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CRESCENT VALLEY BIODIVERSITY MANAGEMENT AREA WILDLIFE ANALYSIS

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This analysis focuses on an area containing biological diversity and richness in a rapidly urbanizing setting—the Crescent Valley watershed, and the included Gig Harbor Biodiversity Management Area (BMA), (Pierce County Biodiversity Alliance 2004, Figure 1). This area is located within Pierce County, in western Washington. In the analysis we utilize metrics and mid-scale fish and wildlife mapping approaches to develop information for local community decision-making.

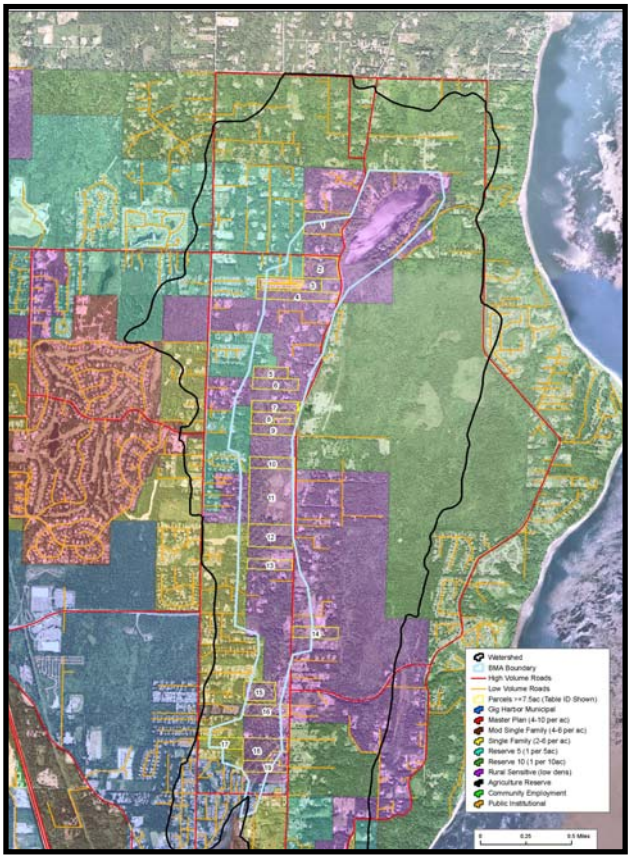

Figure 1. The boundaries for the Gig Harbor Biodiversity Management Area (blue), and the Crescent Valley watershed (black).

There are three predicted at-risk species, 14 state or federal-listed species and 17 Washington Department of Fish and Wildlife (WDFW) priority species in the BMA. The Common Garter Snake (*Thamnophis sirtalis*), was a trigger species[1]. Six amphibians, 74 birds, 43 mammals, and five reptiles are predicted to inhabit this area, and 11 butterfly species have been confirmed. The confluence of Crescent Creek and Gig Harbor Estuary is a WDFW priority habitat; shorelines associated with the estuary are rated high quality, and Chinook Salmon (*Oncorhynchus tshawytscha*, FT, SC) occur in Crescent Creek.

As more people move to Crescent Valley, some species such as the American Robin (*Turdus migratorius*), Raccoon (*Procyon lotor*), and Pacific Treefrog (*Hyla regila*) will continue to thrive, but many more sensitive species will only be retained if care is given to factors such as maintaining large enough patch sizes, and habitat conditions that allow safe movement between patches and seasonal habitats.

Planning Context

- Pierce County has adopted a biodiversity network into open-space classification (http://www.co.pierce.wa.us/pc/services/home/property/pals/other/biodiversity.htm).

[1] Habitat needs for common garter snake and reptiles in general were assured within the Gig Harbor BMA, making this a "trigger species".

- The Gig Harbor Biodiversity Management Area is a specific area within the network.
- Residents from the local community have developed a plan to retain the area's biodiversity with the assistance of Friends of Pierce County, and The Pierce County Biodiversity Alliance.
- The information provided in this chapter was developed to assist the local community with their biodiversity planning.

Focal Species and Response Groups

WDFW Priority Habitats and Species data, species lists within the network document (Pierce County 2004), and additional data from a bioblitz held June 3-4, 2005, provided information on species expected or verified to be present. Through consideration of this information, we chose the following species and groups for analysis:

- Common Garter Snake, based on importance to the biodiversity network,

- Northern Red-legged Frog (*Rana aurora*), based on importance as a food source to the Common Garter Snake, and as an umbrella species to other amphibians,

- Bobcat (*Lynx rufus*)and Coyote (*Canis latrans*), umbrella species for mid-to large sized wide-ranging mammals,

- Bird development response groups based on patch sizes and dwelling density sensitivities.

Stressors to Evaluate

Table 1 provides an overview of development stressors associated with these species/groups.

Table 1. Development response groups, focal/umbrella species, housing density sensitivity, and primary stressors to wildlife to address for the Crescent Valley biodiversity management area.

Development Response Group	Focal/or Umbrella Species	Housing Density Sensitivity	Primary Stressors to Address					
			Habitat Composition	Habitat Configuration	Habitat Connectivity	Roads	Hydrology	Non-Native Species
Terrestrial reptiles, aquatic and terrestrial habitat, extensive spatial scales, live birth	Common garter snake	Moderate sensitivity (expected persistence at ≤1du/10ac)	- natural habitat	- breeding and active-season habitat different	- extensive movement by ground	- road mortality	- changes to hydrology	- domestic cats
Pond-breeding amphibians, intermediate movement scale, require breeding habitats with long hydroperiods	Northern red-legged frog	High sensitivity (expected persistence at ≤1du/20ac)	- natural habitat	- breeding and active-season habitat different	- extensive movement by ground	- road mortality	- changes to hydrology - need longer hydroperiod ponded habitat	- bullfrogs non-native fishes - dogs
Mid-sized mammals with moderate movement capability, moderate fragmentation tolerance	Bobcat	Moderate sensitivity (expected persistence at ≤1du/10ac)	- patch size	- wide ranging	- patch isolation	- road density -road mortality		
Large-sized mammals with extensive movement capability, highly fragmentation tolerant	Coyote	Very low sensitivity (expected persistence at ≤1du/2.5ac)				- road density -road mortality		
Birds, high tolerance for development, moderate to high (or unknown) sensitivity to patch area	Suite of bird species[a]	Low sensitivity (expected persistence at ≤1du/5ac)	need: - patch size >12ac - well developed shrub layer - older conifer nest trees or snags	- patch shape				- domestic cats
Birds, low tolerance for development, moderate sensitivity to patch area	Suite of bird species[b]	Very high sensitivity (expected persistence at ≤1du/20ac)	need: - patch size >12ac - need riparian, conifer, hardwood, wetlands	- patch shape				- domestic cats

[a]Incuding: band-tailed pigeon (*Columba fasciata*), ruby-crowned kinglet (*Regulus calendula*), Cooper's hawk (*Accipiter cooperii*).

[b]Incuding: MacGillivray's warbler (*Oporornis tolmiei*), brown creeper (*Certhia americana*), red-eyed vireo (*Vireo olivaceus*), northern saw-whet owl (*Aegolius acadicus*).

Indicator Metrics for Stressor Analysis

Based on stressors in Table 1, and available metrics and narrative parameters we use these parameters to evaluate current conditions for fish[1] and wildlife in Crescent Valley:

- Dwelling unit densities,
- Watershed hydrology,
- Riparian integrity (to support various aspects of habitat and hydrological function),
- Patch size for mammals,
- Patch size for birds,
- Habitat composition, connectivity and configuration (necessary for those animals with moderate to extensive movement, that must move along the ground),
- Roads (for traffic and amphibians; also road density and crossing issues for mammals), and,
- Non-native animals (bullfrogs, fish, cats, dogs).

Evaluation of Metrics and Narrative Criteria

In this section for each parameter noted above, we show the questions we asked to guide the stressor analyses. We additionally include the applicable metric(s) or narrative parameters, measured results, and examples of the GIS maps produced.

We utilize the watershed boundary for these analyses; the BMA is focused on aquatic/wet environments which necessitate watershed-wide protection for hydrological integrity, and to meet life history needs for animals that utilize the aquatic environments, but must range over larger areas.

Zoning and Dwelling Unit Densities (Figures 2a-d).

Questions:

- What is the existing zoning?
- Are there in-congruencies between existing zoning, and the needs of focal species and development response groups?

Applicable wildlife metrics:

- Coyote has expected persistence at dwelling unit (du) densities of ≤1du/2.5 acres,
- Birds - high development tolerance with >12 acre patch size have expected persistence at ≤1du/5 acres,
- The Common Garter Snake, and Bobcat have expected persistence at ≤1du/10 acres, and
- The Northern Red-legged Frog, and birds - low tolerance for development with >12 acre patch size have expected persistence at ≤1du/20 acres.

Measured values: Much of the watershed is zoned for maximum densities of 1du/5ac or 1/du/10ac. RSR and R10, both 1/10 acres, allow for a density of 1du/5 when 50% of the property is set aside as open space. No areas are zoned for 1du/20ac or less.

[1] Although we don't explicitly evaluate parameters for fish, watershed hydrology and riparian integrity function as important parameters for fish

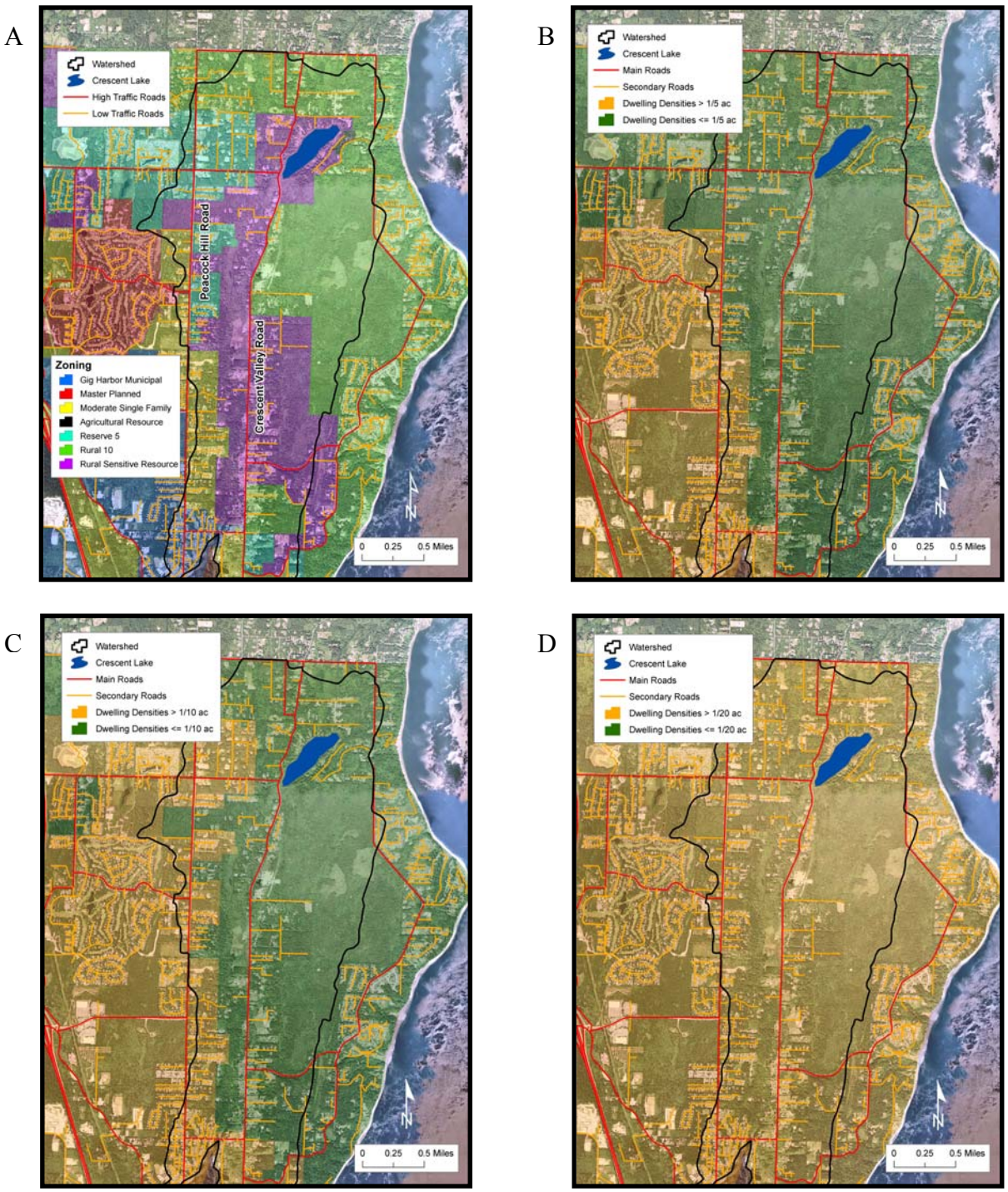

Figure 2 (A-D). A. Zoning designations for the Crescent Creek drainage basin and surrounding areas. B. Dwelling densities that meet the persistence needs of Coyote and birds with high development tolerance (≤1du/5 acres; in green). C. Dwelling densities that meet the persistence needs of Common Garter Snake and Bbobcat (≤1du/10 acres; in green). D. Dwelling densities that meet the persistence needs of the Northern Red-legged Frog, and birds with low tolerance for development (≤1du/20 acres; no green indicates dwelling densities are not expected to be suitable without special measures).

Crescent Valley Watershed Hydrological Integrity (Figure 3)

Question: Does the watershed have enough natural vegetation to protect watershed hydrological function?

Applicable metric: % natural vegetation in watershed.

Measured value: 80% .

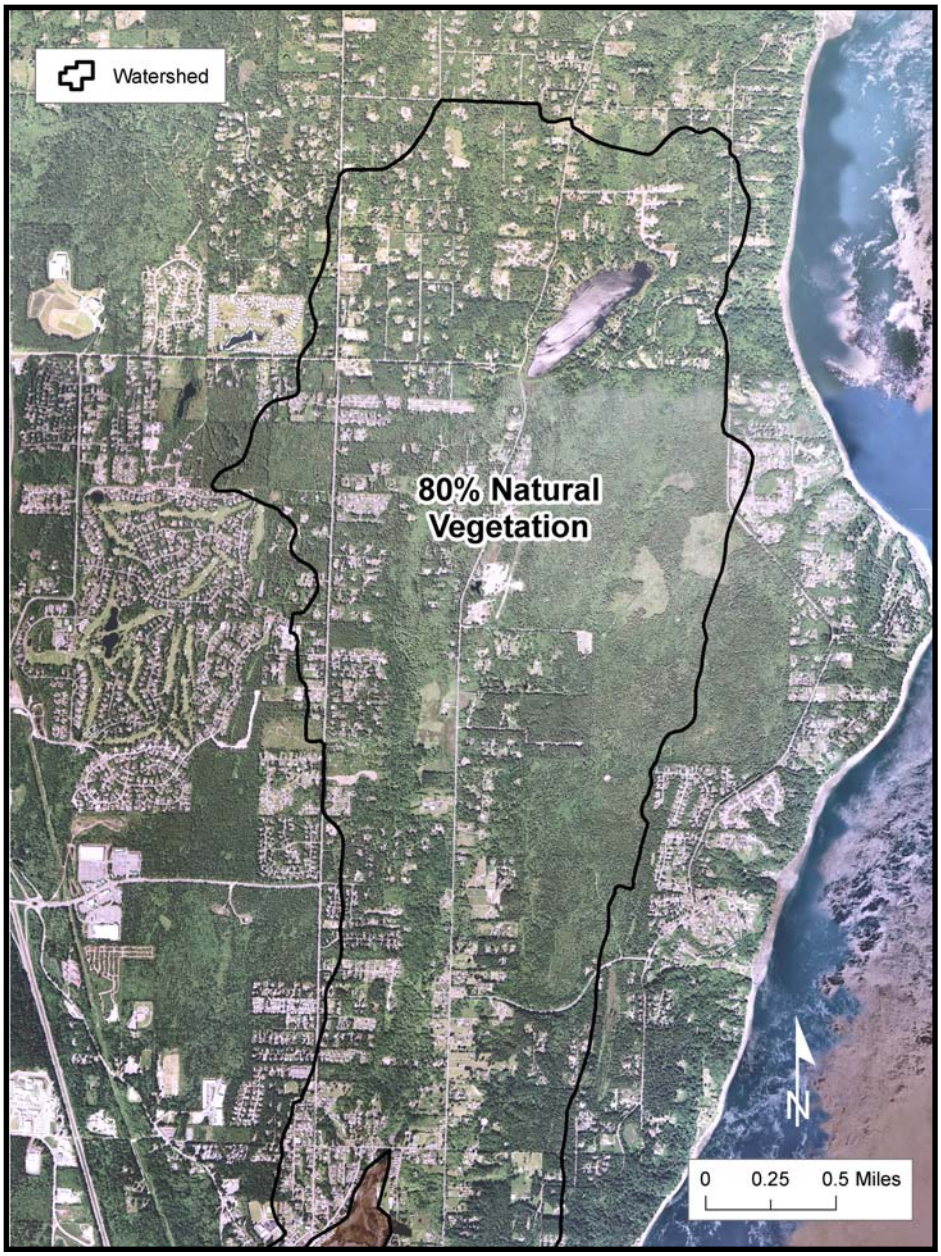

Figure 3. Percent natural vegetation (shades of green in aerial photo) within the Crescent Creek watershed, is analyzed as an indicator of hydrological function.

Crescent Valley Riparian Habitat Integrity (Figure 4)

Questions:

- Do streams have enough intact riparian vegetation to protect water quality and provide riparian habitat for fish and wildlife?
- Where are locations where riparian restoration is needed?

Applicable metrics:

- % riparian corridor >100 ft wide & <35 ft wide,
- Number of road, utility, and path crossings in the corridor per mile.

Measured values: Mainstem Crescent Creek between the lake and the estuary has 44% >100ft and 20% <35ft wide forested or wetland riparian area. The tributaries have 56% >100 ft wide and 21% < 35ft wide forested or wetland riparian area.

There are two road breaks/stream mile along the mainstem, and one break/stream mile along the tributaries.

Figure 4. Riparian areas in the Crescent Valley stream network that meet the criteria for >100 ft riparian

Crescent Valley Mammal and Bird Patch Sizes (Figure 5)

Questions:

- How fragmented is the natural vegetation, and where are the patches of natural vegetation located?
- What size are the remaining patches?

Applicable metrics:

- Patches of natural vegetation 12-100 acres, and >100 acres for birds with sensitivity to patch size,
- Patches of natural vegetation >800 acres to support three female bobcats' persistence.

Measured value: Although the watershed is extensively fragmented by roads, homes, and associated clearings, there still exist large patches and opportunity to plan for the retention of wildlife. There is one patch large enough for three female bobcats on the east side of the watershed (1221 ac); in addition, there are four patches >100 acres, and 12 patches 12-100 acres meeting the requirements for birds with sensitivity to patch size.

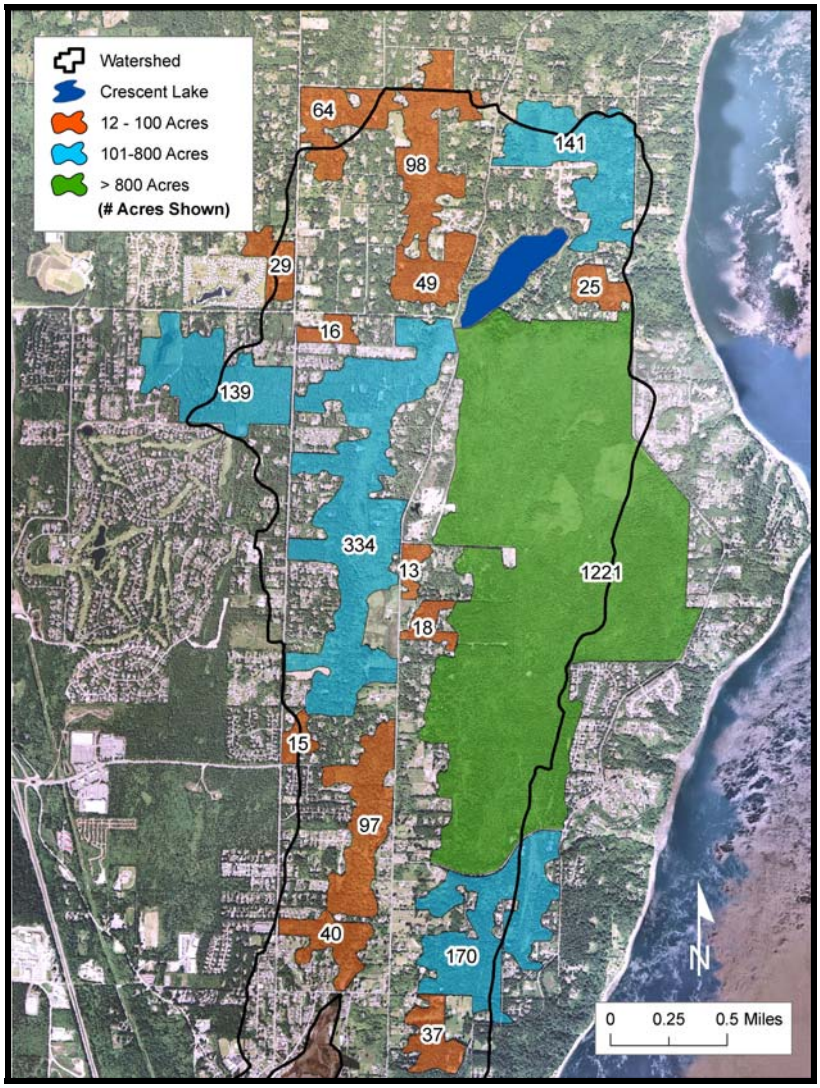

Figure 5. Natural vegetation patches 12-100 acres and >100 acres (for birds with sensitivity to patch size), and >800 acres (for bobcat); that intersect or exist within the Crescent Creek watershed.

Crescent Valley Habitat Composition, Connectivity, and Configuration for Amphibians and Reptiles (Figures 6,7)

Questions:

- Where are palustrine wetlands and how are they spatially distributed?
- What are patterns of connectivity between wetlands, and between wetland habitat and terrestrial habitat (including streams) utilized by amphibians and reptiles during their seasonal cycles?

Applicable metrics:

- Connectivity and habitat zone (CHZ) radius from wetland,
- CHZ % forest/natural vegetation.

Measured values: Percent natural vegetation within the three CHZ components is variable, but overall ranges from approximately 75% to 90%. The three CHZ components each have an approximately 0.5 mi radius (low protective level), however the distance along the valley cumulatively is approximately 3 mi and therefore provides a higher protective level.

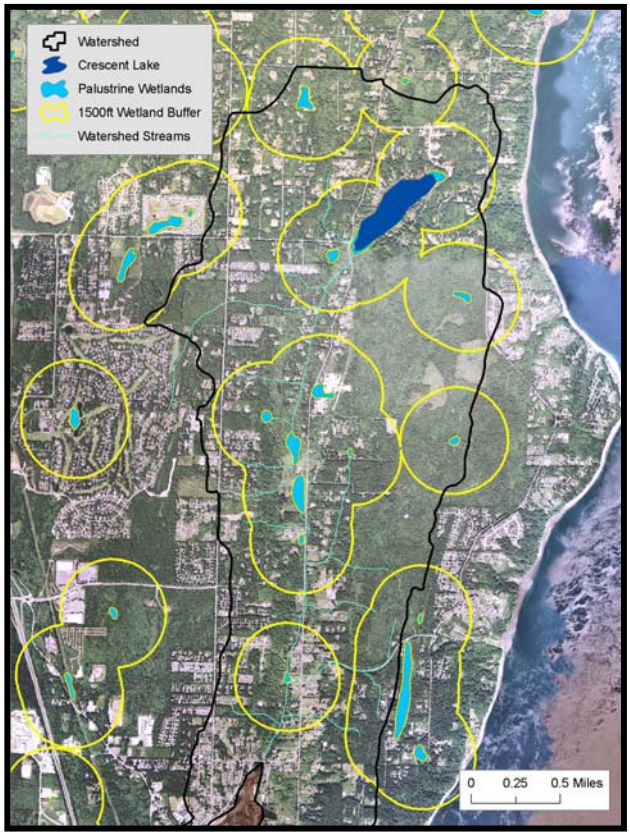

Figure 6. Crescent Valley wetlands and connectivity patterns. This depiction utilizes a radius of 0.3 mi to highlight wetland habitat and potential connectivity patterns for pond-breeding amphibians.

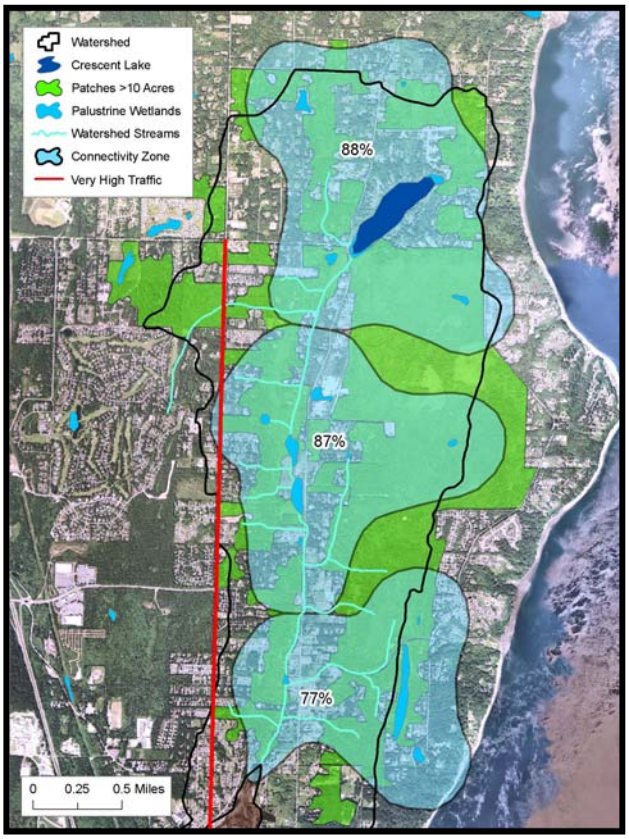

Figure.7. In this depiction, we have broadened the connectivity patterns to indicate linkages between areas along the riparian zone of Crescent Creek, and overlaid this pattern onto the patch map.

Roads (Figure 8)

Questions:

- What are potential road concerns for mammals, amphibians and reptiles?
- Are there suitable numbers of crossing areas for mammals, and how are they spatially distributed?

Applicable metrics:

- Traffic intensity: average daily vehicles per hour,
- Road density,
- Roads and habitat connectivity: locations with natural habitat on both sides of road.

Measured values:

- The overall density within the Crescent Valley Watershed is 5.9 mi of road/mi^2, 1.9 mi of high volume traffic roads/mi^2.
- Crossing areas exist, fragmentation is extensive.

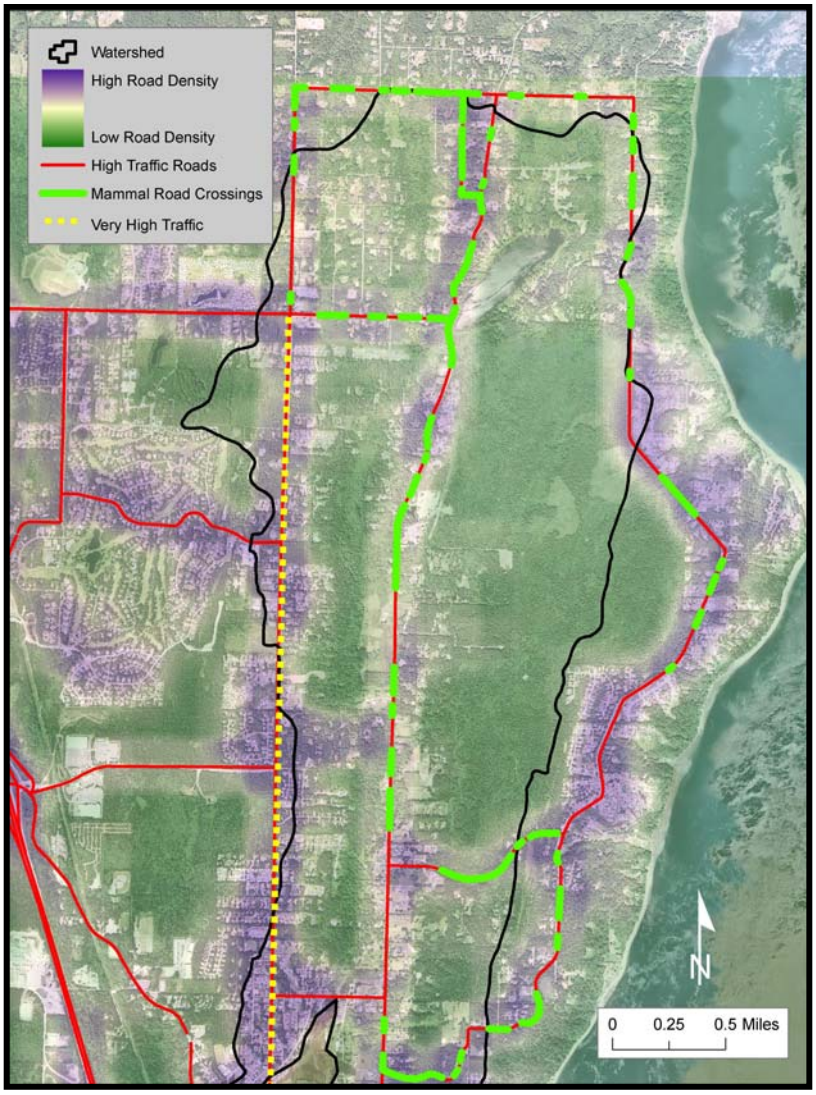

Figure 8. Road traffic volume, relative road density, and expected mammal crossing areas within Crescent Valley watershed and surrounding areas.

Non-Native Species (Figure 9)

Question: Are there issues that should be addressed related to bullfrogs, non-native fish, cats, and dogs?

Applicable narrative parameters:

- Bullfrogs and non-native fish - presence or absence and relative amount,
- Cats and dogs are expected where homes exist.

Measured values: Abundant non-native fish and bullfrogs were found in Crescent Valley during the 2005 Bioblitz.[1]; cats and dogs are expected especially near homes.

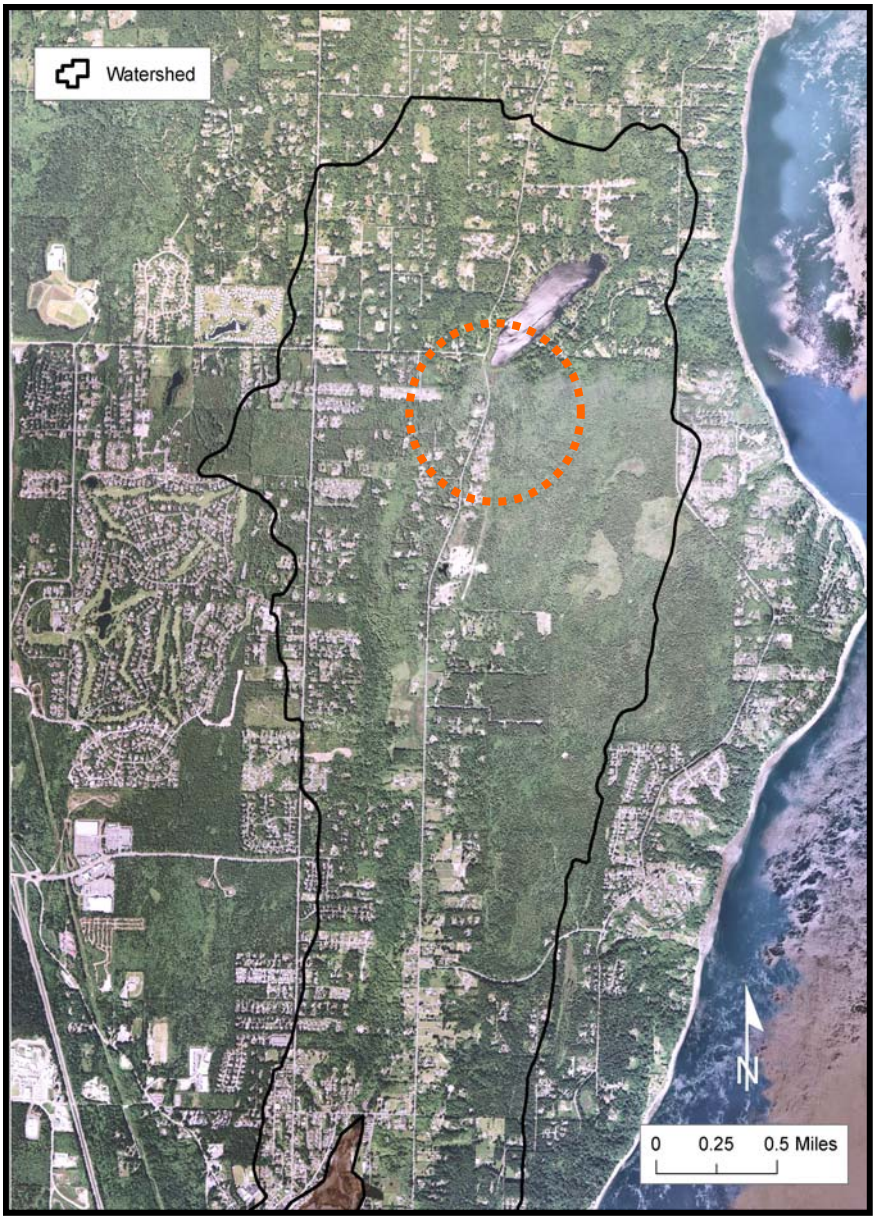

Figure 9. Non-native fish and bullfrogs were found during the 2005 bioblitz in two locations within the area of the dashed circle.

[1] The bioblitz did not undertake a full inventory of areas that might include these species.

Summary of Analysis Information

Discussion and recommendations based on the analyses are presented in Table 2.

Table 2. Summary wildlife metrics/parameters analyses and results for the Gig Harbor Biodiversity Management Area.

Analysis Parameter	Indicator	Crescent Creek Watershed	Discussion	Recommendations for Fish and Wildlife
Dwelling Unit Density	Zoning	Substantial areas are zoned for 1 du/5 and 1du/10 acres; some areas are zoned for higher densities, including Gig Harbor municipal	Both the coyote, and birds with high development tolerance, have zoning compatible with their needs throughout much of the Crescent Valley watershed. However, the lowest dwelling densities of 1 du/5 acres and 1 du/10 acres may be too dense to support the persistence of many: birds with low development tolerance, mammals, amphibians, and reptiles .	Adjusting zoning or obtain conservation easements or similar approaches to better meet the needs of the more sensitive species. Take into account locations of important patches, amphibian connectivity and habitat zone(s), and corridors or connective linkages.
Watershed Hydrology	% forest/natural vegetation in contributing watershed	Approximately 80%	Maintaining the aquatic habitat, water quality, and fish and wildlife species in streams and wetlands within Crescent Valley into the future will depend on maintaining ≥ 65% to 90% forest within the watershed. The current level of 80% forest cover provides for high quality hydrologic function for both wetland water level fluctuation and for stream hydrology. Important for pond breeding amphibians, and reptiles such as the Common garter snake that depend on the amphibians for food; also important for native fish species that utilize the stream, wetland and lake systems.	Maintain ≥65% to 90% natural vegetation throughout the Crescent Creek watershed, and use LID (low impact development) techniques for new development.
Riparian Integrity	% riparian corridor wider than 100 ft ; % corridor < 35 ft wide; number of breaks (road crossings) in the corridor	Crescent Cr. between the lake and estuary has 44% >100ft and 20% <35ft wide forested/wetland riparian area; tributaries have 56% >100 ft wide and 21% < 35ft wide forested/wetland riparian area. There are two road breaks/stream mile along the mainstem, and one break/stream mile along the tributaries.	Riparian integrity is high if >70% of the corridor is wider than 100 ft (each side of stream), and <10% of the corridor is less than 35 ft; and, there are <3 breaks in the corridor/stream mile. Streams with higher levels of riparian integrity have a greater potential for maintaining natural ecological functions (hydrology, bird, mammal, amphibian and reptile habitat, and natural corridor functions). Crescent Valley has variable riparian integrity, with many areas that are good, but overall the integrity does not meet a high quality condition. The mainstem is also impacted by Crescent Valley Road as it is located parallel to Crescent Creek within the riparian area for about 1/3 mile.	Maintain riparian integrity by keeping the riparian corridor intact, and maintaining <3 breaks in the corridor per stream mile. Restore the riparian corridor where opportunities exist. WDFW PHS Riparian Recommendations (Knudsen & Neaf 1997) recommend 150 to 250 feet wide riparian zones; based on this, maintaining or restoring riparian zones wider than 100 feet is recommended. Locations that provide connectivity between patches are a top priority for restoration.
Patch Size: Mammals	Patch size ≥800 acres (based on habitat for 3 female bobcats)	One patch this size exists in Crescent Creek watershed	This patch size indicates habitat needs may be met for mid-size wide-ranging mammals such as the bobcat. This large patch also provides habitat for species such as the long-tailed weasel, mink, and Western spotted skunk.	Maintain a large core patch without development or roads, minimize fragmentation and habitat loss within this patch, join patch to linkage areas that connect patch to interior of valley (first priorty), and to external areas such as the sound, and the penninsula to the north. Encourage development along the east-side of the patch, instead of the west-side or internally.
Patch Size: Birds	Patch sizes 12 to 100 acres, and >100 acres	These patch sizes exist in the Crescent Creek watershed	Crescent Valley includes a rich diversity of birds. Some examples of birds that are sensitive to patch sizes and require larger patches are the brown creeper, band-tailed pigeon, Cooper's hawk, MacGillivray's warbler, northern saw-whet owl, red-eyed vireo, and ruby-crowned kinglet.	Maintain patches 12 to 100, and >100 acres scattered throughout the watershed. Keep patches connected to other habitat areas to increase benefits to wildlife.

Table 2. Continued.

Indicator	Crescent Creek Watershed	Discussion	Recommendations for Fish and Wildlife
% forest/natural vegetation in amphibian and reptile connectivity and habitat zone	88% (upper area), 87% (mid-sections), and 77% (lower section)	Amphibians and reptiles move widely through the Crescent Valley watershed to utilize seasonal habitats (e.g., pond breeding habitat and upland distant summer habitat) and will be at significant risk from loss of habitat and connectivity as the area continues to develop. The measured values indicate connectivity is generally good, although at values below 80% careful attention is needed to ensure patches of habitat are connected. This is particularly evident in the lower CHZ where much of the development is clumped near the stream potentially creating a barrier effect.	Maintain a broad area within the Crescent Valley watershed as a connectivity and habitat zone (CHZ), where animals can easily move through to necessary habitats. Retaining or restoring 50 to 80% natural vegetation (good condition); >80% (best condition) will provide both habitat and connectivity to habitat. Below 80% natural vegetation careful attention to how natural habitat is located is important. Include careful consideration of roads and traffic levels.
Traffic intensity: daily vehicles per hour (v/hr): <15v/hr for amphibian persistence	Information is needed	Traffic levels greater than approximately 15 v/hr are expected to impact amphibian population persistence. Extensive literature indicates a strong relationship between traffic intensity, or road density out past 1 mile from breeding ponds, and amphibian and reptile species richness. In the Crescent Valley, main roads such as the Crescent Valley Road are likely to be impacting amphibian survival due to road crossing mortality. As traffic increases over time, this road could potentially become a complete barrier to movement.	Use traffic softening methods (e.g., lower speed limits) to limit through traffic on Crescent Valley Road which runs through the heart of important wildlife habitat. Locate new development to minimize traffic in the interior areas of Crescent Creek watershed. Underpassings along Crescent Valley Road may be needed for amphibians. Peacock Valley Road is very busy, further from wetland stream systems, and nearer the urban growth boundary. This road appears to be a better choice for higher traffic volumes.
Road density: threshold value = 1mi road/sq mi	The overall density within the Crescent Valley Watershed is 5.9 mi/sq mi overall, and 1.9 mi/sq mi of high traffic roads	Good conditions for mammals are predicted at <1 mi/sq mi; between 1 and 2.4 mi/sq mi special focus is needed to assure adquate conditions for mammals; at >2.4 mi/sq mi, extensive focus and planning will be necessary. The roads of highest concern will be those that carry high traffic loads. Roads are a significant issue for mammals due to direct mortality, noise related impacts, and causing movement barriers.	Minimize the building of new roads.
Roads and habitat connectivity: ca. 165 ft forest along road for mammal crossings	Road crossing areas exist, but fragmentation is extensive	Forest must exist on both sides of road for distances of ca. 165 ft. Note that this habitat needs to be linked up with other habitat blocks (see connective linkages above). Importance is very high for mammals that must cross roads.	Maintain or restore forest and natural habitat along roads. Pay special attention to connective linkages. Sign important areas where wildlife cross roads.
Presence of non-native species	Present	Abundant non-native fish and bullfrogs were found in the biodiversity management area during the 2005 Bioblitz. Non-native fish and bullfrogs can cause reduced abundance and decreased population persistence for pond breeding amphibians and species such as the common garter snake that depend upon the pond-breeding amphibians for food. Dogs and cats that are untended may kill large numbers of wild animals; and dogs running in the edges of ponds when there are developing amphibian egg masses may cause mortality through disturbance.	Utilize signs and other educational opportunities to address these issues. Undertake additional survey effort to determine how extensive the spread of the bullfrogs and non-native fish has been within Crescent Valley. Consider opportunities and methods for removal of the non-native fish and bullfrogs.

Synthesis Questions

Here we ask specific questions to better understand how recommendations for different species or issues might work together for planning purposes.

Patches, connectivity and habitat zone, and riparian areas:

- Where are commonalities between patch needs for mammals and birds, and where do these overlap with stream/riparian areas, and amphibian connectivity and habitat zone (CHZs) components?
- Considering the commonalities, where are priority areas to maintain patches and to refine boundaries for the CHZ?
- Where are priority areas for restoring riparian areas?

Roads:

- How do roads affect conditions in important patches, CHZs, and riparian areas?
- What specific road planning measures are needed?

Corridors and connective linkages:

- Where do connective linkages or corridors need to be maintained to ensure movement capability for mammals, amphibians, and reptiles, between patches within the watershed, and to external areas?
- What are the recommendations for retaining or restoring movement capability within the corridors or linkages?

Hydrological function:

- How do maintaining wildlife patches, riparian areas, and habitat within the CHZs interact with hydrological function for Crescent Valley watershed?
- What are additional needs for retaining hydrological functioning in the watershed?

Dwelling densities:

- Where are zoning densities incompatible with maintaining species in the identified CHZs, habitat patches, and other important locations within the watershed?
- What are recommendations for areas where zoning densities may be incompatible?

Planning Recommendations Summary

Based on consideration of the synthesis questions and recommendations from Table 2, planning recommendations for maintaining fish and wildlife in Crescent Valley are presented below. Note that because the BMA (i.e., the central portion of the valley, see Figure 1) is focused on aquatic/wet environments, a hydrological, watershed-based set of recommendations is provided.[1] Figure 10 indicates one approach to visualize how some of the recommendations may work together.

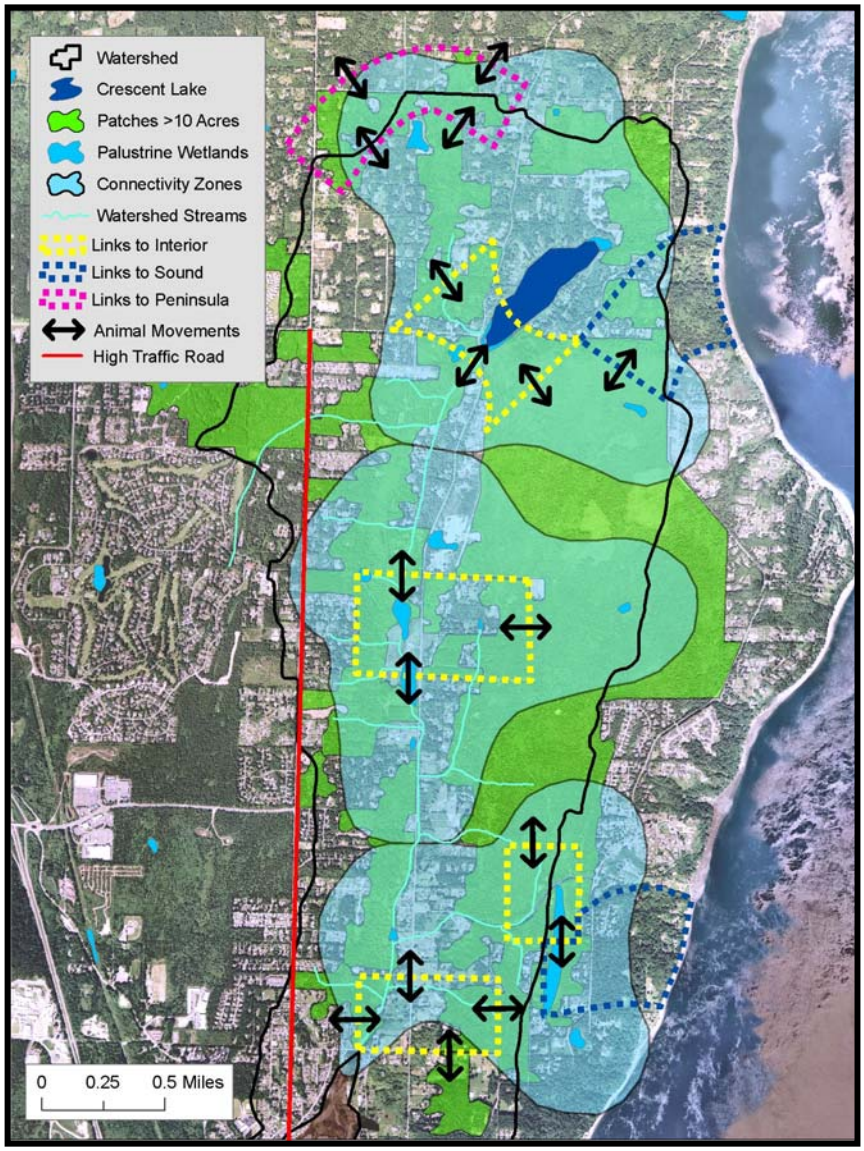

Figure 10. Summary overlay map indicating patches (green), amphibian and reptile connectivity and habitat zones (light blue), the Crescent Creek stream system, and a series of linkage areas to maintain connectivity between patches, and to external areas such as terrestrial areas to the north, and to Puget Sound to the east.

[1] With the best of stewardship solely within the BMA boundaries, much of the fish and wildlife that make this area special would be expected to be poorly retained over time.

Dwelling unit densities:

- Adjusting zoning or obtain conservation easements (or other approaches) to better meet needs of the more sensitive species. Take into account locations of important patches, amphibian connectivity and habitat zone(s), and corridors or connective linkages.

Hydrological function:

- Maintain ≥65% (65 to 90%) natural vegetation throughout the Crescent Valley watershed, and use LID (low impact development) techniques for new development.

Riparian integrity:

- Maintain existing areas of high integrity by keeping the riparian area intact, and by maintaining <3 breaks in the riparian area per stream mile. Restore the riparian area where opportunities exist; locations within connective linkages are a top priority for restoration.

Patches for birds and mammals:

- Birds: maintaining a variety of patch sizes (i.e., 12- 100 acres, and >100 acres) throughout the watershed will benefit many bird species. Keep patches connected to other habitat areas to increase benefits to wildlife.
- Mammals/Bobcats: maintain a large core patch without development or roads, minimize fragmentation and habitat loss within this patch, join the patch to linkage areas that connect the patch to the interior of the valley (first priority), and to external areas such as the sound, and the peninsula to the north. Encourage development along the east-side of the patch, instead of the west-side or internally.

Habitat connectivity zone for amphibians and reptiles:

- Maintain a broad area within the Crescent Valley watershed as a connectivity and habitat zone (CHZ) where animals can easily move through to necessary habitats. Retaining or restoring 50 to 80% natural vegetation (good condition), and >80% (best condition), will provide both habitat and connectivity between habitat patches. At levels <80% natural vegetation, attention to where natural vegetation is located is necessary. Include careful consideration of roads and traffic levels.

Roads:

- Use traffic softening methods (e.g., lower speed limits) to limit through traffic on Crescent Valley Road which runs through the heart of important wildlife habitat. Locate new development to minimize traffic in the interior areas of Crescent Creek watershed. Underpassings along Crescent Valley Road may be needed for amphibians. Peacock Valley Road is very busy, further from wetland stream systems, and nearer the urban growth boundary. This road appears to be a better choice for higher traffic volumes.
- Minimize the building of new roads.
- Maintain or restore forest and natural habitat along roads. Pay special attention to connective linkages. Sign important areas where wildlife cross roads.

Corridors and Connective linkages:

- Maintain linkages with ≥80% natural vegetation. Give special attention to road crossings in linkages: preserve forest/undeveloped habitat on both sides of road, route traffic away from

linkages, sign for wildlife crossing and lower speed limits. Throughout the rest of the CHZ, retain >50% natural vegetation (>80% is best).

Non-native animals:

- Utilize signs and other educational opportunities to address these issues.
- Undertake additional survey effort to determine how extensive the spread of the bullfrogs and non-native fish has been within Crescent Valley.
- Consider opportunities and methods for removal of the non-native fish and bullfrogs.

BMA boundary adjustment:

As described above, the current BMA boundary is not watershed-based and thus does not provide for the long-term persistence of included aquatic species. One approach to rectify this would be to expand the boundary of the BMA to include more of the watershed. Figure 11 depicts an example approach for revised boundaries that takes into consideration the wildlife analyses for birds, mammals, amphibians and reptiles, the hydrological boundary of the watershed, the very busy north/south road on the west, and the large intact parcels of land along much of the east side of the valley.

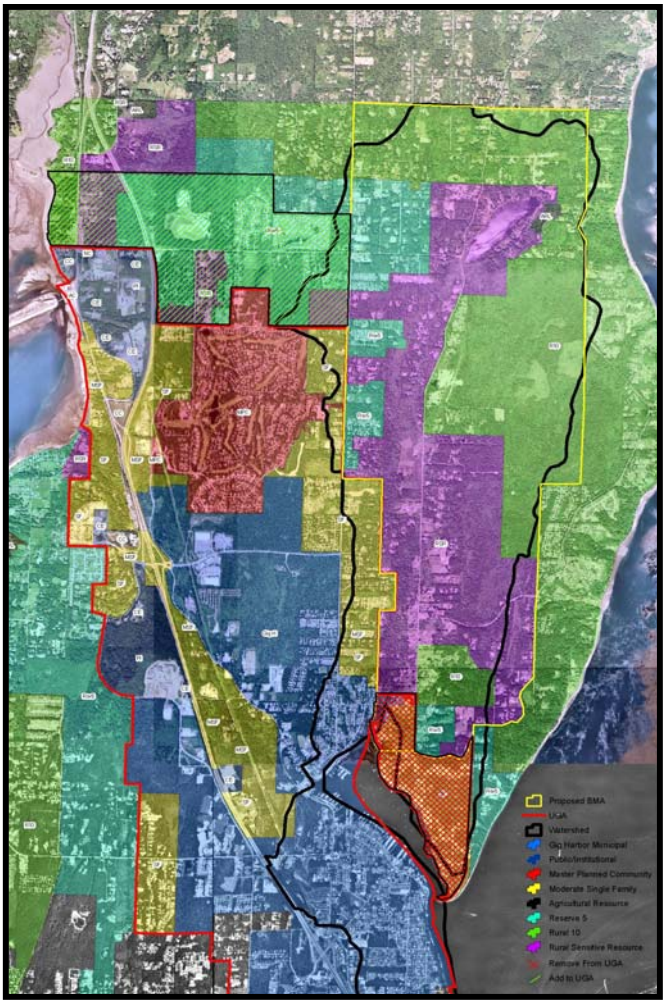

Figure 11. An example of adjusting the biodiversity management area boundary (yellow line) to better include lands necessary for the long-term persistence of aquatic species, as well as other birds, mammals, amphibians and reptiles.

We encourage readers to learn more about the Pierce Biodiversity Network , and the Crescent Valley Alliance. Information is available on the Pierce Biodiverstiy Alliance website: (http://www.fish.washington.edu/naturemapping/pierce_county.html).

Attachment: GIS Mapping Methods for the Crescent Valley Study

Attachment: GIS Mapping Methods for the Crescent Valley Case Study

Zoning and Dwelling Unit Densities (Figures 2a-d). Utilize GIS zoning maps to depict zoning for the planning area. Make additional maps that portray where specific zoning densities meet the persistence metrics for the focal species and groups.

Watershed Hydrological Integrity (Figure 3). Obtain the most recent digital landcover layer that has classes that can be grouped into a "Natural Vegetation" class. Using the watershed boundary layer as a clipping layer, determine the area of natural vegetation values that exist within the watershed boundary. The ratio of area of natural vegetation to the area of the entire watershed will provide the percent natural vegetation.

Riparian Habitat Integrity (Figure 4). Obtain the most spatially accurate digital layer depicting the stream network, and the most current digital orthophotograph. Use the GIS to buffer the streams out 100ft, and display the buffer boundary over the digital photograph. Interpret where riparian vegetation extends the width of the 100ft buffer, and digitize a line along the stream representing the length of those riparian areas. The ratio of the length of the stream segments of 100ft width riparian areas to the total stream length will provide the percent of riparian habitat integrity at a 100ft buffer width. Conduct a similar process for a 35ft buffer width.

To determine breaks/mile, visually observe where breaks exist, and average the number of breaks over the length of the channel section being analyzed.

Mammal and Bird Patch Sizes (Figure 5). Obtain the most current digital landcover layer or digital orthophotographs for your area of interest. If natural vegetation patches are well defined and separated from one another, a GIS could be used with a landcover layer to define patches with good success. However, if the landscape is fairly fragmented as is often the case in an urbanizing environment, a GIS has difficulty identifying spatially distinct patches. The GIS might automatically combine patches because of small areas of 'connectors' between larger area patches. Therefore, you often have to manually determine the patches by conducting on-screen digitizing using digital orthophotographs. (Fragstats can also be used to identify and determine patch characteristics.)

Habitat Composition, Connectivity, and Configuration for Amphibians and Reptiles (Figures 6,7). Obtain the National Wetland Inventory (NWI) digital data layer, and within the GIS extract all of the palustrine type wetlands, as those are the most typically utilized by still-water breeding amphibians during the breeding interval.

Use the GIS to buffer out from the palustrine wetlands at various distances to visualize where; 1) seasonal upland habitats surrounding the wetlands are likely to exist, and 2) wetlands may be near enough to each other to facilitate movement between wetlands by amphibians.

Using on-screen digitizing, draw polygonal boundaries to define CHZs using the wetland buffer boundaries as guides. Note that in Crescent Valley the stream corridor is a connectivity feature along most of the watershed, but we identify three descrete CHZs within the valley for analysis

of % natural habitat to determine if specific areas along the valley have disparate connectivity characteristics.

Obtain the most recent digital landcover layer that has classes that can be grouped into a 'Natural Vegetation' class. Using the CHZs boundary layers as clipping layers, determine the area of natural vegetation values that exist within each CHZ. The ratio of area of natural vegetation to the area of each CHZ will provide the percent natural vegetation for each CHZ.

The CHZs can be shaded based on the percent natural vegetation as follows:

Dark Green = >80%
Light Green = 50 to 80%
Yellow = 40 to < 50%
Tan = 30 to <40%
Dark Orange = <30%

This gradient of colors indicates a spectrum of where the best to least opportunities for connectivity and habitat are likely to exist**.**

Roads (Figure 8). Obtain a current digital vector format road layer and identify the high traffic roads and the lower traffic roads, and weight each road as a value 2 (high) or 1 (low). Create a raster data layer from the vector layer using the weight value attribute, and process the data with a summation GIS function using a 1mi by 1mi analysis 'window' that moves across the entire road data layer. This provides a data layer whose values when divided by 5,280 ft represent the number of linear road miles per square mile, relative to the weighting by traffic road type.

Non-Native Species (Figure 9). Known locations of non-native amphibians and fish can be mapped. In the case of Crescent Valley, the bioblitz identified two locations. Cats and dogs are not mapped in this example, but should be expected most places where there are homes.

Summary Map (Figure 10). This map is largely an overlay map. Connective linkages were located and added to the map based on visual identification of locations where connectivity appeared to currently exist, and to consider maintaining connectivity between patches that would appear otherwise in danger of becoming isolated. We additionally focused on suggestions for connectivity within Crescent Valley in the lower, mid, and upper sections, and to external locations as well.

BMA Example Boundary Map (Figure 11). The purpose for this map is to provide an example for how the BMA boundary might be changed to reflect the broader watershed areas necessary for retaining species within the current BMA. To do this, locations of large patches, dense development, busy roads, and the watershed boundary, along with the suite of mapping results were collectively considered.