effect to bottomland riparian forest.

6.3.2.2 Overall Effects to Bottomland Riparian Forest

Overall effects to bottomland riparian forest are expected to be slightly positive and long term under Alternative 1, neutral under Alternative 2, and intermediate positive in the long term under Alternative 3.

6.3.3 Effects to Mixed Coniferous/Deciduous Forest

Under Alternative 1, mixed coniferous/deciduous forests would experience slight long-term positive effects as new areas would be restored and other areas maintained to benefit this habitat type.

Under Alternative 2 (preferred), slight long-term positive effects would be expected as mixed coniferous/deciduous forest would be expanded from about 49 to 199 acres. In the Atfálat'i and Rock Creek Units, there would be no change to mixed coniferous/deciduous forest acreage. In the Onion Flats Unit, about 3 acres of mixed forest would be converted to oak savanna. In the Tualatin River Unit, about 33 acres of newly restored oak savanna would be allowed to convert to a mixed coniferous/deciduous forest habitat type, and an additional 10 acres of ruderal habitat would be restored to mixed forest. In the Riverboat Unit, about 36 acres would be restored.

Under Alternative 3, intermediate long-term effects would be expected as mixed coniferous/deciduous forest would be expanded from 49 to 252 acres. In the Rock Creek Units, there would be no change to mixed coniferous/deciduous forest acreage. Similar to Alternative 2, about 33 acres of newly restored oak savanna in the Tualatin River Unit would be converted to mixed coniferous/deciduous forest, and about 36 acres in the Riverboat Unit would be restored. In addition, about 6 acres of oak savanna, and 29 acres of ruderal lands in the Atfálat'i Unit would be converted to mixed forest.

6.3.3.1 Overall Effects to Mixed Coniferous/Deciduous Forest

Overall effects to mixed coniferous/deciduous forest are expected to be slightly positive in the long term under Alternatives 1 and 2, and minor positive effects are expected in the long term under Alternative 3.

6.3.4 Effects to Oak Savanna

Under Alternative 1, oak savanna would be expected to have slight long-term positive effects from new restoration projects and maintaining current oak savanna restoration areas.

Under Alternative 2 (preferred), oak savanna would be expected to have slight long-term positive effects as it is increased from 149 to 226 acres. In the Riverboat and Rock Creek Units, there would be no changes to oak savanna. In the Onion Flats Unit, there would be an increase of 17 acres; in the Tualatin River Unit, about 33 acres would be converted to mixed forest; and on the Atfálat'i Unit, about 62 acres would be restored from ruderal lands and other habitat types.

Under Alternative 3, oak savanna would have minor long-term negative effects as it would be reduced from 149 to 141 acres. In the Riverboat, Rock Creek, and Onion Flats Units, there would be no changes to oak savanna. In the Tualatin River Unit and on the Atfálat'i Unit, about 33 and 6 acres, respectively, would be converted to mixed forest.

6.3.4.1 Effects from Public Use Actions

The proposed nature play area (along the existing year-round trail) in Alternative 2 and the tree screen along highways proposed in Alternatives 2 and 3 would both occur in upland/oak savanna habitats that are currently disturbed/degraded and do not connect to other intact habitats.

6.3.4.2 Overall Effects to Oak Savanna

Overall effects to oak savanna are expected to be slightly positive in the long term under Alternative 1 and Alternative 2, and minor negative effects are expected in the long term under Alternative 3.

6.3.5 Effects to Wet Prairie

Under Alternative 1, there would be slight positive long-term effects from maintaining existing wet prairie habitat.

Under Alternative 2 (preferred), wet prairie would experience intermediate positive effects as prairie would increase substantially, from about 27 to 129 acres. In the Onion Flats, Tualatin River, and Rock Creek Units there would be no change. In the Riverboat Unit, about 30 acres of herbaceous wetland and bottomland riparian forest would be converted to wet prairie, and in the Atfálat'i Unit about 13 acres of wet prairie would be converted to bottomland riparian forest, while 85 acres of herbaceous wetland, riparian forest, and ruderal land would be converted to wet prairie. Wet prairie, similar to scrub-shrub wetlands, relies on precipitation and seasonal high groundwater levels rather than active manipulation of water. To convert herbaceous wetlands to wet prairie, manipulation of water would be discontinued. See Section 6.3.6 for further discussion on wetlands.

Under Alternative 3, wet prairie would experience neutral effects as it would increase from about 27 acres to 45 acres. In the Riverboat Unit, about 30 acres of herbaceous wetland and bottomland riparian forest would be converted to wet prairie. In Atfálat'i Unit, 13 acres of wet prairie would be converted to bottomland riparian forest.

6.3.5.1 Effects from Public Use Actions

The junior waterfowl hunt on the Riverboat Unit, proposed in Alternative 2, would have a neutral to slightly negative effect to wet prairie, due to development of two to five blinds and access trails within prairie areas. Water management would be used to benefit wildlife and habitat and would not be used to enhance hunting without an accompanying wildlife and habitat benefit.

Similar effects to prairies from a waterfowl hunting program proposed in Alternatives 2 and 3 at the Wapato Lake Unit would be expected, but the degree of impacts cannot be determined until restoration decisions are made prior to planning a hunt program.

6.3.5.2 Overall Effects to Wet Prairie

Overall, wet prairie is expected to have slight long-term positive effects under Alternative 1, intermediate long-term positive effects under Alternative 2, and be neutral under Alternative 3.

6.3.6 Effects to Herbaceous and Scrub-shrub Wetlands

Alternative 1 would be expected to have neutral effects to herbaceous and scrub-shrub wetlands as these habitats are maintained in their current condition.

Wetlands on the refuge are roughly classified as either herbaceous or scrub-shrub wetland types. Most of the herbaceous wetlands are intensively managed using water control structures, canals, pumps, and dikes to mimic natural hydrology. Scrub-shrub wetlands are typically not intensively

managed and rely on rain water, overland flows, or flood flows from streams and rivers for hydrologic inputs and natural evapotranspiration for drying cycles. Some refuge wetlands have been difficult to manage and exhibit a natural tendency to convert to other habitat types such as wet prairie or bottomland riparian forest. Therefore, refuge staff in consultation with other professionals have suggested converting some wetlands to these other habitat types.

Under Alternative 2 (preferred), there would be a slight positive effect as wetlands would increase from 314 to 387 acres in the Sherwood Units, and an unknown quantity of wetlands would also be restored in the Wapato Lake Unit. In the Riverboat Unit, about 26 acres of herbaceous wetlands would be converted to wet prairie. In the Atfálat'i Unit, some active manipulation of water levels would cease, allowing about 69 acres of wetlands to convert to wet prairie, oak savanna, and scrub-shrub habitats. In the Onion Flats Unit, about 101 acres of cropland would be restored to scrub-shrub wetland. In the Rock Creek Unit, about 27 acres of ruderal wetland would be restored to scrub-shrub wetland.

Under Alternative 3, there would be a minor negative effect as wetlands would decrease from 314 to 260 acres in the Sherwood Units, and an unknown quantity of wetlands would be restored in the Wapato Lake Unit. In the Riverboat Unit, about 26 acres of herbaceous wetlands would be converted to wet prairie, and in the Tualatin River Unit about 28 acres would be converted to bottomland riparian forest. In the Atfálat'i Unit, about 167 acres of wetland would be converted to bottomland riparian forest, while about 17 acres of ruderal wetland would be restored to scrub-shrub wetland. In the Onion Flats Unit, about 101 acres of cropland would be restored to scrub-shrub wetland.

6.3.6.1 Effects from Public Use Actions

The junior waterfowl hunt on the Riverboat Unit, proposed in Alternative 2, would have a neutral to slightly negative effect to wetlands, due to the development of two to five blinds and access trails within wetland areas. Water management would be used to benefit wildlife and habitat, and would not be used to enhance hunting without an accompanying wildlife and habitat benefit.

Similar effects to wetlands from a waterfowl hunting program proposed in Alternatives 2 and 3 at the Wapato Lake Unit would be expected, but the degree of impacts cannot be determined until restoration decisions are made prior to planning a hunt program.

6.3.6.2 Overall Effects to Wetlands

Overall, wetlands are expected to exhibit neutral effects under Alternative 1, slightly positive long-term effects under Alternative 2, and minor negative long-term effects under Alternative 3.

6.3.7 Effects to Streams, Rivers, and Backwater Sloughs

There are no direct maintenance, restoration, or other impacts planned for the Tualatin River under any of the alternatives. However, maintenance and/or restoration of tributary streams, backwater sloughs, and adjacent habitats would have positive long-term effects, as well as slight short-term negative effects to the river.

Under Alternative 1, the refuge would maintain existing streams and backwater sloughs. Additional lands adjacent to stream channels would be restored or maintained that would benefit these habitat types. Effects would be slightly positive in the long term.

Under Alternative 2 (preferred), there would be intermediate long-term positive effects as the refuge would restore 4.3 miles and maintain 9.5 miles of river frontage, stream channels, and backwater sloughs. In the Atfálat'i Unit, Chicken Creek would be restored to its historical footprint and an additional 0.6 mile of backwater slough would be created. In the Onion Flats and Rock Creek Units, about 1.1 miles of Rock Creek would be restored to a more meandering configuration and an additional 1.0 mile of backwater slough would be created. In the Wapato Lake Unit, about 0.3 mile of Ayers Creek and 0.5 mile of Wapato Creek could be also be restored. Additionally, with restoration of other habitat types such as wet prairie and scrub-shrub wetland, construction of backwater sloughs would be incorporated into restoration plans.

Under Alternative 3, there would be intermediate long-term positive effects as the refuge would restore 4.3 miles and maintain 9.5 miles of river frontage, stream channels, and backwater sloughs. In the Atfálat'i Unit, Chicken Creek would be restored to its historical footprint and an additional 0.6 mile of backwater slough would be created. In the Onion Flats and Rock Creek Units, about 1.1 miles of Rock Creek would be restored to a more meandering configuration and an additional 1.0 mile of backwater slough would be created. In the Wapato Lake Unit, about 0.3 mile of Ayers Creek and 0.5 mile of Wapato Creek could be also be restored. Additionally, with restoration of other habitat types such as wet prairie and scrub-shrub wetland, construction of backwater sloughs would be incorporated into restoration plans. Under this alternative, there would be fewer miles of backwater sloughs in the Atfálat'i Unit as wetlands would be converted to bottomland riparian forest.

Restoration and maintenance of streams and backwater sloughs would require constructing new channels with heavy equipment. Construction would have intermediate negative short-term effects from disturbance of soils, causing dust, erosion, and sedimentation; use of diesel fuel causing reduced air quality; and disturbance to resident fish as channels are rerouted and reconnected. Maintenance of streams, backwater sloughs, and adjacent vegetated areas include removing nonnative invasive plants using mechanical, cultural, chemical, and/or biological means (Appendix G, IPM) and would also have intermediate negative short-term effects.

However, intermediate long-term positive effects from restoration would include increased groundwater recharge, benefits to listed anadromous fish, and benefits to native wildlife.

6.3.7.1 Overall Effects to Streams, Rivers, and Backwater Sloughs

Overall, slight positive long-term effects are expected under Alternative 1, and intermediate positive long-term effects to streams, rivers, and backwater sloughs are expected under both Alternatives 2 and 3.

6.3.8 Effects to Croplands

Under Alternative 1, the effects to croplands would be neutral as croplands would be maintained in their current condition and no changes would be expected.

Under both Alternatives 2 (preferred) and 3, effects would be intermediate, negative, and long term as all refuge croplands would be restored to native habitat types. Currently there are 909 acres of croplands. Croplands are currently only present on the Onion Flats and Wapato Lake Units. Short-term minor negative effects might occur as heavy equipment would be used to restore croplands to native habitat types. Restoration might include earth moving that would result in dust, minor erosion,

and siltation on a localized basis. Restoration might also include application of Service-approved herbicide as described in Appendix G.

6.3.8.1 Overall Effects to Croplands

Overall, croplands are expected to experience neutral long-term effects under Alternative 1, and intermediate long-term negative effects under Alternatives 2 and 3 as these lands are converted to native habitat types.

6.3.9 Effects to Ruderal Lands

Under all alternatives, ruderal lands would be restored to native habitat types and would experience long-term intermediate negative effects. Currently there are 181 and 68 acres of ruderal uplands and wetlands, respectively.

6.3.9.1 Overall Effects to Ruderal Lands

Overall, ruderal lands are expected to experience intermediate long-term negative effects as these lands are converted to native habitat types under all alternatives.

6.3.10 Effects to Waterfowl

Under Alternative 1, waterfowl would be expected to experience neutral effects from maintaining existing habitat types. There would be no increase in wetland areas or other habitat types that would benefit waterfowl.

Under Alternative 2 (preferred), waterfowl would be expected to benefit from increased acreage of wetlands and wet prairie, as well as restoration of croplands to native habitat types. In the Sherwood Units, most of the increase in wetland acres would be composed of scrub-shrub wetland types, while herbaceous wetlands would decrease. While waterfowl use scrub-shrub wetlands, these wetlands would not support the same number or diversity of waterfowl as herbaceous wetlands. Scrub-shrub wetlands are a more closed habitat type that would be used by some waterfowl species such as wood ducks and hooded mergansers for foraging, breeding, and brood rearing. Species such as cackling Canada geese and northern pintails, which constitute the majority of wintering birds on the refuge, prefer the more open habitat of herbaceous wetlands. In the Wapato Lake Unit, it is unknown what wetland types would be restored from croplands, but the effect on local waterfowl populations would likely be neutral or slightly positive. In Alternative 2, wet prairie would be restored primarily from herbaceous wetlands, and this would be expected to have a neutral or slightly negative effect on waterfowl.

Under Alternative 3, the effects to waterfowl would likely be neutral as most existing wetlands and wet prairie would be converted to bottomland riparian forest, but cropland would be converted to wetland. Under this alternative, the emphasis would be on providing the largest contiguous blocks of habitat possible with an emphasis on forested habitat types. In the Sherwood Units most remaining wetlands would be composed of scrub-shrub, and in the Wapato Lake Unit wetlands would be restored from croplands.

The conversion of croplands to wetlands under these two alternatives would likely have a positive effect on waterfowl. Even though waterfowl use croplands extensively for foraging, wetlands would

provide a longer season of use than croplands. Croplands are heavily used during periods of winter flooding, but are typically drained during early spring to facilitate planting, whereas wetlands would typically retain water into late spring or early summer, providing additional foraging, roosting, and breeding opportunities for waterfowl.

6.3.10.1 Effects from Public Use Actions

Under Alternative 2, there would be a youth waterfowl hunt on the Riverboat Unit, and general public waterfowl hunting would be considered under Alternatives 2 and 3 at the Wapato Lake Unit. Blinds would be constructed and placed to minimize disturbance to waterfowl, and vegetative screening on trails approaching blinds may be used to increase cover and reduce silhouetting of hunters. Individual ducks and geese would be taken; however, the impact to the population as a whole would remain neutral. Duck populations have not changed substantially nationwide since comprehensive surveys began in 1955 (USFWS 2011b), and with the exception of dusky Canada geese, all populations of geese that occur on the refuge have been increasing during the past 30 years (USFWS 2011c). Recreational hunting would be implemented in accordance with regulations and laws of the State of Oregon. The junior hunt at the Riverboat Unit would have a minor negative impact to waterfowl. The effects from hunting at the Wapato Lake Unit would likely be similar, but the degree cannot be determined until restoration decisions are made prior to planning a hunt program. Specific effects to waterfowl from hunting are discussed in Section B.2 of Appendix B, Compatibility Determinations.

6.3.10.2 Overall Effects to Waterfowl

Overall, waterfowl are expected to experience neutral effects under Alternative 1, minor long-term positive effects under Alternative 2, and neutral long-term effects under Alternative 3.

6.3.11 Effects to Songbirds

Under Alternative 1, songbirds would be expected to benefit as areas that have been restored begin to mature, and maintenance of intact habitat continues. The presence of croplands would continue to have a slight negative effect on most songbird species. Because cropland areas are often planted or harvested during spring and summer, there would be negative effects because of disturbance and direct impacts to ground-nesting birds attempting to nest in these areas. In addition, application of herbicide may directly or indirectly affect songbirds via direct ingestion, or via foraging on insects or plants that have been sprayed with herbicide. Refer to Appendix G, Integrated Pest Management, for more information.

Under Alternative 2 (preferred), a diversity of habitat types would be maintained, enhanced, and restored that would benefit a multitude of songbird species. Bottomland riparian forest, mixed coniferous/deciduous forest, wet prairie, and scrub-shrub wetland habitat types would all increase, while herbaceous wetland and oak savanna would be reduced in the Sherwood Units. In the Wapato Lake Unit, croplands would be converted mainly to native wetland types, which would benefit some songbird species. Songbirds occupy all the habitat types represented on the refuge. Larger contiguous blocks of forested habitats would benefit forest interior species such as many of the warblers. Habitat edges and transition zones benefit other species such as red-tailed hawks that typically nest and roost in tall forest trees while foraging in open grassy habitat types. Grassland songbirds would benefit from restoration of wet prairie. A variety of resident and migratory songbirds such as swallows, willow flycatchers, and marsh wrens use both herbaceous and scrub-shrub wetland types.

Under Alternative 3, bottomland riparian forest, mixed coniferous/deciduous forest, and scrub-shrub wetland would expand by about 82 percent, 515 percent, and 980 percent, respectively. Many species of songbirds would benefit from these expansions of habitat, especially the expansion of forested habitat types. Herbaceous wetland and oak savanna would be substantially reduced in the Sherwood Units, and wet prairie would remain about the same. The reduction of oak savanna would have indirect negative effects on some songbirds specializing in oak and grassland habitat types. In the Wapato Lake Unit, croplands would be converted mainly to native wetland types, which would benefit some songbird species. Larger contiguous blocks of forested habitat types would benefit a host of interior songbird guilds. One of the goals of the Oregon Conservation Strategy (Oregon Department of Fish and Wildlife [ODFW] 2006) is to maintain and restore important stopover sites for migratory birds, and restoring large blocks of forested habitat helps achieve this goal.

6.3.11.1 Overall Effects to Songbirds

Overall, slight long-term positive effects are expected under Alternative 1, intermediate long-term positive effects to songbirds are expected with an increase in overall diversity of habitat types under Alternative 2, and slight long-term positive effects are expected under Alternative 3.

6.3.12 Effects to Shorebirds

Under Alternative 1, shorebirds would experience neutral effects as current habitat types are maintained.

Under Alternative 2 (preferred), shorebirds would benefit from proposed habitat restoration and maintenance. In the Atfálat'i and Riverboat Units, some herbaceous wetlands would be converted to other habitat types that would not be as attractive to most shorebird species, while restoration of wet prairie in these units would be attractive to such species as Wilson's snipe. However, restoration of wetlands in the Wapato Lake Unit would provide positive benefits for a multitude of shorebird species such as greater yellowlegs, least and western sandpipers, and killdeer. Currently at Wapato Lake, water is drained early in spring to facilitate farming and remains dry into fall, until rain begins to fill the basin. Under its restored condition, water would likely remain throughout much of summer, providing foraging and resting habitat for migrating and locally breeding shorebirds. Restoring cropland in the Onion Flats Unit to native habitat types likewise would have benefits for a number of shorebird species.

Under Alternative 3, with an emphasis on large blocks of forested habitat types, many wetlands in the Atfálat'i, Riverboat, and Tualatin River Units would be converted to habitat types less suitable for shorebirds. Currently, migrating and locally breeding shorebirds use these wetlands for foraging. However, restoration of native wetland habitat types in the Onion Flats and Wapato Lake Units from croplands would provide foraging and nesting opportunities to shorebirds.

6.3.12.1 Overall Effects to Shorebirds

Under Alternative 1 shorebirds would be expected to experience neutral long-term effects from current habitat management. Under Alternative 2 shorebirds are expected to experience slight positive long-term effects from proposed habitat changes. Under Alternative 3 shorebirds are expected to experience neutral long-term effects from proposed habitat changes.

6.3.13 Effects to Marshbirds and Waders

Under Alternative 1, marshbirds and waders would experience neutral effects from maintaining current habitat types.

Under Alternative 2 (preferred), marshbirds and waders would benefit from conversion of cropland in the Onion Flats and Wapato Lake Units to native wetland habitat types. Species such as Virgina rail, American bittern, and great blue heron would thrive in these restored habitat types, which would provide forage and, for some species, nesting cover. In the Atfálat'i Unit habitat changes would likely be neutral overall as some herbaceous wetlands would be converted to other habitat types, while new areas of scrub-shrub and wet prairie would benefit this guild by providing foraging habitat. In the Riverboat Unit changes in habitat types would also likely benefit this guild as herbaceous wetland is converted to scrub-shrub and wet prairie. Any enhancement or restoration projects in the Rock Creek Unit would also benefit this guild by improving habitat conditions there.

Under Alternative 3, several herbaceous wetland areas in the Sherwood Units would be converted to other habitat types. This would likely cause short-term negative effects to marshbirds and waders as some of these herbaceous wetlands are converted to scrub-shrub wetlands and wet prairie, and would cause long-term negative effects as some of these wetlands are converted to forested habitat types that are less suitable for this guild. As in Alternative 2, croplands in the Onion Flats and Wapato Lake Units would be converted to scrub-shrub wetland and other native habitat types that would benefit this guild in the long term.

6.3.13.1 Overall Effects to Marshbirds and Waders

Under Alternative 1 marshbirds and waders would be expected to have neutral long-term effects from current habitat management. Under Alternative 2 marshbirds and waders would be expected to have intermediate positive long-term effects from proposed habitat changes. Under Alternative 3 marshbirds and waders would be expected to experience slight positive long-term effects from habitat changes.

6.3.14 Effects to Raptors

Under Alternative 1, raptors would be expected to experience neutral effects from current habitat management.

Under Alternative 2 (preferred), raptors would benefit from proposed habitat changes such as converting croplands to native habitat types in the Onion Flats and Wapato Lake Units. Species such as bald eagles, peregrine falcons, and northern harriers frequently forage in wetlands such as those that would result from habitat restoration. Increasing bottomland riparian forest habitat in the Tualatin River and Atfálat'i Units would benefit species such as Cooper's hawks, sharp-shinned hawks, and great horned and western screech owls by providing foraging and nesting habitat. Restoring wet prairie would benefit short-eared and barn owls, red-shouldered hawks, and American kestrels by providing foraging habitat.

Under Alternative 3, raptors would benefit from proposed habitat changes such as converting croplands to native habitat types in the Onion Flats and Wapato Lake Units. Under this alternative there would be an emphasis on restoring and expanding forested habitat types that would benefit interior forest species such as Cooper's hawks, sharp-shinned hawks, and great horned and western

screech owls by providing foraging and nesting habitat, but there might be a slight negative effect for edge species such as red-tailed hawks. There would be less wet prairie, oak savanna, and wetlands for open-area foraging species such as American kestrel and northern harrier.

6.3.14.1 Overall Effects to Raptors

Under Alternative 1 raptors would be expected to have neutral long-term effects as a result of current management practices. Under both Alternatives 2 and 3, raptors would be expected to have slight positive long-term effects from proposed changes in habitat.

6.3.15 Effects to Mammals

A wide range of mammal species from shrews to black-tailed deer use refuge lands during all or part of their lives. Most species are adapted to native habitat types, but many thrive in human altered landscapes as well.

Under Alternative 1, mammals would be expected to have slight positive effects as restored areas such as bottomland riparian forest begin to mature and habitat changes occur.

Under both Alternatives 2 (preferred) and 3, most mammal species would be expected to benefit from continued enhancement and restoration of native habitat types. Conversion of croplands to native habitat types would benefit numerous mammal species, especially aquatic-associated species such as beaver, mink, and muskrat, but may negatively affect coyotes by reducing foraging areas. Creating larger blocks of contiguous habitat would also benefit many species such as black-tailed deer, western gray squirrel, and bobcat. In most cases, conversion of one native habitat type to another would require minimal ground-disturbing activities that would have a slight negative effect on small mammals such as rodents. Restoration activities often involve ground-disturbing activities such as mowing and discing, which would have a short-term negative effect on small rodents and possibly other mammals. Long-term effects from most habitat enhancement and restoration would likely be beneficial to mammals.

6.3.15.1 Overall Effects to Mammals

Under Alternative 1, most mammal species would be expected to experience slight long-term positive effects with current management activities. Under both Alternatives 2 and 3, mammals would be expected to have minor positive long-term effects from proposed changes in habitat.

6.3.16 Effects to Native Fish

Under Alternative 1, native fish would likely benefit as native habitat types mature and positively influence river and streamside waterways.

Under both Alternatives 2 (preferred) and 3, most native fish species would benefit from proposed restoration and enhancement measures. Restoration of the historical Chicken and Rock Creek channels would provide benefits such as shaded waterways, off-channel refugia during flood events, coarse woody debris to create channel diversity and refuge from predators, and a diversity of riffle and pool habitats. Riffle and pool habitats are largely missing from Rock Creek at present. Henning et al. (2007) found that enhanced wetlands were beneficial to salmonids and other native fish. Restoration of Wapato Lake would likely result in reconnecting the lake bed with the Tualatin River,

Wapato and Ayers Creeks, and possibly other perennial streams. Reconnecting the lake bed with the river and streams would create off-channel refugia during flood events. Construction of new stream channels and backwater sloughs using heavy equipment might have short-term negative effects such as erosion and siltation, removal of streamside vegetation, and disturbance of stream beds, but resulting habitats would likely provide benefits for salmonids (Jeffres et al. 2008) and have intermediate long-term effects. Any in-stream work would be conducted in accordance with ODFW regulations (ODFW 2008) and best management practices to minimize effects to native fish.

6.3.16.1 Effects from Public Use Actions

Alternative 2 proposes a fishing program in the Tualatin River from the Atfálat'i Unit of the refuge. The most likely catch at this location would be warm-water, nonnative fish such as crappie, bluegill, and largemouth bass. A less-likely catch would be native fish such as cutthroat trout and steelhead, and anglers would be encouraged to release native fish. Recreational fishing would be implemented in accordance with regulations and laws of the State of Oregon. A slight negative effect would result to native fish populations if these species were caught on a regular basis and not released. Specific effects to native fish from fishing are discussed in Section B.5 of Appendix B, Compatibility Determinations.

6.3.16.2 Overall Effects to Native Fish

Under Alternative 1, native fish would be expected to experience slight positive long-term effects as native habitat types mature. Under both Alternatives 2 and 3, native fish species would likely experience intermediate long-term positive effects from proposed activities.

6.3.17 Effects to Reptiles

Under Alternative 1, reptiles would benefit as restoration and maintenance of native habitat types continues.

Under both Alternatives 2 (preferred) and 3, most native reptile species would benefit from proposed restoration and enhancement measures. Native reptiles using refuge lands and waters include various snakes, lizards, and both northwestern pond turtles and painted turtles. Turtles would benefit as croplands are converted to native wetland habitat types and as stream channels and backwater sloughs are restored or created. Restoration activities that include introduction of basking logs or similar structures would enhance habitat for turtles. Restoring wet prairie, oak savanna, and forested habitat types would benefit snakes and lizards, as well as providing nesting sites for turtles. Construction activities, such as disturbance from heavy equipment and removal of nonnative vegetation in preparation for planting native vegetation in restoration sites, might produce short-term negative effects for reptiles. Any in-stream work would be conducted in accordance with ODFW regulations (ODFW 2008) and best management practices to minimize effects to reptiles.

6.3.17.1 Overall Effects to Reptiles

Under Alternative 1, reptiles would be expected to experience slight positive long-term effects as habitats mature. Under Alternatives 2 and 3, reptiles would be expected to experience intermediate long-term positive effects from proposed activities.

6.3.18 Effects to Amphibians

Under Alternative 1, amphibians would benefit as current habitat types mature and prosper with ongoing maintenance activities.

Under Alternative 2 (preferred), most amphibian species would benefit from proposed restoration and enhancement measures. Native salamanders, newts, and frogs use refuge wetlands and adjacent uplands to complete their annual life cycles. Conversion of herbaceous wetlands to wet prairie and scrub-shrub wetlands would likely have a neutral effect on amphibians.

Under Alternative 3, amphibians would likely experience negative effects from loss of breeding habitat as wetlands are converted to forest habitat types on the Atfálat'i and Tualatin River Units.

Under both Alternatives 2 and 3, restoration of streams and backwater sloughs would have positive effects on species such as northern red-legged frogs and long-toed salamanders as these species would use side pools for foraging and breeding. In addition, conversion of croplands to native habitat types such as wetlands would have a positive effect on amphibians by providing additional areas for breeding and over-wintering. Restoration and enhancement activities might have short-term negative effects from heavy equipment and removal of vegetation in preparation for establishing native vegetation. Any in-stream work would be conducted in accordance with ODFW regulations (ODFW 2008) and best management practices to minimize effects to amphibians.

6.3.18.1 Overall Effects to Amphibians

Under Alternative 1, amphibians would be expected to experience slight positive long-term effects from habitat maintenance. Under Alternative 2, amphibians would be expected to experience minor long-term positive effects from proposed activities, and under Alternative 3 amphibians would be expected to experience slight long-term positive effects.

6.3.19 Effects to Federally and State-listed Species

Listed species receive special consideration in terms of refuge management. Federally listed species are trust resources that require additional consultation whenever an activity conducted by or permitted by the refuge may have an effect on these species or their habitats. Impacts to these species from wildlife-dependent recreation and habitat management are assessed in this chapter. Impacts associated with the use of herbicides and pesticides are assessed in the IPM plan in Appendix G.

Federally listed species that are known to occur on or adjacent to the refuge include Nelson's checker-mallow, upper Willamette River Chinook salmon, and upper Willamette River steelhead. In addition to these three species, which are also state-protected under Oregon Administrative Rules (OAR) (OAR 2011), additional Oregon state-listed species known to occur on or adjacent to the refuge include only the bald eagle.

Nelson's checker-mallow exists as experimental populations on the Atfálat'i, Tualatin River, and Riverboat Units of the refuge; there is also one small area on the Atfálat'i Unit that had plants existing before the introduction program began. Nelson's checker-mallow is a hearty perennial plant that prefers wet prairies, wetland margins, sloughs and stream sides, or other moist open habitat (USFWS 2010b). Activities in these habitat types might include mowing, discing, burning, or application of Service-approved herbicide. In areas of known Nelson's checker-mallow populations,

mowing or burning might be conducted, but discing and application of herbicide would be avoided. Mowing and burning would likely have a net positive effect as these management actions help to reduce woody species that would otherwise outcompete or shade out Nelson's checker-mallow. Discing or application of herbicide would likely have a negative effect on Nelson's checker-mallow. Enhancement and restoration of additional native habitat types would provide opportunities for additional planting and expansion of Nelson's checker-mallow into new areas to meet recovery objectives.

Upper Willamette River Chinook and steelhead use the mainstem of the Tualatin River to reach headwater tributary streams, and may use tributary streams along the lower reaches of the river as well. Surveys conducted between 1999 and 2001 (Leader 2001) found that upper Willamette River Chinook represented only 0.08 percent of all fish in 22 reaches of 10 tributary streams of the Tualatin River and were located in only one reach of one stream. Rainbow trout (genetically identical to steelhead) represented 1.01 percent of all fish and were found in seven reaches of five streams. Ward (1995) suggested that enhancing portions of Rock and Chicken Creeks, as proposed in this CCP/EA, would benefit salmonid and other native fish species. Enhancing and restoring streams and backwater sloughs, as well as enhancing and restoring native habitat types adjacent to the Tualatin River, streams, and sloughs would benefit native fish by providing protective cover, food inputs, shade, and reduced erosion. In addition, converting croplands in Wapato Lake to native habitat types and reconnecting the Tualatin River and perennial streams to the lake bed would likely be a benefit to outmigrating juvenile salmonids and other native fish by providing off-channel refugia.

Bald eagles are frequently observed on refuge lands during fall, winter, and spring. During the last decade there have been no bald eagles documented nesting on refuge lands. However, a bald eagle nest was observed during 2008 and 2009 on private land adjacent to the refuge. This nest was blown down during a winter storm and was not rebuilt. During fall and winter, bald eagles primarily forage on waterfowl that are attracted to refuge wetlands. Some waterfowl remain to breed in spring, and bald eagles would continue to prey upon them and their young. In addition, as wetlands are drawn down for management purposes in late spring and early summer, bald eagles would also forage on nonnative fish, particularly carp, that gather in the remaining pools. By mid-summer, food sources are scarce and eagles move off the refuge. Enhancement and restoration of native habitat types that support waterfowl would likely benefit bald eagles. In addition, bald eagles typically nest in tall trees, snags, or power towers. Enhancement of forest habitats would likely benefit bald eagles over the long term. Public use programs on the refuge have been designed to minimize disturbance to waterfowl that in turn benefit bald eagles. Any expansion of public use programs would seek to continue this practice. Restoration projects involving the use of heavy equipment would likely occur during summer and thus minimize disturbance to bald eagles.

6.3.19.1 Overall Effects to Federally and State-listed Species

Under Alternative 1, listed species would be expected to experience minor positive long-term effects from current management, and under Alternative 2, they would experience minor positive long-term effects from the increase in rare habitat types that support those species. Under Alternative 3, listed species would be expected to have slight positive long-term effects as native habitats are restored and enhanced.

6.4 Effects to Cultural and Historical Resources

The Service is committed to the protection of known cultural resources under all alternatives; however, Alternatives 2 and 3 would implement actions to build stronger inventory, evaluation, and protection procedures. In addition, Alternatives 2 and 3 would provide actions to form partnerships and improve interpretation of these resources. In general, this would help to strengthen long-term protection and preservation of all cultural resources.

The National Historic Preservation Act (NHPA) of 1966, as amended, defines historic preservation as the protection, rehabilitation, restoration, and reconstruction of sites, buildings, structures, and objects significant in American history, architecture, engineering, and archaeology.

Title I, Section 106, of the NHPA requires Federal agencies having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking in any state to take into account the effect of the undertaking on any historic property in the project vicinity. Regulatory procedures for complying with Section 106 are found in 36 Code of Federal Regulations (CFR) 800. All ground-disturbing activities proposed for the refuge and for any parcels that might be acquired in the future, as well as alterations to significant historic structures or infrastructure, would be subject to compliance with Section 106 of the NHPA, which may require a pedestrian survey and other identification efforts as appropriate.

Prior to implementing undertakings, the applicable cultural resource compliance investigation would be undertaken. If significant cultural resources are found, appropriate procedures and protocols would be followed to protect them. Whenever possible, resources would be avoided or mitigated. Mitigation options, in addition to site avoidance by relocating or redesigning facilities, include data recovery, using either collection techniques or in-situ site stabilization procedures, or other measures as appropriate.

Under all alternatives, the Service would seek to develop appropriate strategies to address maintenance needs of existing structures that are eligible or potentially eligible for listing in the National Register of Historic Places (NRHP). The Service would actively recruit funding and seek to develop partnerships to address these needs. However, under Alternatives 2 and 3, unless funding sources are adequate to cover all needs, structures that are either low priority or unsafe without near-term maintenance could potentially be removed. Under Alternative 1, historic structures would continue to deteriorate, though none would be deliberately removed. All structures would need to be evaluated in the context of the NHPA prior to any work or removal. Maintenance and improvement of historic resources would meet the Secretary of the Interior's standards, resulting in positive impacts to cultural resources, while also causing some temporary noise and disturbance at and near the site. Lead paint may have the potential to be mobilized during any maintenance or removal process; enacting best practices (such as stripping the paint with a product that limits dust and binds with the lead, creating an inert substance for easier disposal, or covering the lead paint with an encapsulating paint product) would minimize this risk. Removal of historic resources would have a negative effect to cultural resources and could cause some temporary disturbance and soil compaction, as heavy equipment would likely be used in the removal process.

Section 110 of the NHPA requires Federal agencies to create a program to identify and protect historic properties. This program includes the nomination of eligible properties to the NRHP; the designation of a qualified agency historic preservation officer; the presence of agency programs and

activities that consider preservation values; and the authority of Federal agencies to include the costs of preservation activities within overall project costs during undertakings. Many opportunities exist to comply with Section 110, including but not limited to the development of interpretive materials and exhibits, refuge-based cultural heritage curricula and resources for use both on and off the refuge, and a systematic program for recording and evaluating the refuge's cultural resources. These opportunities also present excellent prospects for partnerships with Tribal communities and historical societies. The myriad ways in which the refuge's rich cultural history can be shared with refuge audiences should be considered during any planning project or undertaking on the refuge.

A more comprehensive understanding and inventory of cultural resources on-site would occur under Alternatives 2 and 3. The Service would complete a comprehensive review of resources, develop a museum management plan for existing and new properties, and collect oral histories. This gathering of data and knowledge would help the refuge protect and understand the cultural resources of this area, resulting in a slight positive effect for cultural resources as they would be more protected.

Partnerships, interpretation, and education would be expanded under Alternatives 2 and 3, compared to Alternative 1, and this expansion would strengthen current partnerships and provide high-quality interpretation and education opportunities. This effort would assist in laying the groundwork for establishment of more effective partnerships and coordination. Additionally, this would contribute to the public's understanding and appreciation for archaeological and historic resources and would have a slight positive effect to cultural resources.

6.4.1 Overall Effects to Cultural Resources

Under Alternative 1, cultural resources would be expected to experience slight negative long-term effects from lack of adequate protection and interpretation. Under Alternatives 2 and 3, cultural resources would be expected to experience minor long-term positive effects from proposed activities.

6.5 Social Effects

The baseline against which all alternatives are compared is the current public use program as described in Chapter 5. Unless otherwise noted, throughout this section, Alternative 1, the no-action alternative, is assumed to have a neutral effect because minimal or no changes to programs would occur under Alternative 1.

6.5.1 General Effects

6.5.1.1 General Effects from Public Use

Several general social effects from public use apply across the visitor services program and are not tied to specific wildlife-dependent recreation and education opportunities.

With the proposed increase in public use opportunities, expanded outreach and information, new facilities proposed in Alternative 2, new communication tools, and current rising interest in the refuge, visitation is estimated to grow to 250,000 visitors per year. With this increased contact with the public, the most likely results would be better understanding and support of the refuge and the Refuge System; more visitors from diverse backgrounds, in particular urban residents; increased environmental awareness of natural resources; better protection of natural resources; and more

involvement by community members, volunteers, and partners. More formal evaluation of programs would lead to improved and more effective learning outcomes and experiences. Improvement of existing public use facilities would lead to a safer and more comfortable visitor experience. On the other hand, increased visitation may lead to more crowding at times such as weekends and during summer months, when visitation tends to be greatest. This could lead to a slight long-term negative effect to the quality of individual visitor experience.

User fees for photography blinds and hunting and fishing programs, proposed in Alternatives 2 and 3, and entrance fees proposed in all alternatives could provide additional financial support for public use on the refuge. However, if fees were implemented, visitors may be discouraged from visiting the refuge or participating in certain activities. On the other hand, the refuge's need for program support may encourage stakeholders (such as hunting groups or photography clubs) to take an active role in implementing and managing public use programs to offset the need for fees. If implemented, fees would have a minor negative effect to the visiting public.

The cumulative general effects from public use would be a minor positive effect for visitors. See remaining sections of Chapter 6 and Appendix B, Compatibility Determinations, for more detailed analysis of wildlife-dependent recreation and education activities.

6.5.1.2 Effects of Wildlife and Habitat Actions on Public Use from Restoration/Habitat Actions

The refuge is currently composed of a mosaic of fragmented habitats. Alternatives 2 and 3 would strive to combine these fragments into larger contiguous blocks of native habitat types within the landscape and to restore relic or disappearing habitat types. The result for refuge visitors participating in wildlife-dependent recreation and education would generally be positive as these habitat actions would likely result in enhanced opportunities to experience native wildlife and native habitats. As enhancement and restoration projects occur, there would likely be negative short-term minor effects to visitor experience. Examples of these effects in both Alternatives 2 and 3 include disruption from construction activities (heavy equipment, installation of water control structures, earth moving) and habitat actions such as conducting prescribed fire (refer to Chapter 2 for a complete list of habitat management strategies). The effect from day-to-day habitat maintenance as described in Alternative 1 would be neutral, as these activities already occur on the refuge within areas open to the public.

6.5.2 Opportunities for Quality Wildlife Observation and Photography

All existing wildlife observation and photography facilities are to be maintained and/or improved in all alternatives, and several new facilities are being proposed in Alternative 2.

Maintaining seasonal closures, improving habitat conditions near viewing facilities, adding a tree buffer along highways, and altering the trail surface to be quieter would all create a minor positive effect by increasing chances of viewing abundant and diverse wildlife by reducing disturbance and creating a more natural and quieter setting for visitors

The addition of one to three photo blinds in Alternative 2 would provide more people opportunities to participate in wildlife photography; other vantage points with either a landscape view or more intimate habitat setting; a wider variety of habitat types such as oak savanna, scrub-shrub wetland, wet prairie, and forested areas, in addition to the current herbaceous wetland habitat; and increased photo quality by orienting blinds with the sun behind the photographer.

Boat access would be considered in Alternative 2, and connection to regional trail systems would be explored in Alternatives 2 and 3. These new features, if implemented, would increase areas for wildlife observation and photography, provide better connectivity to other natural areas and communities, and encourage alternative transportation to the refuge. Both actions would rely on partners and have the potential to enhance existing and create new partnerships with local organizations.

Collectively, in Alternatives 2 and 3, the result would be a minor positive effect for the public participating in wildlife observation and photography.

6.5.2.1 Effects from Habitat Actions

Restoration and/or enhancement of habitats in all alternatives would continue to provide high-quality viewing and photography opportunities by providing habitats that favor diverse and abundant wildlife, although actual species viewed may shift based on future habitat and restoration actions. Viewing opportunities from the current wetland observation deck (Atfálat'i Unit) would shift from herbaceous wetland to wet prairie in Alternative 2 and to bottomland riparian forest in Alternative 3. Both would still provide a diversity of wildlife, but would be less likely to provide views of abundant waterfowl. Herbaceous wetlands would be maintained below the plaza overlook in all alternatives and would continue to provide abundant waterfowl and waterbird viewing opportunities.

6.5.3 Opportunities for Quality Environmental Education

Alternative 2 proposes to add two new off-trail areas to support the environmental education program—a designated study area within the bottomland riparian forest for students participating in registered field trips and a nature play area in the upland designed for small children to participate in less-structured nature play. Both features would provide a slightly more rustic and/or quieter experience for students and children, provide a better learning environment for certain education lessons, provide an area where students and children can disperse but still be supervised by adults, and provide opportunities for more individual learning in addition to the group learning that occurs in the trail study sites. The nature play area would specifically provide a new activity area dedicated to young children (6 years and under) that would teach children and their parents how to interact with nature. These two new opportunities would result in an intermediate positive effect by offering opportunities that do not currently exist on the refuge.

Alternatives 2 and 3 propose to improve the quality of the existing environmental education program through formal evaluation, educational materials enhancement, and adaptive management. Both Alternatives 2 and 3 propose to add environmental education opportunities for communities surrounding the Wapato Lake Unit. Alternative 2 proposes to increase the capacity of the environmental education program by reaching more students, youth, and educators through on-site field trips, teacher workshops, after-school programs, and off-site education programs. In addition, capacity would be increased by enhancing the quality of the education programs through evaluation and better alignment with state learning standards. This would result in the development of environmental literacy for more students; more involvement with diverse communities; more environmental education teaching skills and resources for educators and schools; and overall better learning outcomes.

Collectively, these actions would create an intermediate positive effect in Alternatives 2 and a minor positive effect in Alternative 3 by enhancing the current program.

6.5.4 Opportunities for Quality Interpretation

All existing interpretive facilities, signs, kiosks, and overlooks would be maintained in all alternatives. In Alternatives 2 and 3, the refuge would improve the quality of interpretive programs through more in-depth staff/volunteer training and program evaluation. These improvements would be guided by the nationally recognized and Service-adopted Interpretive Process Model, which has interpretative guidelines (Larsen 2003). Alternatives 2 and 3 would also build new partnerships with organizations such as the National Association of Interpretation and the Confederated Tribes of Grand Ronde to develop new programs. Collectively, these enhancements would result in a minor positive effect to the quality of the interpretive program.

6.5.5 Opportunities for Quality Hunting

Alternative 2 proposes to establish a youth waterfowl hunting program on the Riverboat Unit. This would provide an opportunity for youth to hunt where very few nearby opportunities currently exist in the community; it would also meet the community's desire to share and teach hunting traditions to youth, provide an opportunity for the refuge to offer hunter education and mentorship programs, and provide an opportunity for stakeholders and partners to get involved in implementing and sustaining the program. Alternatives 2 and 3 propose to establish waterfowl hunting at the Wapato Lake Unit once land acquisition and habitat restoration have progressed enough to sustain a safe and quality hunt program. Adding youth and/or general public waterfowl hunts would result in an intermediate positive effect because the refuge would provide a new wildlife-dependent public use (as defined in the National Wildlife Refuge System Improvement Act [Improvement Act]) that is not currently offered on the refuge.

6.5.6 Opportunities for Quality Fishing

Alternative 2 proposes to establish a fishing program from the existing River Overlook on the Atfálat'i Unit of the refuge. Due to the presence of the existing trail and overlook, this action would provide a location for disabled visitors and families to fish where they may otherwise not have safe and/or wheelchair access to the Tualatin River. In addition, this action would provide an opportunity to teach angler education and for stakeholders and partners to get involved in implementing and sustaining a fishing program. Adding fishing would result in an intermediate positive effect because the refuge would provide a new wildlife-dependent public use (as defined in the Improvement Act) that is not currently offered on the refuge.

6.5.7 Opportunities for Nonwildlife-dependent Recreation

Currently, nonwildlife-dependent recreation activities are not permitted or offered on the refuge and no new nonwildlife-dependent activities are being proposed. Thus, the resulting effect for all alternatives is neutral.

6.5.8 Projected User Numbers in 15 Years

Refuge management can influence the number of visitors. Refuge decisions about features of public use management—such as how many facilities to build, where to build those facilities, how much staff time to devote to programs, and how much parking to provide—influence visitation for years to

come. Similarly, and often playing a greater role, demographic shifts, cultural preferences, and economics influence refuge visitation. Even small annual shifts can have a profound effect over time.

As a piece of the analysis, the CCP planning team projected the number of visits that would be expected at the end of 15 years, by alternative. Table 6-3 displays the number of visits to the refuge expected under a variety of different uses. Assumptions used in generating the projections are provided as footnotes to the table. A key assumption was that overall visitation would increase by 2.5 times over the course of 15 years, to 250,000 visitors annually.

Table 6-3. Annual Refuge Visits, Projected in 15 Years, by Activity

Estimated Number of Annual Recreation Visits			
Recreation Activity	**Alternative 1 (baseline: 2011 recorded annual visitation)**	**Alternative 2**	**Alternative 3**
Wildlife observation	69,900	250,000	250,000
Wildlife photography	1,764	10,000	9,000
Environmental education	4,228	12,000	6,000
Interpretation	4,288	9,000	5,000
Waterfowl hunting	0	1,200	1,140
Fishing	0	1,000	0
Auto tour visits	0	100,000	100,000

Notes

Activity Descriptions:
Wildlife observation includes pedestrian visits to trails and overlooks.
Wildlife photography includes photo blind reservations, photographers using trails and overlooks, and photography club events
Environmental education includes formal student programs (field trips), teacher workshops, youth group programs (scouts, after-school clubs), off-site education fairs, off-site student programs led by the Service
Interpretation includes guided walks and talks, naturalist-led programs, workshops, and special events (e.g., bird festival, refuge week, spring break exploration days, and others).
Waterfowl hunting includes youth hunt on the Riverboat Unit and public hunt on the Wapato Lake Unit.
Fishing includes fishing in the Tualatin River from the existing river overlook on the Atfálat'i Unit.
Auto tour visits reflect potential future use at the Wapato Lake Unit that would occur on existing state and county roads, if overlooks, kiosks, and pullouts were to be developed over the life of the CCP.

Assumptions for Projections in Alternatives 2 and 3:
Wildlife observation: Alternatives 2 and 3 assume 2.5-fold increase in visitors at the Sherwood Units (175,000), plus an additional 75,000 people at the Wapato Lake Unit. Potential future visits to the Wapato Lake Unit were calculated based on the current visits of nearby Jackson Bottom Wetlands Preserve (30,000) multiplied by 2.5.

Wildlife photography: Alternative 2 assumes a 2.5-fold increase in visitors at the Sherwood Units (4,500), plus an additional 4,500 visits at the Wapato Lake Unit. It is expected that although the Wapato Lake Unit

is more rural, it would command a large draw of photographers due to its large expanse and potential for photographing abundant waterfowl such as tundra swan. Alternative 3 would not include new photography blinds at the Sherwood Units and is therefore projected to experience a 10% decrease as compared to Alternative 2.

Environmental education: Alternative 2 assumes a 2.5-fold increase in visitors at the Sherwood Units (10,000), plus an additional 2,000 students at the Wapato Lake Unit. Student use at the Wapato Lake Unit was calculated as 25% of the total 2010-2011 student body of the Gaston, Forest Grove, and Yamhill-Carlton School Districts. Alternative 3 would not include expansion of the environmental education program and would rely on current management capacity and staffing; therefore, it is expected to only have a modest increase to 6,000 students a year.

Interpretation: Alternative 2 assumes a twofold increase in visitors for the Sherwood Units (9,000 people), plus an additional 1,000 participants at the Wapato Lake Unit. This projection includes special events, where participation tends to be steadier than other activities; therefore, interpretation was calculated at a lower growth rate as compared to wildlife observation, photography, and education. Participation at the Wapato Lake Unit is based on an estimated 600 people a year attending special events and 25 to 30 attendees at monthly, guided interpretive programs. Alternative 3 would not include expansion of the interpretive program and would rely on current management capacity and staffing; therefore, we would only expect a modest increase to 5,000 participants a year.

Fishing: Alternative 2 assumes that fishing would attract 30% of the participation that currently occurs at nearby refuges (William L. Finley National Wildlife Refuge in Oregon and Nisqually National Wildlife Refuge in Washington). Access to fishing at Tualatin River National Wildlife Refuge would be considerably more limited than at these nearby refuges. Alternative 3 does not include a fishing program.

Waterfowl hunting: Alternative 2 assumes that a youth hunt on the Riverboat Unit would include two people per four blinds, two days a month, for three months a year. At the Wapato Lake Unit, it is assumed that the refuge would draw approximately 60% of the participation that currently occurs (1,900) at nearby Ridgefield National Wildlife Refuge in Washington. It is assumed that the Wapato Lake Unit could support slightly more than half the number of blinds that Ridgefield Refuge has. Alternative 3 would not include a youth waterfowl hunt.

Auto tour visits: Alternatives 2 and 3 assume that a future auto tour route would attract a similar number of visitors to what Baskett Slough National Wildlife Refuge in Oregon currently experiences. As compared to Baskett Slough Refuge, the Wapato Lake Unit sits in a similar setting and with similar proximity to urban areas and travel corridors.

6.5.9 Amount of Illegal Use

Trespass into closed areas, nonwildlife-dependent activities (e.g., jogging, dog walking, bicycling), and theft are the primary illegal activities that occur on the refuge. Under all alternatives, the refuge intends to curb illegal activities, protect natural resources, and provide a safe environment for visitors. In all alternatives, visitation to the refuge is projected to increase substantially. With more visitors comes increased likelihood of illegal activities, creating a minor to intermediate negative effect. In Alternatives 2 and 3, a new law enforcement officer position is proposed to provide full-time resource and visitor protection, and if this strategy is implemented, a minor positive effect would be expected.

6.5.10 Environmental Justice

Since CCP implementation is expected to result in generally positive effects on the human environment, all alternatives and their proposed actions have little risk of having disproportionate adverse effects on human health, economics, or the social environment. All public use alternatives propose to reach out to increasingly diverse audiences and therefore would likely increase the amount of benefit provided to the whole community and have a minor long-term positive effect.

6.5.11 Overall Social Effects

As indicated in the beginning of Section 6.5, Alternative 1, the no-action alternative, is assumed to have a neutral effect because minimal or no changes to programs would occur. Alternative 2 would result in an overall intermediate positive effect due to addition of new wildlife-dependent public uses, addition of new facilities, enhancement of current programs, and expansion of the number of people reached through programs resulting from increased environmental awareness of natural resources, better protection of natural resources, and more effective learning outcomes and experiences. Alternative 3 would result in similar effects for the reasons described for Alternative 2, except that Alternative 3 does not add new wildlife-dependent public uses or new facilities, resulting in an overall minor positive effect for Alternative 3.

6.6 Economic Effects

6.6.1 Approach to Estimating Economic Effects

From an economic perspective, Tualatin River National Wildlife Refuge provides a variety of environmental and natural resource goods and services used by people either directly or indirectly. The use of these goods and services may result in economic impacts to both local and state economies. The various services the refuge provides can be grouped into five broad categories: (1) maintenance and conservation of environmental resources, services, and ecological processes; (2) production and protection of natural resources such as fish and wildlife; (3) production and protection of cultural and historic sites and objects; (4) provision of educational and research opportunities; and (5) outdoor and wildlife-related recreation. People who use these services benefit in the sense that their individual welfare or satisfaction level increases with the use of a particular good or service.

One measure of the magnitude of the change in welfare or satisfaction associated with using a particular good or service is economic value. *Economic value* is the economic trade-off people would

be willing to make to obtain some good or service. It is the maximum amount people would be willing to pay to obtain a particular good or service minus the actual cost of acquisition. In economic theory this is known as *net economic value* or *consumer surplus*. In the context of this report, estimates of the economic value of particular recreational activities are used to determine the aggregate value of recreational use of Tualatin River National Wildlife Refuge.

Aside from the effect on the individual, use of the good or service usually entails spending money in some fashion. These expenditures, in turn, create a variety of economic effects collectively known as economic impacts. *Economic impacts* refer to employment, employment or labor earnings, economic output and Federal, local, county, and state tax revenue that occur as the result of refuge activities. To estimate the total economic activity, employment, employment income, and Federal and state taxes generated by refuge activities, this report uses IMPLAN[1] (Impact Analysis for Planning), a regional input-output model and software system. The following is a list of terms and definitions that are commonly used in economic impact analysis (Miller and Blair 1985; Minnesota IMPLAN Group, Inc. 2004).

Economic output includes three types of effects: direct, indirect, and induced effects. Direct effects are the expenditures associated with a particular activity (such as refuge recreation visits and management activities). "Indirect effects result from changes in sales for suppliers to the directly-affected businesses (including trade and services at the retail, wholesale and producer levels). Induced effects are associated with further shifts in spending on food, clothing, shelter and other consumer goods and services, as a consequence of the change in workers and payroll of directly and indirectly affected businesses" (Weisbrod and Weisbrod 1997:11). The indirect and induced effects represent any multiplier effect. Both job income and tax revenue are derived from total economic output (aggregate sales). For example, labor costs are paid out of total sales revenue for a company as are taxes. To add taxes and job income to output would double-count economic impacts.

Jobs and *job income* include direct, indirect, and induced effects in a manner similar to economic output. Employment includes both full- and part-time jobs, with a job defined as one person working for at least part of the calendar year, whether one day or the entire year.

Tax revenues[2] are shown for business taxes, income taxes, and a variety of taxes at the local, state, and national level. Like output, employment, and income, tax impacts include direct, indirect, and induced tax effects.

A comprehensive economic profile (baseline) of the refuge and estimates of the economic effects of alternative management strategies would address all applicable economic effects associated with the use of refuge-produced goods and services. However, for those goods and services having nebulous or nonexistent links to the marketplace, economic effects are more difficult or perhaps even impossible to estimate. Some of the major contributions of the refuge to the natural environment, such as watershed protection, maintenance and stabilization of ecological processes, and the enhancement of biodiversity would require extensive on-site knowledge of biological, ecological,

[1] "IMPLAN … was originally developed by the USDA [U.S. Department of Agriculture] Forest Service in cooperation with the Federal Emergency Management Agency and the USDOI [U.S. Department of the Interior] Bureau of Land Management to assist the Forest Service in land and resource management planning" (Minnesota IMPLAN Group, Inc. 2004). First developed in 1979, IMPLAN data and software was privatized in 1993 by the Minnesota IMPLAN Group, Inc. For additional information, see www.implan.com. For additional information on input-output modeling, see *Input-Output Analysis* (Miller and Blair 1985).

[2] The overall tax rate is about 13.7 percent of economic output and includes direct, indirect, and induced tax effects nationwide. The tax rate is calculated within the economic modeling software used to estimate economic impacts.

and physical processes and interrelationships even to begin to formulate economic benefit estimates. This is beyond the scope of this report.

This report focuses on a limited subset of refuge goods and services, primarily those directly linked in some fashion to the marketplace, such as recreation use and refuge budget expenditures. It should be kept in mind that the emphasis on these particular market-oriented goods and services should not be interpreted to imply that these types of goods and services are somehow more important or of greater value (economic or otherwise) than the nonmarket goods and services previously discussed.

For this report, two types of economic impacts are addressed: (1) impacts associated with annual consumer expenditures on refuge-related recreation and (2) impacts associated with refuge budget expenditures. The economic impacts are presented as annual impacts over a 15-year time period. For Alternative 1, the analysis is based on 2011 refuge recreation visits and budget expenditures. For Alternatives 2 and 3, the analysis presents the impacts that would result assuming that all management objectives are implemented and achieved. Note that funds are not currently present to implement all objectives and strategies identified; however, the analysis for Alternatives 2 and 3 assumes that funding would manifest.

6.6.2 Economic Impacts from Recreational Activities

Tualatin River National Wildlife Refuge receives visitors from across North America and the world. The majority of refuge visitors live in the local area. Spending by recreational visitors when visiting the refuge impacts the local economy by creating jobs and generating tax revenue.

Economic impacts for the recreation baseline (Alternative 1) and action alternatives (Alternatives 2 and 3) are addressed in this section. Two types of information are needed to estimate the economic impacts of recreational visits to the refuge: (1) the amount of recreational use on the refuge by activity and (2) expenditures associated with recreational visits to the refuge. Recreational use is estimated by refuge staff (Table 6-4). Expenditure patterns used in this report were obtained from the *2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (U.S. Department of the Interior [USDOI] et al. 2007). These expenditures include only travel-related expenses, including food, lodging, transportation, and other miscellaneous travel-related expenses. With this information, total expenditures for each activity can be estimated. These expenditures, in turn, can be used in conjunction with regional economic models to estimate industrial output, employment, employment income and tax impacts associated with these expenditures. The economic impact area for recreational activities is defined as the greater Portland metropolitan area including Clackamas, Marion, Multnomah, Washington, and Yamhill Counties. It is assumed that visitor expenditures occur primarily within this five-county area.

The economic impacts from recreation expenditures estimated in this report are gross area-wide impacts. Information on where expenditures may occur locally and the magnitude and location of resident and nonresident expenditures (resident and nonresident relative to the geographical area of interest) is not currently available. Generally speaking, nonresident expenditures bring outside money into the area and thus generate increases in real income or wealth. Spending by residents is simply a transfer of expenditures on one set of goods and services to a different set within the same area. To calculate net economic impacts within a given area derived from resident expenditures, much more detailed information would be necessary on expenditure patterns and visitor characteristics. Since this information is not currently available, the gross area-wide estimates are the maximum impact for the net economic impacts of total resident and nonresident spending in the five-county area. The

economic impacts of nonresident spending represent a real increase in wealth and income for the area (for additional information, see Loomis 1993:191).

6.6.3 Alternative 1 (Baseline): Recreational Activities

Under Alternative 1, there would be no changes to the recreational activities offered at the refuge. All programs would continue to follow current management goals. The refuge would continue to offer a variety of nonconsumptive public uses, including wildlife observation, photography, interpretation, and environmental education. Visitation is increasing as people continue to discover the refuge, which opened to the public in 2006. Refer to Section 6.5.8 for a summary of projected user numbers in 15 years.

Table 6-4 shows the 2010 visitation for the refuge. The refuge had 80,180 visits in 2010. Pedestrian visits represented 87 percent of all visits. Interpretation visits include naturalist-led programs and special events. In addition to recreation visits, the refuge also had about 4,200 environmental education visits. The environmental education program includes student field trips, teacher workshops, youth group programs, and various off-site educational programs.

Table 6-4. Alternative 1: Fiscal Year 2010 Visitation at the Refuge

Activity	Residents*	Nonresidents*	Total
Nonconsumptive			
Pedestrian	55,920	13,980	69,900
Auto tour	0	0	0
Boat trail/launch	0	0	0
Bicycling	0	0	0
Photography	1,676	88	1,764
Interpretation	4,074	214	4,288
Environmental education	4,228	0	4,228
Hunting			
Waterfowl	0	0	0
Other migratory birds	0	0	0
Upland game	0	0	0
Big game	0	0	0
Fishing			
Fresh water	0	0	0
Salt water	0	0	0
Total visitation	**65,897**	**14,283**	**80,180**

*Resident versus nonresident estimates are based on informal data gathered from visitor logbook, special event records, and direct visitor contacts.

6.6.3.1 Regional Economic Analysis

Visitor recreation expenditures for Alternative 1 are shown in Table 6-5. Environmental education opportunities for residents do not contribute to the local economic impacts because the events typically do not bring visitors who spend money on travel-related goods and services. Total annual expenditures were about $927,400, with nonresidents accounting for about $422,100 or 46 percent of total expenditures. Under Alternative 1, these annual expenditures are expected to continue.

Table 6-5. Alternative 1: Visitor Recreation Expenditure (2010 dollars in thousands)

Activity	Residents	Nonresidents	Total
Nonconsumptive			
Pedestrian	$452.0	$411.9	$863.9
Photography	$20.3	$3.9	$24.2
Interpretation	$32.9	$6.3	$39.2
Total nonconsumptive	$505.2	$422.1	$927.4
Hunting			
Total hunting	–	–	–
Fishing			
Total fishing	–	–	–
Total Expenditures	**$505.2**	**$422.1**	**$927.4**

Input-output models were used to determine the economic impact of expenditures on the refuge's local economy. The estimated economic impacts are expected to occur in the greater Portland metropolitan area. It is assumed that visitor expenditures occur primarily within this area. Table 6-6 summarizes the local economic effects associated with recreation visits. Final demand totaled $1.8 million, with associated employment of 14 jobs, $543,000 in employment income, and $258,700 in total tax revenue.

Table 6-6. Alternative 1: Local Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Residents	Nonresidents	Total
Final demand	$1,011.5	$798.0	$1,809.5
Jobs	8	6	14
Job income	$305.9	$237.1	$543.0
Total tax revenue	$144.8	$113.9	$258.7

6.6.4 Alternative 2: Recreational Activities

6.6.4.1 Description of Recreational Activities

Under Alternative 2, additional activities would be assessed as future land acquisition and habitat restoration progresses on the Wapato Lake Unit. New opportunities that would be considered include expanded environmental education and interpretation programs, and new waterfowl hunting and fishing opportunities. Management under this alternative would be focused on expanding developed facilities and programs for casual visitors, and beginning, moderate, and advanced birders.

Table 6-7 shows the visitation that would occur if Alternative 2 is fully implemented. Approximately 383,200 visits would be related to a variety of recreational opportunities, interpretation programs, and environmental education. Pedestrian visits would continue to represent the majority of all visits. In addition to recreation visits (nonconsumptive activities, hunting, and fishing), the refuge also would support 9,800 environmental education visits.

Under Alternative 2, recreation visits are projected to more than quadruple at the end of 15 years, compared to Alternative 1. Refuge staff estimate that the majority of recreational visitors would live within the greater Portland metropolitan area. Similar to Alternative 1, nearly all recreational visitors would participate in nonconsumptive activities. Less than 1 percent of visitors would participate in hunting and fishing combined.

Table 6-7. Alternative 2: Annual Refuge Visitation

Activity	Residents	Nonresidents	Total
Nonconsumptive			
Pedestrian	200,000	50,000	250,000
Auto tour	80,000	20,000	100,000
Boat trail/launch	0	0	0
Bicycling	0	0	0
Photography	9,000	1,000	10,000
Interpretation	8,100	900	9,000
Environmental education	12,000	0	12,000
Hunting			
Waterfowl	1,080	120	1,200
Other migratory birds	0	0	0
Upland game	0	0	0
Big game	0	0	0
Fishing			
Fresh water	1,000	0	1,000

Table 6-7. Alternative 2: Annual Refuge Visitation

Activity	Residents	Nonresidents	Total
Salt water	0	0	0
Total Visitation	**311,180**	**72,020**	**383,200**

6.6.4.2 Regional Economic Analysis

Visitor recreation expenditures associated with a fully implemented Alternative 2 are shown in Table 6-8. Total annual expenditures would be about $6.2 million, with nonresidents accounting for about $2.9 million or 46 percent of total expenditures. Expenditures associated with nonconsumptive activities would account for 99 percent of all expenditures, followed by hunting and fishing at less than 1 percent.

Table 6-8. Alternative 2: Visitor Recreation Expenditures (2010 dollars in thousands)

Activity	Residents	Nonresidents	Total
Nonconsumptive			
Pedestrian	$2,424.8	$2,209.9	$4,634.7
Auto tour	$646.6	$589.3	$1,235.9
Boat trail/launch	–	–	–
Bicycling	–	–	–
Photography	$109.1	$44.2	$153.3
Interpretation	$98.2	$39.8	$138.0
Total nonconsumptive	$3,278.8	$2,883.2	$6,161.9
Hunting			
Waterfowl	$43.6	$16.8	$60.5
Other migratory birds	–	–	–
Upland game	–	–	–
Big game	–	–	–
Total hunting	$43.6	$16.8	$60.5
Fishing			
Fresh water	$14.8	–	$14.8
Salt water	–	–	–
Total fishing	$14.8	–	$14.8
Total Annual Expenditures	**$3,337.2**	**$2,900.0**	**$6,237.2**

Input-output models were used to determine the economic impact of expenditures on the refuge's local economy under Alternative 2. The estimated economic impacts are expected to occur in the greater Portland metropolitan area. It is assumed that visitor expenditures occur primarily within the five-county area. Table 6-9 summarizes the local economic effects associated with recreation visits. Under Alternative 2, final demand would total $12.2 million, with associated employment of 96 jobs, $3.6 million in employment income, and $1.7 million in total tax revenue.

Table 6-9. Alternative 2: Local Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Residents	Nonresidents	Total
Final demand	$6,681.2	$5,482.3	$12,163.5
Jobs	54	42	96
Job income	$2,020.5	$1,628.6	$3,649.1
Total tax revenue	$956.5	$782.7	$1,739.2

6.6.5 Alternative 3: Recreational Activities

6.6.5.1 Description of Recreational Activities

Under Alternative 3, additional activities would be assessed as future land acquisition and habitat restoration progresses on the Wapato Lake Unit. Visitation related to nonconsumptive activities and hunting would increase compared to Alternative 1. Management for recreational activities, environmental education, and interpretation would be similar to Alternative 2, but photography, interpretation, and environmental education programs would be developed to a lesser extent. Also, fishing would not be permitted under Alternative 3.

Table 6-10 shows the visitation that would occur if Alternative 3 is fully implemented. Approximately 371,140 visits would be related to a variety of recreational opportunities, interpretation programs, and environmental education. Pedestrian visits would continue to represent the majority of all visits. In addition to recreation visits (nonconsumptive activities and waterfowl hunting), the refuge would also support 6,000 environmental education visits.

Under Alternative 3, recreation visits are projected to more than quadruple at the end of 15 years, compared to Alternative 1. Refuge staff estimate that the majority of recreational visitors would live within the greater Portland metropolitan area. Similar to Alternative 1, nearly all recreational visitors would participate in nonconsumptive activities. Less than 1 percent of visitors would participate in waterfowl hunting.

Table 6-10. Alternative 3: Refuge Visitation

Activity	Residents	Nonresidents	Total
Nonconsumptive			
Pedestrian	200,000	50,000	250,000
Auto tour	80,000	20,000	100,000
Boat trail/launch	0	0	0
Bicycling	0	0	0
Photography	8,100	900	9,000
Interpretation	4,500	500	5,000
Environmental education	6,000	0	6,000
Hunting			
Waterfowl	1,026	114	1,140
Other migratory birds	0	0	0
Upland game	0	0	0
Big game	0	0	0
Fishing			
Fresh water	0	0	0
Salt water	0	0	0
Total Visitation	**299,626**	**71,514**	**371,140**

6.6.5.2 Regional Economic Analysis

Visitor recreation expenditures estimated for Alternative 3 are shown in Table 6-11. Total annual expenditures would be about $6.1 million, with nonresidents accounting for $2.9 million or 47 percent of total expenditures.

Table 6-11. Alternative 3: Visitor Recreation Expenditures (2010 dollars in thousands)

Activity	Residents	Nonresidents	Total
Nonconsumptive			
Pedestrian	$2,424.8	$2,209.9	$4,634.7
Auto tour	$646.6	$589.3	$1,235.9
Boat trail/launch	–	–	–
Bicycling	–	–	–
Photography	$98.2	$39.8	$138.0

Table 6-11. Alternative 3: Visitor Recreation Expenditures (2010 dollars in thousands)

Activity	Residents	Nonresidents	Total
Interpretation	$54.6	$22.1	$76.7
Total nonconsumptive	$3,224.2	$2,861.1	$6,085.3
Hunting			
Waterfowl	$41.5	$16.0	$57.4
Other migratory birds	–	–	–
Upland game	–	–	–
Big game	–	–	–
Total hunting	$41.5	$16.0	$57.4
Fishing			
Fresh water	–	–	–
Salt water	–	–	–
Total fishing	–	–	–
Total Annual Expenditures	**$3,265.6**	**$2,877.1**	**$6,142.7**

Input-output models were used to determine the economic impact of expenditures on the refuge's local economy. The estimated economic impacts, including visitor expenditures, are expected to occur in the local five-county area. Table 6-12 summarizes the local economic effects associated with recreation visits. Under Alternative 3, final demand would total nearly $12.0 million, with associated employment of 95 jobs, $3.6 million in employment income, and $1.7 million in total tax revenue.

Table 6-12. Alternative 3: Local Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Residents	Nonresidents	Total
Final demand	$6,537.9	$5,438.9	$11,976.8
Jobs	53	41	95
Job income	$1,977.2	$1,615.7	$3,592.9
Total tax revenue	$936.0	$776.5	$1,712.5

6.6.6 Summary of Recreational Visitation Impacts

Tables 6-13 and 6-14 provide a summary of the potential economic impacts related to recreational visitation for each alternative. Under Alternatives 2 and 3, recreation visitation would quadruple after the management alternative is fully implemented. As a result, economic output, jobs, job income, and tax revenue would increase.

Table 6-13. Annual Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Alternative 1	Alternative 2	Alternative 3
Recreation visits	80,180	383,200	371,140
Expenditures	$927.4	$6,237.2	$6,142.7
Economic output	$1,809.5	$12,163.5	$11,976.8
Jobs	14	96	95
Job income	$543.0	$3,649.1	$3,592.9
Total tax revenue	$258.7	$1,739.2	$1,712.5

Table 6-14. Change in Average Annual Recreation Visitors and Expenditures Compared to the Baseline (Alternative 1) (2010 dollars in thousands)

	Alternative 2	Alternative 3
Visitors	+303,020	+290,960
Economic output	+$10,354.0	+$10,167.3
Jobs	+82	+80
Job income	+$3,106.2	+$3,049.9
Total tax revenue	+$1,480.5	+$1,453.8

6.6.7 Economic Effects from Refuge Budget

Annual costs reflect refuge spending of base funds allocated each year. These are also known as recurring costs and are usually associated with day-to-day operations. Nonsalary expenditures are primarily fixed costs such as utilities, fuel, office supplies, water district assessments, and other expenses. Large restoration and facility costs are currently undetermined for each alternative and are not included in the average annual expenditures presented below.

Table 6-15 shows that average annual expenditure would be about $732,000 for Alternative 1, and about $1.5 million for Alternatives 2 and 3. The estimated expenditures for Alternatives 2 and 3 assume that the alternatives are fully funded as described in the CCP. Thus, the expenditures for Alternatives 2 and 3 include an additional six full-time staff members compared to Alternative 1.

Table 6-15. Refuge Average Annual Expenditures (2010 dollars in thousands)

Expenditure	Alternative 1	Alternative 2	Alternative 3
Salary	$498.0	$996.1	$996.1
Nonsalary	$233.8	$467.5	$467.5
Total	$731.8	$1,463.6	$1,463.6

Table 6-16 shows the economic impact of average annual (salary and nonsalary) expenditures. Impacts associated with annual expenditures would continue to occur throughout the 15-year timeline of the CCP if the alternative chosen is fully funded. Under Alternative 1, the refuge's annual expenditures would generate approximately $1.3 million in economic output, 10 jobs, $500,000 in job income, and $193,000 in tax revenue. Economic impacts for Alternatives 2 and 3 would be the same. Annual expenditure under Alternatives 2 and 3 would generate an economic output of $2.7 million, 19 jobs, $1.0 million in job income, and $385,300 in tax revenue.

Table 6-16. Local Annual Economic Effects Associated with Average Annual Refuge Budget (2010 dollars in thousands)

	Alternative 1	Alternative 2	Alternative 3
Economic output	$1,340.4	$2,680.8	$2,680.8
Jobs	10	19	19
Job income	$499.6	$999.3	$999.3
Total tax revenue	$192.5	$385.0	$385.0

Table 6-17 shows the change in economic impacts associated with the refuge budget compared to the baseline (Alternative 1). Once fully funded, annual expenditures for Alternatives 2 and 3 would each increase by about $732,000, compared to Alternative 1 (Table 6.15). Under Alternatives 2 and 3, economic impacts associated with annual expenditures would increase by $1.3 million in economic output, 9 jobs, and $500,000 in job income.

Table 6-17. Change in Annual Expenditures Compared to the Baseline (Alternative 1) (2010 dollars in thousands)

	Alternatives 2 and 3
Annual expenditures	+$731.8
Economic output	+$1,340.4
Jobs	+9
Job income	+$499.6
Total tax revenue	+$192.5

6.6.8 Summary of Economic Impacts by Alternative

This section summarizes the economic impacts generated by refuge management activities for each alternative. Table 6-18 summarizes the economic impacts in the greater Portland metropolitan area for Alternative 1. Under Alternative 1, refuge activities would generate an estimated $3.1 million in economic output, 24 jobs, $1.0 million in job income, and $451,300 in tax revenue in the local economy. These economic impacts under Alternative 1 represent less than 1 percent of total income and total employment in the local area economy.

Table 6-18. Summary of Annual Economic Impacts for Alternative 1 (2010 dollars in thousands)

	Economic Output	Jobs	Job Income	Tax Revenue
Recreation	$1,809.5	14	$543.0	$258.7
Budget	$1,340.4	10	$499.6	$192.5
Total	$3,149.9	24	$1,042.6	$451.3

Table 6-19 summarizes the economic impacts for Alternative 2. Under Alternative 2, refuge activities would generate an estimated $14.8 million in economic output, 115 jobs, $4.6 million in job income, and $2.1 million in tax revenue in the local economy. These economic impacts under Alternative 2 represent less than 1 percent of total income and total employment in the local area economy.

Table 6-19. Summary of Annual Economic Impacts for Alternative 2 (2010 dollars in thousands)

	Economic Output	Jobs	Job Income	Tax Revenue
Recreation	$12,163.5	96	$3,649.1	$1,739.2
Budget	$2,680.8	19	$999.3	$385.0
Total	$14,844.2	115	$4,648.4	$2,124.3

Table 6-20 summarizes the economic impacts for Alternative 3. Under Alternative 3, refuge activities would generate an estimated $14.7 million in economic output, 114 jobs, $4.6 million in job income, and $2.1 million in tax revenue in the local economy. These economic impacts under Alternative 3 represent less than 1 percent of total income and total employment in the local area economy.

Table 6-20. Summary of Annual Economic Impacts for Alternative 3 (2010 dollars in thousands)

	Economic Output	Jobs	Job Income	Tax Revenue
Recreation	$11,976.8	95	$3,592.9	$1,712.5
Budget	$2,680.8	19	$999.3	$385.0
Total	$14,657.6	114	$4,592.2	$2,097.6

6.7 Other Effects

6.7.1 Potential Impacts on Adjacent Lands and Associated Natural Resources

Under Alternative 1, as maintenance and management continue across all refuge lands, there is potential for both positive and negative effects to surrounding natural resources. Various land uses surround the Sherwood Units, including residential, retail/commercial, industrial, agricultural, recreational, and native habitat types. The land around the Wapato Lake Unit is mainly agricultural with some residential and commercial uses. As management and maintenance continue, waterfowl hunting clubs may benefit from waterfowl using habitats in the refuge that also venture to the nearby hunting clubs. As native habitat types on the refuge mature, adjacent native habitats may benefit from exchange of genetic material among plants, and animals may benefit from larger blocks of habitat. As refuge habitats are maintained, nonnative plants may be reduced and produce less seed that has the potential to spread to neighboring lands. On the other hand, many neighboring landowners may consider native or other plants beneficial to the refuge as nuisance species especially to agricultural operations. For example, many native grass species are unwelcome for agricultural growers, who may have to control these species. For natural areas owned by Metro and others, the refuge and its habitats provide a stepping stone in a chain of native habitats within the Tualatin River Basin. Overall, slight positive long-term benefits should result from continuing Alternative 1.

Under Alternative 2 (preferred), proposed restoration and maintenance activities would create larger contiguous blocks of habitat both within the refuge and connecting with habitats outside the boundary, which should benefit a number of wildlife communities. Mammals such as black-tailed deer and mink would have larger blocks of habitat in which to live and move about the Tualatin River Basin. Many songbird species would benefit from larger blocks of habitat as well. Lands adjacent to the refuge may see an increase in local populations of wildlife as a result of improved habitat conditions. For some landowners, this increase in population may be welcome, but for others such as agricultural operators an increase in some wildlife populations may have a negative effect. One of the largest impacts would be terminating farming of croplands and restoring those parcels to native habitat types. These conversions would be expected to have positive effects to wildlife and neighboring native habitats. On the Sherwood Units, conversion of herbaceous wetlands to other native habitat types and restoration of croplands to native habitat types could cause a decrease in waterfowl numbers using this area of the refuge. This may be considered a negative impact among waterfowl hunters in the area who hunt on neighboring land. Overall, intermediate positive long-term effects would be expected under this alternative.

Under Alternative 3, larger blocks of forested habitat types would be restored, providing even more contiguous forested habitat connecting with neighboring lands. Croplands would also be restored to native habitat types. This would likely have similar results to wildlife populations as described under Alternative 2 above. Overall, intermediate positive long-term effects would be expected under this alternative.

6.7.2 Potential Impacts to Nearby Residents

Under all alternatives, effects that may occur from management and maintenance activities include dust created while mowing or discing, and possibly the smell and effects of unwanted drift of herbicide being used on refuge lands; however, these effects would be greatly reduced by following the refuge IPM plan (Appendix G). There would be some level of noise associated with operating heavy equipment such as farm tractors and backhoes.

Under Alternative 1, refuge habitats would continue to be maintained as they currently are. Most effects to local residents would be expected to be positive as habitats mature and provide viewing opportunities for wildlife. Most residents enjoy observing wildlife, and this opportunity should increase slightly over the 15-year life of this plan. Although black-tailed deer and other wildlife species currently inhabit the refuge and surrounding areas, slight negative effects might occur as wildlife interact with nearby residents and cause damage to gardens or crops.

Under both Alternatives 2 (preferred) and 3, as larger blocks of contiguous habitats are restored, local wildlife populations may increase, providing both benefits in terms of wildlife observation and negative effects in wildlife conflicts with local residents. At the Wapato Lake Unit, conversion of croplands to native habitat types would likely change the look of the area and composition of wildlife communities using the area. This also may result in both positive and negative effect to neighboring residents, such as an increase in watchable wildlife and an increase in wildlife/human interactions. Additionally, fully restoring Wapato Lake may result in a change in interactions of the Tualatin River and creeks in the area with the restored lake. This may result in reduced flooding of neighboring lands during winter or other unknown effects. Maintaining water in the lake during summer may increase the incidence of mosquitoes in the area. Prescribed fire would be used to maintain certain habitat types and may cause irritation due to smoke and falling ash to nearby residents.

6.8 Cumulative Effects

Cumulative effects can result from the incremental effects of a project when added to other past, present, and reasonably foreseeable future projects in the area. Cumulative impacts can result from individually minor but cumulatively significant actions over a period of time. This analysis is intended to consider the interaction of activities at the refuge with other actions occurring over a larger spatial and temporal frame of reference.

The Council on Environmental Quality (CEQ) regulations for implementing the provisions of the National Environmental Policy Act (NEPA) define several different types of effects that should be evaluated in an EA, including direct, indirect, and cumulative effects. Direct and indirect effects are addressed in the resource-specific sections of this draft CCP/EA. This section addresses cumulative effects.

The CEQ (40 CFR 1508.7) (CEQ 1997) provides the following definition of cumulative effects as:

> *The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.*

It should be noted that the cumulative effects analysis has essentially been completed by virtue of the comprehensive nature by which direct and indirect effects associated with implementing the various alternatives were presented. The analysis in this section primarily focuses on effects associated with reasonably foreseeable future events and/or actions regardless of what entity undertakes that action.

6.8.1 Effects from Reasonably Foreseeable Future Refuge Activities

As described in Chapter 4, cumulatively, there has been a substantial modification to native habitats of the Tualatin River Basin over the past 150 years. Although a number of natural areas have been designated and are maintained in the area, modification and loss of native habitats continue at a regional scale. There is a clear trend of regionally increasing population growth, which is bringing increased development and associated habitat loss, particularly in the Portland area. Invasive species and altered ecosystem processes are widespread within the area. Within this context, region-wide biological integrity may be at risk. Over time, the refuge, although relatively small and isolated from other natural lands, may become increasingly valuable for the persistence of native wildlife of the Willamette Valley. Active improvement of refuge habitats would increase or maintain the value of refuge lands and waters for a wide variety of native fish and wildlife, and biological diversity (the number of species present on the refuge) would probably remain about the same. All of the alternatives would maintain refuge habitats valuable to wildlife. The Service would improve the availability and quality of wildlife-dependent recreation, but within a regional context, there would be little cumulative difference in recreational opportunity. Although mortality would occur to some wildlife under the refuge's hunt program, the analysis presented in this chapter supports the conclusion that there would be no adverse population-level impacts to hunted or nonhunted wildlife species, even when added to other hunt programs regionally or nationally.

Compared to Alternative 1, Alternatives 2 and 3 present the potential for more benefit to conservation of native species in the Tualatin River Basin and to recreational users, because under these alternatives the Service would restore and maintain larger blocks of wildlife habitat, restore waterways, and develop additional public use features. Further land acquisition would provide protection and restoration of additional habitats that may presently, or in the future, support rare species. Such additional lands may eventually be opened to public use, providing direct opportunity for enjoyment of nature and wildlife. However, even if they are never opened to the public, managing additional lands for conservation values would bolster and support native species populations in the Tualatin River Basin, benefiting recreationists using the refuge and surrounding lands.

6.8.2 Potential Effects from Climate Change

According to the Climate Impacts Group at the University of Washington, "even subtle changes in Pacific Northwest precipitation and temperature have noticeable impacts on the region's mountain snowpack, river flows and flooding, the likelihood of summer droughts, forest productivity and forest fire risk, salmon abundance, and quality of coastal and near-shore habitat" (Climate Impacts Group 2011). Warming is expected to affect a variety of natural processes and associated resources. However, the complexity of ecological systems and interactions means that there is tremendous uncertainty about the exact eeffect climate change would have. In addition, localized effects still require more research (Parmesan et al. 2011). The following paragraphs attempt to identify the key

potential effects of climate change on refuge-specific habitats and plants and wildlife, using the available science and projections, combined with awareness of refuge-specific conditions. By necessity this brief assessment is incomplete, and all projected effects should be treated as hypotheses and tested over time using scientific methods.

Vegetation models indicate that in western Oregon, areas of mixed evergreen and subtropical mixed forest are projected to expand, marking a major transition from temperate to subtropical species (Oregon Climate Change Research Institute [OCCRI] 2010). Pests and diseases would continue to expand northward into Oregon, affecting forest species (Waring et al. 2011). Mountain pine beetle occurrence has been increasing over the last eight years and would likely continue to increase in a warmer climate, along with forest pathogens. Drought also increases vulnerability to mountain pine beetle. Other pests and diseases, including sudden oak death, have been spreading northward from California into southwestern Oregon since the beginning of the twenty-first century. In the case of sudden oak death, extreme precipitation events tend to infect more trees, which then become more vulnerable to mortality during droughts. Generally, insects and diseases would expand northward in latitude, toward the coast, and upward in elevation in a warming climate.

Wildfires would likely increase in all Oregon forest types in the coming decades. Warmer and drier summers leave forests more vulnerable to fire, while wetter winters provide abundant fuel in the form of grasses and shrubs. Wildfire frequency in western forests increased fourfold during 1987-2003 as compared to 1970-1986, while the total area burned increased sixfold (Westerling et al. 2006). Westerling et al. (2006) demonstrated that earlier snowmelt dates correspond to increased wildfire frequency. Trouet et al. (2006) confirmed that these increases in area burned are tied to climate conditions, despite forest suppression management practices such as thinning. As shown above, virtually all climate model projections indicate that warmer springs and summers would occur over the region in coming decades. Prolonged dry and hot periods are generally required for large fires (Gedalof et al. 2005), and future conditions would likely make these periods, and resultant wildfires, more likely.

Climate change effects on species' ranges, phenology, and physiology have been well documented (Lovejoy and Hannah 2005; Parmesan 2006; Rosenzweig et al. 2008; Schneider and Root 2002). Fish and wildlife in the Willamette Valley include both migratory and resident species. There is evidence that the abundance and distribution of species are shifting in response to climate change, and would shift more rapidly as habitats on land and in water are altered due to increasing temperatures and related environmental changes (OCCRI 2010). Among the observed species changes:

- Insects are moving in from the south of Oregon;
- Frogs are reproducing earlier in the year;
- Landbirds are shifting their distributions northward and migrating earlier; and
- Fish are losing their cool-water habitats.

Rising temperatures, shifts in precipitation patterns, and other climatic change may also affect other ecological interactions, such as densities of species; timing of events such as spring flowering times, emergence timing, patterns for insect and pollinator species, egg laying, and migration; changes in morphology, such as body size, and behavior; and changes in genetic frequencies such as those caused by a disruption in the connectedness among species (Root et al. 2003). These changes can unfold in complex cascading direct and indirect effects such as those described by Martin and Marin

(2012). The refuge's wetland, riparian, and aquatic species are perhaps the most vulnerable to these effects (Lawler et al. 2008).

However, predicting biological response at the population level is difficult (Akcakaya et al. 2006; Pereira et al. 2010). In a warmer climate, plant and animal species may respond by occupying different parts of the landscape. Rare or endangered species may become less abundant or extinct; insect pests, invasive species, and harmful algal blooms may become more abundant. Declines in abundance of species may be caused directly by physiological stress related to changes in temperature, water availability, and other environmental shifts, and/or indirectly by habitat degradation and negative interactions with factors that are benefited by climate change (diseases, parasites, predators, and competitors), but it remains difficult to model how species' range and population abundance (increasing or declining) can be projected from a suite of interrelated climate-related variables (Fordham et al. 2012). Researchers are improving models, and the refuge would evaluate the results of a new Willamette Valley vegetative and species response model currently being undertaken by the University of Washington (led by Dr. Josh Lawler and funded by the North Pacific Landscape Conservation Cooperative).

The increase of invasive species risk is due to a variety of reasons. For example, invasive species have a broader climate tolerance and larger geographic ranges, along with characteristics that favor rapid range shifts. Also, climate change may alter transport and introduction mechanisms, establish new invasive species, alter the impact of existing invasive species, and affect other risk factors (Hellmann et al. 2008; Rahel and Olden 2008; Willis et al. 2010). One example that affects Tualatin River National Wildlife Refuge is the potential population growth of nutria. Nutria are currently at a nuisance level at the refuge in terms of physical damage to embankments and vegetation, but with milder winters projected, they may become more abundant and more disruptive to water management, recreation access, and native species conservation.

The good news is that hotter and drier summers generally favor fire-adapted communities such as Willamette Valley prairie and savanna communities (Bachelet et al. 2011). Bachelet et al. (2011) also found that:

> *Many of the aggressive exotic species that occur in both wet and dry prairies in the western Pacific Northwest currently have wide range distributions in the U.S. (Dennehy et al. 2011), so it is reasonable to assume that they will be relatively adaptable to changing climate. Consequently, they may provide even more of a competitive challenge to native Pacific Northwest prairie species in the future than they do currently. However, as we mentioned above, many native prairie species are well adapted to summer drought, which could give them an advantage over many exotic species as summer drought extends and intensifies…*
>
> *Directly relevant to the future of prairies and oak savannas, Shafer et al. (2001) showed significant contraction of the range of Garry oak [Oregon White Oak] on the west side of the Cascades and a shift and expansion to the east side of the mountains by the end of the 21st century. However, a recent study conducted by Bodtker et al. (2009) found that climate suitability for Garry oak is likely to improve overall in Washington, Oregon, and British Columbia, where it is the dominant oak species, with some declines in specific areas…*
>
> *The effects of warming on grasslands have also been experimentally studied by a variety of scientists who focused on plant community structure, productivity, or phenology… Findings include: warming often causes a decrease in plant biodiversity (Zavaleta et al. 2003, Klein et*

> *al. 2004, Walker et al. 2006), while species-specific effects are mediated through changes in litter quantity (Weltzin et al. 2001, Klein et al. 2004, Weltzin et al. 2005, Suttle et al. 2007) and nutrient availability (Shaver et al. 2000, De Valpine and Harte 2001, Rustad et al. 2001, An et al. 2005, Suttle et al. 2007). Pfeifer-Meister and Bridgham (2007) showed strong seasonal controls of temperature and moisture on carbon and nutrient cycling in a Willamette Valley/Puget Trough/Georgia Basin prairie, with competition between native and exotic species mediated by moisture and nutrient availability (Pfeifer-Meister et al. 2008).*

A recently completed vulnerability assessment for Willamette Valley provides an analysis of effects to many species and habitats managed by the refuge (Steel et al. 2011). A summary of the findings is excerpted here:

> *Of the 46 species and subspecies assessed, the four most vulnerable to climate change were Coastal Cutthroat Trout (Southwest Columbia River ESU; Oncorhynchus clarkii pop. 2), Chinook Salmon (Lower Columbia River ESU, Fall Run; Oncorhynchus tshawytscha pop. 22), Way-side Aster (Aster vialis), and Fender's Blue Butterfly (Icaricia icarioides fendereri). Among the species assessed, invertebrates, fishes, and plants tended to be the most vulnerable groups on average. The ecological parameters that most contributed to climate change sensitivity were inferred limitations in temperature tolerance, negative response to disturbance regimes, dependence on current precipitation/hydrologic regimes, dependence on specific habitat attributes, and dependence on cooler microsites within habitats.*

When analyzing Conservation Opportunity Areas (COAs), the authors focused on climate sensitivity and overall vulnerability. The Tualatin River is ranked as a highly vulnerable area. However, the authors also note that in many cases nonclimate factors may remain more threatening to COAs than climate change.

6.8.3 Other Reasonably Foreseeable Events and Activities

Development and population growth: By 2030, the population of the greater Portland area is expected to be as high as 3.5 million people. Population growth would continue to place stress upon the ecosystems of the Willamette Valley, both through direct loss of remaining habitats, and indirectly through fragmentation and degradation of the valley's remaining parcels of wildlife habitat.