> *"Of all our natural resources, water has become the most precious…in an age when man has forgotten his origins and is blind even to his most essential needs for survival, water along with other resources has become the victim of indifference."*

RACHEL CARSON, SILENT SPRING, 1962

## PROJECT FINDINGS

This section summarizes the results of the project research, fieldwork, and GIS modeling efforts for the Kitsap County study area. Details on watershed characteristics can be found in Appendix A. Data on salmonid distribution can be found in Appendix B. Available habitat assessment data is compiled in Appendix C. Appendix D contains information on water quality data, including any bio-monitoring that has been conducted in the study area. A summary of best available science related to riparian areas is included in Appendix E and nearshore information is summarized in Appendix F. The GIS data generated during this project can be found in Appendix G.

### SALMONID DISTRIBUTION

The distribution of native salmonids in the study area is summarized in Table 21 and is shown on maps contained in Appendix B (WCC, 2002). Salmonid distribution is presented on the watershed scale and is based on both historic and current known salmonid utilization (WDFW, 1975 and WCC, 2002). In addition, salmonid distribution also includes "potential" utilization based on the stream gradient, confinement, and streamflow data discussed earlier in this report. The data utilized in this report reflects the most conservative assessment of salmonid distribution that can be supported by scientific data. Appendix B also contains a discussion of specific habitat requirements and stock status for the populations of each species found in the study area.

In general, all accessible perennial streams within the study area support populations of cutthroat trout and coho salmon. In addition, those streams that drain directly to marine waters also support fall and/or winter chum salmon runs. The other species of salmonid present in the study region require other habitat characteristics in order to be present in a stream. Steelhead are native to almost all the larger streams and river systems. In general, chinook are found only in the major rivers within the study area, including the Dewatto, Tahuya, and Union systems, as well as a few of the larger streams systems (e.g. Coulter, Rocky, Blackjack, Gorst, Chico, Big Beef). Many of these chinook are likely of hatchery origin. Pinks are found only in the Dewatto, Tahuya, and Union Rivers. In addition to these same river systems, summer chum salmon are only found in a limited number of the larger stream systems within the Hood Canal sub-region (e.g. Big Beef, Big Anderson, and Big Mission Creeks).

| Watershed Stream | WRIA# | ID | Chinook | Coho | Fall Chum | Summer Chum | Pink | Steelhead | Cutthroat |
|---|---|---|---|---|---|---|---|---|---|
| **East Kitsap Streams** | | | | | | | | | |
| Coulter | 15.0002 | CLT | X | X | X | | | X | X |
| Rocky | 15.0015 | RKY | X | X | X | | | X | X |
| Minter | 15.0048 | MTR | X | X | X | | | X | X |
| Huge | 15.0052 | HUG | X | X | X | | | X | X |
| Burley | 15.0056 | BUR | X | X | X | | | X | X |
| Purdy | 15.0060 | PUR | | X | X | | | | X |
| Sunny Cove | 15.0105 | SNY | | X | X | | | | X |
| Olalla | 15.0107 | OLA | X | X | X | | | X | X |
| Fragaria | 15.0115 | FRA | | X | X | | | | X |
| Wilson (Southworth) | 15.0178 | WLS | | X | X | | | | X |
| Wilson (Harper) | 15.0183 | WLH | | X | X | | | | X |
| Curley | 15.0185 | CUR | X | X | X | | | X | X |
| Salmonberry | 15.0188 | SLB | | X | X | | | X | X |
| Duncan | 15.0191 | DUN | | X | X | | | | X |
| Beaver | 15.0192 | BVR | | X | X | | | X | X |
| Manchester | 15.0193 | MAN | | X | X | | | | X |
| Rich Cove | 15.0194 | RCV | | X | X | | | | X |
| Karcher | 15.0195 | KAR | | X | X | | | | X |
| Sacco | 15.0196 | SAC | | X | X | | | | X |
| Sullivan | 15.0200 | SUL | | X | X | | | | X |
| Olney | 15.0201 | OLN | | X | X | | | | X |
| Annapolis | 15.0202 | ANP | | X | X | | | | X |
| Blackjack | 15.0203 | BLJ | X | X | X | | | X | X |
| Ruby | 15.0205 | RBY | | X | X | | | X | X |
| Square | 15.0207 | SQR | | X | X | | | X | X |
| Ross | 15.0209 | ROS | | X | X | | | X | X |
| Anderson | 15.0211 | ANG | | X | X | | | X | X |
| Bailey | 15.0215 | BLY | | X | X | | | | X |
| Gorst | 15.0216 | GOR | X | X | X | | | X | X |
| Jarstad | 15.0218 | JAR | | X | X | | | | X |
| Parish | 15.0220 | PAR | | X | X | | | | X |
| Heins | 15.0221 | HNS | | X | X | | | X | X |
| Wright | 15.0225 | WRT | | X | X | | | | X |
| Ostrich Bay | 15.0226 | OSB | | X | X | | | | X |
| Jackson Park | 15.0228 | JKP | | X | X | | | | X |
| Chico | 15.0229 | CCO | X | X | X | | | X | X |
| Kitsap | 15.0230 | KIT | | X | X | | | X | X |

| Watershed Stream | WRIA# | ID | Chinook | Coho | Fall Chum | Summer Chum | Pink | Steelhead | Cutthroat |
|---|---|---|---|---|---|---|---|---|---|
| Dickerson | 15.0231 | DCK | | X | X | | | X | X |
| Lost | 15.0234 | LST | | X | X | | | X | X |
| Wildcat | 15.0238 | WLD | | X | X | | | X | X |
| Erlands | 15.0241 | ERL | | X | X | | | | X |
| Crystal | 15.0243 | CRY | | X | X | | | | X |
| Woods | 15.0244 | WDS | | X | X | | | | X |
| Koch | 15.0245 | KCH | | X | X | | | | X |
| Strawberry | 15.0246 | STR | | X | X | | | X | X |
| Clear | 15.0249 | CLR | X | X | X | | | X | X |
| Barker | 15.0255 | BRK | X | X | X | | | X | X |
| Stampede | 15.0257 | STM | | X | X | | | | X |
| Peterman | 15.0258 | PET | | X | X | | | | X |
| Mosher | 15.0259 | MSR | | X | X | | | | X |
| Pahrmann | 15.0260 | PAH | | X | X | | | | X |
| Narrows | 15.0262 | NAR | | X | X | | | | X |
| Dee-Enetai | 15.0265 | DEN | | X | X | | | | X |
| Illahee | 15.0266 | ILL | | X | X | | | X | X |
| Cove | 15.0268 | COV | | X | X | | | | X |
| Brownsville | 15.0269 | BRV | | X | X | | | | X |
| Burke Bay | 15.0272 | BBY | | X | X | | | | X |
| Steele | 15.0273 | STL | X | X | X | | | X | X |
| South Keyport | 15.0276 | SKY | | X | X | | | | X |
| North Keyport | 15.0277 | NKY | | X | X | | | | X |
| Daniels | 15.0278 | DAN | | X | X | | | | X |
| Little Scandia | 15.0279 | LSC | | X | X | | | | X |
| Big Scandia | 15.0280 | BSC | | X | X | | | X | X |
| Johnson | 15.0283 | JHN | | X | X | | | | X |
| Dogfish | 15.0285 | DOG | X | X | X | | | X | X |
| Bjorgen | 15.0290 | BJN | | X | X | | | | X |
| Lemolo | 15.0291 | LEM | | X | X | | | | X |
| Sam Snyder | 15.0293 | SAM | | X | X | | | | X |
| Klaebel | 15.0294 | KLB | | X | X | | | | X |
| Remington | 15.0295 | REM | | X | X | | | | X |
| Thompson | 15.0296 | TMP | | X | X | | | | X |
| Cowling | 15.0298 | COW | | X | X | | | | X |
| Grovers | 15.0299 | GRV | X | X | X | | | X | X |
| Kitsap | 15.0305 | NKC | | X | X | | | | X |
| Indianola | 15.0305a | IND | | X | X | | | | X |
| Carpenter | 15.0309 | CAR | | X | X | | | X | X |
| Silver | 15.0310 | SLV | | X | X | | | | X |
| Eglon | 15.0311 | EGL | | X | X | | | | X |

| Watershed Stream | WRIA# | ID | Chinook | Coho | Fall Chum | Summer Chum | Pink | Steelhead | Cutthroat |
|---|---|---|---|---|---|---|---|---|---|
| Bainbridge Island Streams | | | | | | | | | |
| Hidden Cove | 15.0319 | HDC | | X | X | | | | X |
| Dripping Water | 15.0320 | DRW | | X | X | | | | X |
| Murden Cove | 15.0321 | MRC | | X | X | | | | X |
| Winslow | 15.0324 | WIN | | X | X | | | | X |
| Sportsmans | 15.0325 | SPT | | X | X | | | | X |
| Cooper | 15.0326 | COP | | X | X | | | | X |
| Schel-Chelb | 15.0328 | SCH | | X | X | | | | X |
| Blakely Falls | 15.0330 | BLF | | X | X | | | | X |
| Blakely Harbor | 15.0331 | BLH | | X | X | | | | X |
| Gazzam | 15.0332 | GAZ | | X | X | | | | X |
| Fletcher | 15.0340 | FLT | | X | X | | | | X |
| Manzanita | 15.0344 | MNZ | | X | X | | | | X |
| West Kitsap Streams | | | | | | | | | |
| Hawks Hole | 15.0345 | HWK | | X | X | | | | X |
| Jukes | 15.0348 | JUK | | X | X | | | | X |
| Shipbuilder | 15.0349 | RES | | X | X | | | | X |
| Little Boston | 15.0350 | LTB | | X | X | | | | X |
| Reservation | 15.0351 | RES | | X | X | | | | X |
| Middle | 15.0352 | MID | | X | X | | | | X |
| Martha John | 15.0354 | MJN | | X | X | | | X | X |
| Gamble | 15.0356 | GMB | | X | X | | | X | X |
| Todhunter | 15.0360 | TDH | | X | X | | | | X |
| Laudine DeCouteau | 15.0360a | LAD | | X | X | | | | X |
| Machias | 15.0360b | MCH | | X | X | | | | X |
| Hudson | 15.0361 | HUD | | X | X | | | | X |
| Cougar | 15.0362 | CGR | | X | X | | | | X |
| Fern | 15.0363 | FRN | | X | X | | | | X |
| Spring | 15.0366 | SPR | | X | X | | | | X |
| Kinman | 15.0367 | KIN | | X | X | | | X | X |
| Jump-Off-Joe | 15.0369 | JOJ | | X | X | | | | X |
| Cattail | 15.0370 | CAT | | X | X | | | | X |
| Devils Hole | 15.0374 | DVH | | X | X | | | | X |
| Bangor | 15.0376 | BGR | | X | X | | | | X |
| Little Anderson | 15.0377 | LAN | | X | X | X | | X | X |
| Johnson (Lone Rock) | 15.0387 | JLR | | X | X | | | | X |
| Big Beef | 15.0389 | BBF | X | X | X | X | | X | X |
| Little Beef | 15.0399 | LBF | | X | X | | | | X |
| Seabeck | 15.0400 | SEA | | X | X | X | | X | X |
| Big Cedar | 15.0403 | BAC | | X | X | | | | X |
| Stavis | 15.0404 | STV | | X | X | X | | X | X |

| Watershed Stream | WRIA# | ID | Chinook | Coho | Fall Chum | Summer Chum | Pink | Steelhead | Cutthroat |
|---|---|---|---|---|---|---|---|---|---|
| Boyce | 15.0407 | BOY | | X | X | | | | X |
| Nellita | 15.0407a | NEL | | X | X | | | | X |
| Harding | 15.0408 | HRD | | X | X | | | | X |
| Big Anderson | 15.0412 | BAN | X | X | X | X | | X | X |
| Thomas | 15.0417 | THM | | X | X | | | | X |
| Dewatto | 15.0420 | DWT | X | X | X | X | X | X | X |
| Rendsland | 15.0439 | RND | | X | X | | | | X |
| Brown | 15.0444 | BRN | | X | X | | | | X |
| Caldervin | 15.0445 | CLD | | X | X | | | | X |
| Tahuya | 15.0446 | THY | X | X | X | X | X | X | X |
| Schoolhouse | 15.0477 | SCH | | X | X | | | | X |
| Shoofly | 15.0478 | SHF | | X | X | | | | X |
| Little Shoofly | 15.0483 | LSY | | X | X | | | | X |
| Cady | 15.0486 | CDY | | X | X | | | | X |
| Nursery | 15.0487 | NUR | | X | X | | | | X |
| Stimson | 15.0488 | STM | | X | X | | | | X |
| Hall | 15.0491 | HAL | | X | X | | | | X |
| Sundstrom | 15.0492 | JBF | | X | X | | | | X |
| Little Mission | 15.0493 | LMS | | X | X | | | X | X |
| Big Mission | 15.0495 | BMS | | X | X | | | X | X |
| Union | 15.0503 | UNR | X | X | X | X | X | X | X |

*Table 21: Kitsap County Salmonid Distribution.*

Notes:
1) Data represent current, historical, and potential salmonid utilization.
2) Most creeks support resident cutthroat and sea-run cutthroat populations.
3) Basic population characteristics are included in Appendix B.
4) Salmonid distribution maps are also included in Appendix B.
5) Data based on interviews with local biologists and available data.

### SALMONID DIVERSITY AND PRODUCTIVITY

The qualitative analysis of salmonid diversity and productivity (see methods section of this report) was conducted on the scale of potential refugia areas. In general, this was at the stream-segment or sub-watershed scale. Table 22 summarizes the results of this analysis. The maximum possible diversity score is 7 and the maximum possible productivity score is 5, for a combined maximum total score of 12. The minimum score for this study area was a 4, the maximum was 10, and the median score was 8 for all areas evaluated.

**Kitsap Refugia Project Salmonid Diversity & Productivity Scores**

**East WRIA-15 Salmonid-Bearing Streams**

| Potential Refugia | WRIA ID# | Chinook | Coho | Fall/Winter Chum | Summer Chum | Pink | Sockeye | Steelhead | Cutthroat | Diversity Score | Productivity Score | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Coulter Creek** | 15.0002 | | | | | | | | | | | |
| RM 0.0-0.8 | 15.0002 | X | X | X | | | | X | X | 5 | 4 | 9 |
| West Trbutary | 15.0004 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 0.8-2.5 | 15.0002 | X | X | X | | | | X | X | 5 | 4 | 9 |
| North Trbutary | 15.0007 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 2.5-4.0 | 15.0002 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 4.0-HW | 15.0002 | | X | | | | | X | X | 3 | 2 | 5 |
| **Rocky Creek** | 15.0015 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0015 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.5-1.5 | 15.0015 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 1.5-HW | 15.0015 | | X | | | | | X | X | 3 | 4 | 7 |
| West Fork | 15.0021 | | X | | | | | X | X | 3 | 2 | 5 |
| East Fork | 15.0016 | | X | | | | | X | X | 3 | 2 | 5 |
| **Minter Creek** | 15.0048 | | | | | | | | | | | |
| RM 0.0-1.5 | 15.0048 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 1.5-HW | 15.0048 | | X | | | | | X | X | 3 | 4 | 7 |
| Huge Creek | 15.0052 | X | X | | | | | X | X | 4 | 4 | 8 |
| **Burley Creek** | 15.0056 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0056 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.5-1.5 | 15.0056 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 1.5-HW | 15.0056 | | X | | | | | X | X | 3 | 4 | 7 |
| **Purdy Creek** | 15.0060 | | X | X | | | | | X | 3 | 2 | 5 |
| **Sunny Cove Creek** | 15.0105 | | X | X | | | | | X | 3 | 1 | 4 |
| **Olalla Creek** | 15.0107 | | | | | | | | | | | |
| RM 0.0-1.5 | 15.0107 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 1.5-HW | 15.0107 | | X | | | | | X | X | 3 | 4 | 7 |
| **Fragaria Creek** | 15.0115 | | X | | | | | X | X | 3 | 1 | 4 |
| **Wilson Creek(Southworth)** | 15.0178 | | X | | | | | X | X | 3 | 1 | 4 |
| **Wilson Creek (Harper)** | 15.0183 | | X | | | | | X | X | 3 | 1 | 4 |
| **Curley Creek** | 15.0185 | X | X | X | | | | X | X | 5 | 4 | 9 |
| **Salmonberry Creek** | 15.0188 | | X | | | | | X | X | 3 | 4 | 7 |
| **Duncan Creek** | 15.0191 | | X | X | | | | | X | 3 | 1 | 4 |
| **Beaver Creek** | 15.0192 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0192 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 0.5-HW | 15.0192 | | X | | | | | X | X | 3 | 2 | 5 |
| **Manchester Creek** | 15.0193 | | X | X | | | | | X | 3 | 1 | 4 |
| **Rich Cove Creek** | 15.0194 | | X | X | | | | | X | 3 | 1 | 4 |
| **Karcher Creek** | 15.0195 | | X | X | | | | | X | 3 | 1 | 4 |
| **Sacco Creek** | 15.0196 | | X | X | | | | | X | 3 | 1 | 4 |
| **Sullivan Creek** | 15.0200 | | X | X | | | | | X | 3 | 1 | 4 |
| **Olney Creek** | 15.0201 | | X | X | | | | | X | 3 | 1 | 4 |
| **Annapolis Creek** | 15.0202 | | X | X | | | | | X | 3 | 1 | 4 |
| **Blackjack Creek** | 15.0203 | | | | | | | | | | | |
| RM 0.0-1.5 | 15.0203 | X | X | X | X | | | X | X | 6 | 4 | 10 |
| RM 1.5-3.0 | 15.0203 | | X | | | | | X | X | 3 | 4 | 7 |
| Ruby Creek | 15.0205 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 3.0-5.5 | 15.0203 | | X | | | | | X | X | 3 | 2 | 5 |
| Square Creek | 15.0207 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 5.5-HW | 15.0203 | | X | | | | | X | X | 3 | 2 | 5 |
| Ross Creek | 15.0209 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0209 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 0.5-HW | 15.0209 | | X | | | | | X | X | 3 | 2 | 5 |
| Anderson Creek | 15.0211 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0211 | | X | X | | | | X | X | 4 | 2 | 6 |
| West Fork | 15.0211 | | X | X | | | | X | X | 4 | 2 | 6 |
| East Fork | 15.0212 | | X | X | | | | X | X | 4 | 2 | 6 |
| Bailey Creek | 15.0215 | | X | X | | | | | X | 3 | 2 | 5 |

**Kitsap Refugia Project Salmonid Diversity & Productivity Scores**
**East WRIA-15 Salmonid-Bearing Streams**

| Potential Refugia | WRIA ID# | Chinook | Coho | Fall/Winter Chum | Summer Chum | Pink | Sockeye | Steelhead | Cutthroat | Diversity Score | Productivity Score | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gorst Creek** | 15.0216 | | | | | | | | | | | |
| RM 0.0-0.25 | 15.0216 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.25-0.5 | 15.0216 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 0.5-0.75 | 15.0216 | | X | X | | | | X | X | 4 | 4 | 8 |
| Jarstad Creek | 15.0218 | | X | | | | | X | X | 3 | 2 | 5 |
| Parish Creek | 15.0220 | | X | | | | | X | X | 3 | 2 | 5 |
| Heins Creek | 15.0221 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 0.75-1.0 | 15.0216 | | X | | | | | X | X | 3 | 2 | 5 |
| RM 1.0-HW | 15.0216 | | X | | | | | X | X | 3 | 2 | 5 |
| Wright Creek | 15.0225 | | X | X | | | | | X | 3 | 2 | 5 |
| Ostrich Bay Creek | 15.0226 | | X | X | | | | | X | 3 | 1 | 4 |
| Jackson Park Creek | 15.0228 | | X | X | | | | | X | 3 | 1 | 4 |
| **Chico Creek** | 15.0229 | | | | | | | | | | | |
| RM 0.0-0.75 | 15.0229 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.75-1.25 | 15.0229 | X | X | X | | | | X | X | 5 | 4 | 9 |
| Kitsap Creek | 15.0230 | | X | X | | | | X | X | 4 | 2 | 6 |
| Dickerson Creek | 15.0231 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 1.25-2.5 | 15.0229 | | X | X | | | | X | X | 4 | 4 | 8 |
| Lost Creek | 15.0234 | | X | | | | | X | X | 3 | 4 | 7 |
| Wildcat Creek RM 2.5-4.5 | 15.0229 | | X | | | | | X | X | 3 | 4 | 7 |
| Wildcat Creek RM 4.5-HW | 15.0229 | | X | | | | | X | X | 3 | 2 | 5 |
| Erlands Creek | 15.0241 | | X | X | | | | | X | 3 | 1 | 4 |
| Crystal Creek | 15.0243 | | X | X | | | | | X | 3 | 1 | 4 |
| Woods Creek | 15.0244 | | X | X | | | | | X | 3 | 1 | 4 |
| Koch Creek | 15.0245 | | X | X | | | | | X | 3 | 1 | 4 |
| Strawberry Creek | 15.0246 | | X | X | | | | X | X | 4 | 2 | 6 |
| **Clear Creek** | 15.0249 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0249 | X | X | X | | | | X | X | 5 | 4 | 9 |
| East Fork RM 1.0-2.0 | 16.0249 | | X | X | | | | X | X | 4 | 4 | 8 |
| Ridgetop Tributary | 15.0253 | | X | | | | | X | X | 3 | 1 | 4 |
| Mountainview Tributary | 15.0254 | | X | | | | | X | X | 3 | 2 | 5 |
| East Fork RM 2.0-HW | 16.0249 | | X | | | | | X | X | 3 | 2 | 5 |
| West Fork RM 0.0-0.5 | 15.0250 | | X | X | | | | X | X | 4 | 4 | 8 |
| West Fork RM 0.5-1.0 | 15.0250 | | X | X | | | | X | X | 4 | 4 | 8 |
| West Fork RM 1.0-2.0 | 15.0250 | | X | X | | | | X | X | 4 | 4 | 8 |
| West Fork RM 2.0-HW | 15.0250 | | X | | | | | X | X | 3 | 2 | 5 |
| Bangor Tributary | 15.0251 | | X | | | | | X | X | 3 | 2 | 5 |
| **Barker Creek** | 15.0255 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0255 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.5-1.0 | 15.0255 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 1.0-1.5 | 15.0255 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 1.5-HW | 15.0255 | | X | | | | | X | X | 3 | 2 | 5 |
| Hoot Creek Tributary | 15.0256 | | X | | | | | X | X | 3 | 1 | 4 |
| Stampede Creek | 15.0257 | | X | X | | | | | X | 3 | 1 | 4 |
| Peterman Creek | 15.0258 | | X | X | | | | | X | 3 | 1 | 4 |
| Mosher Creek | 15.0259 | | X | X | | | | | X | 3 | 1 | 4 |
| Pahrman Creek | 15.0260 | | X | X | | | | | X | 3 | 1 | 4 |
| Narrows Creek | 15.0262 | | X | X | | | | | X | 3 | 1 | 4 |
| Dee-Enetai Creek | 15.0265 | | X | X | | | | | X | 3 | 1 | 4 |
| **Illahee Creek** | 15.0266 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0266 | | X | X | | | | X | X | 4 | 2 | 6 |
| North Fork RM 1.0-1.5 | 15.0266 | | X | | | | | X | X | 3 | 2 | 5 |
| North Fork RM 1.5-HW | 16.0266 | | X | | | | | X | X | 3 | 2 | 5 |
| South Fork | 15.0267 | | X | | | | | X | X | 3 | 2 | 5 |
| Cove Creek | 15.0268 | | X | X | | | | | X | 3 | 1 | 4 |
| Brownsville Creek | 15.0269 | | X | X | | | | | X | 3 | 1 | 4 |
| Burke Bay Creek | 15.0272 | | X | X | | | | | X | 3 | 1 | 4 |

| Kitsap Refugia Project Salmonid Diversity & Productivity Scores | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **East WRIA-15 Salmonid-Bearing Streams** | | | | | | | | | | | | |
| **Potential Refugia** | **WRIA ID#** | **Chinook** | **Coho** | **Fall/Winter Chum** | **Summer Chum** | **Pink** | **Sockeye** | **Steelhead** | **Cutthroat** | **Diversity Score** | **Productivity Score** | **Total Score** |
| **Steele Creek** | 15.0273 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0273 | X | X | X | | | | X | X | 4 | 4 | 8 |
| South Fork RM 0.5-1.0 | 15.0274 | | X | X | | | | X | X | 4 | 4 | 8 |
| South Fork RM 1.0-HW | 15.0274 | | X | X | | | | | X | 3 | 2 | 5 |
| North Fork RM 0.5-HW | 15.0273 | | X | X | | | | | X | 3 | 2 | 5 |
| Crouch Creek Tributary | 15.0275 | | X | X | | | | | X | 3 | 2 | 5 |
| South Keyport Creek | 15.0276 | | X | X | | | | | X | 3 | 1 | 4 |
| North Keyport Creek | 15.0770 | | X | X | | | | | X | 3 | 1 | 4 |
| Daniels Creek | 15.0278 | | X | X | | | | | X | 3 | 1 | 4 |
| Little ScandiaCreek | 15.0279 | | X | X | | | | | X | 3 | 1 | 4 |
| **Big Scandia Creek** | 15.0280 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0280 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 1.0-HW | 15.0280 | | X | X | | | | X | X | 4 | 2 | 6 |
| Johnson Creek | 15.0283 | | X | X | | | | | X | 3 | 2 | 5 |
| **Dogfish Creek** | 15.0285 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0285 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.5-1.0 | 15.0285 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 1.0-3.0 | 15.0285 | | X | | | | | X | X | 3 | 4 | 7 |
| RM 3.0-HW | 15.0285 | | X | | | | | X | X | 3 | 2 | 5 |
| West Fork RM 0.0-1.0 | 15.0286 | | X | | | | | X | X | 3 | 4 | 7 |
| West Fork RM 1.0-HW | 15.0286 | | X | | | | | X | X | 3 | 2 | 5 |
| South Fork - Poulsbo Tributary | 15.0287 | | X | | | | | X | X | 3 | 2 | 5 |
| Bjorgen Creek | 15.0290 | | X | X | | | | | X | 3 | 2 | 5 |
| Lemolo Creek | 15.0291 | | X | X | | | | | X | 3 | 2 | 5 |
| Sam Snyder Creek | 15.0293 | | X | X | | | | | X | 3 | 1 | 4 |
| Klaebel Creek | 15.0294 | | X | X | | | | | X | 3 | 1 | 4 |
| Remington Creek | 15.0295 | | X | X | | | | | X | 3 | 1 | 4 |
| Thompson Creek | 15.0296 | | X | X | | | | | X | 3 | 1 | 4 |
| Cowling Creek | 15.0298 | | X | X | | | | | X | 3 | 2 | 5 |
| **Grovers Creek** | 15.0299 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0299 | X | X | X | | | | X | X | 5 | 4 | 9 |
| RM 0.5-2.0 | 15.0299 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 2.0-3.0 | 15.0299 | | X | | | | | X | X | 3 | 4 | 7 |
| RM 3.0-HW | 15.0299 | | X | | | | | X | X | 3 | 2 | 5 |
| Kitsap Creek | 15.0305 | | X | X | | | | | X | 3 | 2 | 5 |
| Indianola Creek | 15.0305a | | X | X | | | | | X | 3 | 2 | 5 |
| **Carpenter Creek** | 15.0309 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0309 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 1.0-1.5 | 15.0309 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 1.5-HW | 15.0309 | | X | | | | | X | X | 3 | 2 | 5 |
| Silver Creek | 15.0310 | | X | X | | | | | X | 3 | 1 | 4 |
| Eglon Creek | 15.0311 | | X | X | | | | | X | 3 | 2 | 5 |
| **Bainbridge Island Streams** | | | | | | | | | | | | |
| Hidden Cove Creek | 15.0319 | | X | X | | | | | X | 3 | 1 | 4 |
| Dripping Water Creek | 15.0320 | | X | X | | | | | X | 3 | 1 | 4 |
| Murden Cove Creek | 15.0321 | | X | X | | | | | X | 3 | 2 | 5 |
| Winslow Creek | 15.0324 | | X | X | | | | | X | 3 | 1 | 4 |
| Sportsman Creek | 15.0325 | | X | X | | | | | X | 3 | 1 | 4 |
| Cooper Creek | 15.0326 | | X | X | | | | | X | 3 | 1 | 4 |
| Schel-Chelb Creek | 15.0328 | | X | X | | | | | X | 3 | 1 | 4 |
| Blakely Falls Creek | 15.0330 | | X | X | | | | | X | 3 | 1 | 4 |
| Blakely Harbor Creek | 15.0331 | | X | X | | | | | X | 3 | 1 | 4 |
| Gazzam Creek | 15.0332 | | X | X | | | | | X | 3 | 1 | 4 |
| Fletcher Creek | 15.0340 | | X | X | | | | | X | 3 | 2 | 5 |
| Manzanita Creek | 15.0344 | | X | X | | | | | X | 3 | 2 | 5 |

*Table 22: East Kitsap Salmonid Diversity and Productivity.*

| Potential Refugia | WRIA ID# | Chinook | Coho | Fall/Winter Chum | Summer Chum | Pink | Sockeye | Steelhead | Cutthroat | Diversity Score | Productivity Score | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kitsap Refugia Project Salmonid Diversity & Productivity Scores** | | | | | | | | | | | | |
| **West WRIA-15 Salmonid Streams** | | | | | | | | | | | | |
| **Hawks Hole Creek** | 15.0345 | | X | X | | | | | X | 3 | 2 | 5 |
| **Jukes Creek** | 15.0348 | | X | X | | | | | X | 3 | 1 | 4 |
| **Shipbuilder Creek** | 15.0349 | | X | X | | | | | X | 3 | 1 | 4 |
| **Little Boston Creek** | 15.0350 | | X | X | | | | | X | 3 | 1 | 4 |
| **Reservation Creek** | 15.0351 | | X | X | | | | | X | 3 | 1 | 4 |
| **Middle Creek** | 15.0352 | | X | X | | | | | X | 3 | 1 | 4 |
| Martha John Creek | 15.0353 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0353 | | X | X | | | | X | X | 4 | 2 | 6 |
| North Tributary | 15.0354 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 0.5-HW | 15.0353 | | X | X | | | | X | X | 4 | 2 | 6 |
| **Gamble Creek** | 15.0356 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0356 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 1.5-HW | 15.0356 | | X | X | | | | X | X | 4 | 2 | 6 |
| **Todhunter Creek** | 15.0360 | | X | X | | | | | X | 3 | 1 | 4 |
| **Laudine DeCouteau Creek** | 15.0360a | | X | X | | | | | X | 3 | 1 | 4 |
| **Machias Creek** | 15.0360b | | X | X | | | | | X | 3 | 1 | 4 |
| **Hudson Creek** | 15.0361 | | X | X | | | | | X | 3 | 1 | 4 |
| **Cougar Creek** | 15.0362 | | X | X | | | | | X | 3 | 1 | 4 |
| **Fern Creek** | 15.0363 | | X | X | | | | | X | 3 | 1 | 4 |
| **Spring Creek** | 15.0366 | | X | X | | | | | X | 3 | 1 | 4 |
| **Kinman Creek** | 15.0367 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0367 | | X | X | | | | X | X | 4 | 2 | 6 |
| South-Lofall Tributary | 15.0367a | | X | X | | | | | X | 3 | 1 | 4 |
| NorthTributary | 15.0368 | | X | X | | | | | X | 3 | 1 | 4 |
| RM 0.5-HW | 15.0367 | | X | X | | | | X | X | 4 | 2 | 6 |
| Jump-Off-Joe Creek | 15.0369 | | X | X | | | | | X | 3 | 2 | 5 |
| Cattail Creek | 15.0370 | | X | X | | | | | X | 3 | 1 | 4 |
| Devils Hole Creek | 15.0374 | | X | X | | | | | X | 3 | 2 | 5 |
| Bangor Creek | 15.0376 | | X | X | | | | | X | 3 | 1 | 4 |
| **Little Anderson Creek** | 15.0376 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0376 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 0.5-1.0 | 15.0376 | | X | X | | | | X | X | 4 | 2 | 6 |
| RM 1.0-HW | 15.0376 | | X | X | | | | X | X | 4 | 2 | 6 |
| Johnson (Lone Rock) Creek | 15.0387 | | X | X | | | | | X | 3 | 1 | 4 |
| **Big Beef Creek** | 15.0389 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0389 | X | X | X | X | | | X | X | 6 | 4 | 10 |
| RM 1.0 -5.5 | 15.0389 | | X | X | | | | X | X | 4 | 4 | 8 |
| Lake Symington RM 5.5-6.0 | 15.0389 | | X | | | | | X | X | 3 | 4 | 7 |
| RM 6.0-6.5 | 15.0389 | | X | | | | | X | X | 4 | 4 | 8 |
| RM 6.5-HW | 15.0389 | | X | | | | | X | X | 4 | 4 | 8 |
| Little Beef Creek | 15.0399 | | X | X | | | | | X | 3 | 2 | 5 |
| **Seabeck Creek** | 15.0400 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0400 | | X | X | X | | | X | X | 5 | 4 | 9 |
| RM 0.5-1.0 | 15.0400 | | X | X | | | | X | X | 4 | 4 | 8 |
| Seabeck Heights Tributary | 15.0401 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 1.0-HW | 15.0400 | | X | X | | | | X | X | 4 | 4 | 8 |
| Big Cedar Creek | 15.0403 | | X | X | | | | | X | 3 | 1 | 4 |
| **Stavis Creek** | 15.0404 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0404 | | X | X | X | | | X | X | 5 | 4 | 9 |
| West Fork | 15.0405 | | X | X | | | | X | X | 4 | 4 | 8 |
| East Fork | 15.0404 | | X | X | | | | X | X | 4 | 4 | 8 |
| Boyce Creek | 15.0407 | | X | X | | | | | X | 3 | 2 | 5 |
| Nellita Creek | 15.0407a | | X | X | | | | | X | 3 | 1 | 4 |
| Harding Creek | 15.0408 | | X | X | | | | | X | 3 | 2 | 5 |
| **Big Anderson Creek** | 15.0412 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0412 | X | X | X | X | | | X | X | 6 | 4 | 10 |
| RM 1.0-1.5 | 15.0412 | | X | X | | | | X | X | 4 | 4 | 8 |
| South Tributary | 15.0413 | | X | X | | | | X | X | 4 | 4 | 8 |
| South Fork | 15.0414 | | X | X | | | | X | X | 4 | 4 | 8 |
| North Fork | 15.0412 | | X | X | | | | X | X | 4 | 4 | 8 |
| Thomas Creek | 15.0417 | | X | X | | | | | X | 3 | 1 | 4 |

| Kitsap Refugia Project Salmonid Diversity & Productivity Scores | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| West WRIA-15 Salmonid Streams | | | | | | | | | | | | |
| Potential Refugia | WRIA ID# | Chinook | Coho | Fall/Winter Chum | Summer Chum | Pink | Sockeye | Steelhead | Cutthroat | Diversity Score | Productivity Score | Total Score |
| **WRIA-15 Mason Cty** | | | | | | | | | | | | |
| **Dewatto River** | 15.0420 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0420 | X | X | X | X | X | | X | X | 7 | 4 | 11 |
| RM 1.0-4.0 | 15.0420 | X | X | X | X | X | | X | X | 7 | 4 | 11 |
| RM 4.0-HW | 15.0420 | | X | | | | | X | X | 3 | 4 | 7 |
| Cady Lake Creek | 15.0421 | | X | | | | | X | X | 3 | 2 | 5 |
| White Creek | 15.0422 | | X | | | | | X | X | 3 | 2 | 5 |
| Shoe Lake Creek | 15.0424 | | X | | | | | X | X | 3 | 2 | 5 |
| Larsen Lake Creek | 15.0425 | | X | | | | | X | X | 3 | 2 | 5 |
| Alder Creek | 15.0426 | | X | | | | | X | X | 3 | 2 | 5 |
| Ralph Creek | 15.0428 | | X | | | | | X | X | 3 | 2 | 5 |
| Oak Lake Creek | 15.0429 | | X | | | | | X | X | 3 | 2 | 5 |
| Cutthroat Creek | 15.0434 | | X | | | | | X | X | 3 | 2 | 5 |
| Ludvick Lake Creek | 15.0435 | | X | | | | | X | X | 3 | 2 | 5 |
| Blacksmith Creek | 15.0436 | | X | | | | | X | X | 3 | 2 | 5 |
| Erickson Lake Creek | 15.0437 | | X | | | | | X | X | 3 | 2 | 5 |
| Rendsland Creek | 15.0439 | | X | X | | | | | X | 3 | 2 | 5 |
| Brown Creek | 15.0444 | | X | X | | | | | X | 3 | 1 | 4 |
| Caldervin Creek | 15.0445 | | X | X | | | | | X | 3 | 2 | 5 |
| **Tahuya River** | 15.0446 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0446 | X | X | X | X | X | | X | X | 7 | 4 | 11 |
| RM 1.0-4.0 | 15.0446 | X | X | X | X | X | | X | X | 7 | 4 | 11 |
| RM 4.0-8.0 | 15.0446 | | X | | | | | X | X | 3 | 4 | 7 |
| RM 8.0-16.0 | 15.0446 | | X | | | | | X | X | 3 | 4 | 7 |
| RM 16.0-HW | 15.0446 | | X | | | | | X | X | 3 | 4 | 7 |
| Little Tahuya Creek | 15.0454 | | X | | | | | X | X | 3 | 2 | 5 |
| Andy Creek | 15.0458 | | X | | | | | X | X | 3 | 2 | 5 |
| Erdman Creek | 15.0459 | | X | | | | | X | X | 3 | 2 | 5 |
| Haven Lake Creek | 15.0461 | | X | | | | | X | X | 3 | 2 | 5 |
| Twin Lake Creek | 15.0463 | | X | | | | | X | X | 3 | 2 | 5 |
| Outlet Creek | 15.0466 | | X | | | | | X | X | 3 | 2 | 5 |
| Blacksmith Lake Creek | 15.0468 | | X | | | | | X | X | 3 | 2 | 5 |
| Buffoon Creek | 15.0470 | | X | | | | | X | X | 3 | 2 | 5 |
| Morgan Marsh Creek | 15.0471 | | X | | | | | X | X | 3 | 2 | 5 |
| Panther Lake Creek | 15.0472 | | X | | | | | X | X | 3 | 2 | 5 |
| Gold Creek | 15.0474 | | X | | | | | X | X | 3 | 2 | 5 |
| Grata Creek | 15.0475 | | X | | | | | X | X | 3 | 2 | 5 |
| Tin Mine Creek | 15.0476 | | X | | | | | X | X | 3 | 2 | 5 |
| Schoolhouse Creek | 15.0477 | | X | X | | | | | X | 3 | 1 | 4 |
| Shoofly Creek | 16.0478 | | X | X | | | | | X | 3 | 1 | 4 |
| Little Shoofly Creek | 15.0483 | | X | X | | | | | X | 3 | 1 | 4 |
| Cady Creek | 15.0486 | | X | X | | | | | X | 3 | 1 | 4 |
| Stimson Creek | 15.0488 | | X | X | | | | | X | 3 | 2 | 5 |
| Hall Creek | 15.0491 | | X | X | | | | | X | 3 | 1 | 4 |
| Sundstrom Creek | 15.0492 | | X | X | | | | | X | 3 | 1 | 4 |
| **Little Mission Creek** | 15.0493 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0493 | | X | X | X | | | X | X | 5 | 4 | 9 |
| RM 0.5-HW | 15.0493 | | X | X | | | | X | X | 4 | 4 | 8 |
| **Big Mission Creek** | 15.0495 | | | | | | | | | | | |
| RM 0.0-0.5 | 15.0495 | | X | X | X | | | X | X | 5 | 4 | 9 |
| RM 0.5-2.5 | 15.0495 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 2.5-4.0 | 15.0495 | | X | X | | | | X | X | 4 | 4 | 8 |
| RM 4.0-HW | 15.0495 | | X | X | | | | X | X | 4 | 4 | 8 |
| **Union River** | 15.0503 | | | | | | | | | | | |
| RM 0.0-1.0 | 15.0503 | X | X | X | X | X | | X | X | 7 | 4 | 11 |
| RM 1.0-5.0 | 15.0503 | X | X | X | X | X | | X | X | 7 | 4 | 11 |
| RM 5.0-HW | 15.0503 | | X | | | | | X | X | 3 | 4 | 7 |
| Courtney Creek | 15.0505 | | X | | | | | X | X | 3 | 2 | 5 |
| Bear Creek | 15.0510 | | X | | | | | X | X | 3 | 2 | 5 |
| Airport Creek | 15.0514 | | X | | | | | X | X | 3 | 2 | 5 |
| Hazel Creek | 15.0516 | | X | | | | | X | X | 3 | 2 | 5 |

*Table 23: West Kitsap Salmonid Diversity and Productivity.*

## SALMONID HABITAT CONDITIONS

The habitat quality analysis is based on available quantitative habitat assessment data, qualitative habitat surveys conducted as part of this project, and from information provided by local habitat biologists, the so-called "local knowledge" of stream conditions. The analysis of salmonid habitat quality (see methods section of this report) was conducted on the scale of potential refugia areas. In general, this was at the stream-segment scale or "reach" (on the order of a river-mile (RM) or less). In some cases, these analysis units included more than a single stream reach and in other cases the analysis incorporated data from a single sub-watershed. For example, several headwater or tributary sub-watersheds were considered for refugia status and therefore were analyzed as a single unit. Based on the information and data gathered, each potential refugia area was scored using the multi-metric habitat assessment score sheet (see Methods section). Appendix C contains habitat assessment scores for all potential refugia areas.

In general, salmonid habitat within the study area reflected the range of existing conditions found throughout the Puget Sound region. That is to say, there are a few streams that still contain relatively high quality habitat, and many streams that have been significantly degraded from their natural conditions. The level of habitat degradation is generally proportional to the level of landscape alteration, land-use, and human activities that exist within the watershed, as has been observed throughout the Puget Sound region (May et al., 1997). In addition, the historical land-uses and human activities (timber harvest, agriculture, and mining) have had a cumulative impact on salmonid habitat conditions. There has also been direct human manipulation of salmonid habitat, such as the removal of LWD during "stream cleaning" efforts by WDFW in the late 1960 and early 1970's (Amato, 1996). The legacy of these cumulative impacts is the present degraded condition of many of our streams and rivers. As with many previous assessments, the most significant habitat deficiencies found during this project include:

- More frequent high stream flows in developing watersheds.
- The loss of headwater wetlands and beaver pond habitat.
- Fragmentation of the stream-riparian ecosystem corridor.
- A lack of coniferous trees within the riparian areas.
- A general lack of LWD, especially large "key" pieces of LWD.
- Decreased LWD recruitment potential from riparian zones.
- Little high quality juvenile salmonid rearing habitat (pools).
- Fine sediment deposition in stream spawning gravels.
- Channelized streams, especially in agricultural areas.
- Encroachment of human land-use into the riparian zone.
- A degradation of riparian forest quality and maturity.
- The loss of floodplain and off-channel wetland habitat.

The most significant salmonid habitat problems noted within the Kitsap County study area include the following:

1) The general loss of riparian forest and wetland areas on almost all stream systems within the study area due to the encroachment of human land-use activities. In addition, roads and other crossings fragment the stream-riparian corridors of most streams.

2) Channelization of streams within historic or current agricultural areas such as the middle-mainstem segments of Burley, Olalla, Salmonberry, Blackjack, Clear, Scandia, Dogfish, Steele, Carpenter, Eglon, Gamble, and Grovers Creeks.

3) Disconnection of natural floodplains and off-channel habitat where levees and dikes have been installed to facilitate farming and/or residential development. Examples of this impact can be found on the Tahuya, Dewatto, and Union Rivers.

4) Loss of riparian extent and quality, especially the loss of mature conifers that provide long-term LWD recruitment, in areas that have seen several cycles of timber harvest. Examples include the headwaters of Rocky, Chico, Stavis, and Big Anderson Creeks, as well as the Dewatto and Tahuya Rivers.

5) Migration barriers in the form of partial or complete blocking culverts on some streams such as Mosher Creek, as well as several small tributary streams.

6) The general loss and degradation of high-quality instream rearing habitat and habitat complexity due to the lack of natural levels of LWD, especially large, stable "key" pieces of LWD.

7) The loss or degradation of headwater and off-channel wetlands and beaver ponds that traditionally provided seasonal rearing habitat and local refugia for several species of salmonids, most notably coho salmon and cutthroat trout (e.g. Carpenter, Grovers, Dogfish, Clear, and Little Anderson Creeks).

8) The degradation of salmonid spawning habitat due to the deposition of fine sediment from logging roads, agricultural runoff, roads, and construction sites.

## COMBINED FISH-CENTERED ANALYSIS RESULTS

The combined fish-centered score is the sum of the diversity and productivity scores combined with the salmonid habitat scores for each potential refugia area. Appendix G contains a summary of this data. The use of the data gathered for this report and the specific problems identified above can also provide a starting point for developing potential rehabilitation and enhancement projects to improve salmonid habitat conditions within the study area.

## GIS LANDSCAPE MODEL FRESHWATER RESULTS

The results of the GIS landscape analysis are contained in Appendix G to this report (see Table G-1). Table 24 summarizes the GIS landscape metrics used in this model. Figure 43 shows the general relationship between the fish-centered analysis and the landscape-centered analysis. In

| Refugia Landscape Analysis GIS Model Components | | | | | |
|---|---|---|---|---|---|
| Metric# | GIS Layer | Data Type | Source Data | Weighting Factor | Comments |
| **Freshwater Refugia Model** | | | | | |
| | | | **Riparian Metrics** | | |
| 1 | Stream Crossings/Riparian Fragmentation | Point | LFA Streams & TIGER Roads | 3 | Measured as # breaks per length of stream channel. Include roads, trails, utility lines, etc. |
| 2 | Riparian Corridor Extent/Width | Polygon | LFA Streams & Land-Sat Land-Cover | 3 | Use SPTH (200 ft) buffer for initial analysis (Also do both > 30 m and > 100 m buffers as a sensitivity analysis). Includes all natural vegetation. |
| 3 | Riparian Vegetation Quality | Polygon | LFA Streams & Land-Sat Land-Cover | 3 | Include Coniferous and Mixed forest as well as wetlands. Use SPTH (200 ft) buffer for analysis. |
| 4 | Steep Slopes & Mass Wasting Potential | Polygon | DEM | 1 | % Riparian Slopes > 30% |
| 5 | Floodplain Modification | Polygon | DEM & Land-Sat LULC | 2 | % Floodplain with human land-use (land-use or roads) |
| 6 | Salmon Migration Barriers | Point | SSHEAR DB | 3 | % stream length with impeded passage due to man-made barriers on type 1, 2, or 3 channels only (<10% = 9, 10-20% = 5, >20% = 3, and >50% = 1). Includes partial & complete barriers. |
| | | | **Watershed Metrics** | | |
| 7 | Hydrologic Condition | Polygon | Watershed DB | 2 | Combines hydrologic parameters (Annual Precipitation = 3, Basin Area = 2, & Drainage Density=1) into a single metric. |
| 8 | Total Impervious Surface Area (%TIA) | Polygon | Land-Sat | 3 | Use standard conversion factors based on % Urban/Suburban/Commercial/Industrial/Rural |
| 9 | % Agricultural Land-Use | Polygon | Land-Sat | 2 | % Agricultural Land-Use (includes both grazing & row-cropping as well as hobby farms) |
| 10 | Road Density | Line | Roads | 1 | #km of road per km^2 Basin Area |
| 11 | Wetlands | Polygon | NWI Wetlands | 3 | % NWI wetland area w/in watershed |
| 12 | Urban Development | Polygon | County Zoning DB | 1 | % within UGA, Rural Centers (Local Areas of More Intense Rural Development LAMIRD), or Commercial Area Boundaries (per Comp Plan) |
| 17 | Forest Cover | Polygon | Land-Sat | 3 | Coniferous = 4 , Mixed = 3, Deciduous = 2, & Clear-Cut = 1 |
| **Nearshore Refugia Model** | | | | | |
| 1 | Nearshore Modifications | line | Shorezone | 3 | Includes bulkheads (concrete, rip-rap, & wood), groins and boat-ramps (% of SZ drift-cell). |
| 2 | Docks, Floats, and Piers | point | Shorezone | 2 | Includes all perpendicular over-water structures (# per km of SZ drift-cell). |
| 3 | Marinas | point | Shorezone | 1 | Includes commercial marinas only (# per SZ drift-cell). Marinas are defined as areas where fueling, boat/hull repair, or sewage pump-out operations are performed. |
| 4 | Aquatic Vegetation | line | Shorezone | 3 | Includes all marine vegetation (Eel Grass or Kelp Beds) used as salmonid habitat (% per km of SZ drift-cell). Continuous = 3, Patchy = 2, & None = 1. Forage fish habitat (SZ) also included. |
| 5 | Nearshore Riparian | line | Shorezone | 3 | Use both 30 m & 100m bands corresponding to each SZ drift-cell to test sensitivity. May use SPTH as for FW riparian analysis. Include Coniferous or Mixed and Late or Mid-Seral Stage. Also include any nearshore wetlands. |

*Table 24: Refugia Landscape Analysis GIS Model Components*

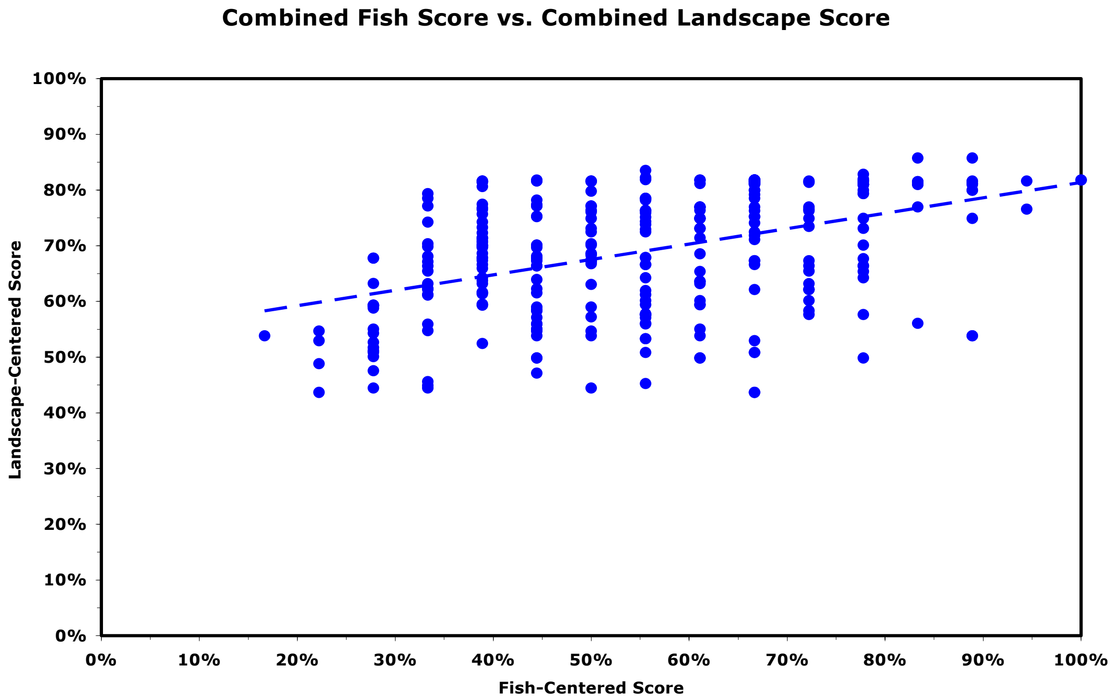


*Figure 43: Relationship between GIS Landscape and Fish-Centered Scores for the combined Jefferson and Kitsap County Model.*

general, there is a direct relationship between more natural landscape conditions (higher GIS landscape scores) and higher scores from the fish-centered approach. This is to be expected in that instream conditions (i.e. water quality, biological integrity, salmonid habitat, etc.) generally reflect the overall watershed conditions. In most cases, salmonid habitat quality, species diversity, and productivity are higher when natural conditions have been maintained on the watershed and riparian landscape scale. This basic relationship has been demonstrated in other studies as well (Rieman and McIntyre, 1993; Allendorf et al., 1997; May et al., 1997; Beechie and Boulton, 1999; Booth et al., 2001; Pess et al., 2002). However, there are many cases where this correlation is not as strong. There are cases where salmonid habitat quality remains relatively natural and/or where native salmonid populations also remain relatively diverse and/or productive, while landscape conditions have been significantly modified. These areas, while unusual, are also not uncommon. In most cases, unique ecological and/or biological conditions found in these areas have resulted in a higher level of resistance to degradation and resilience to disturbance. Because of their unique conditions, these areas, along with the relatively undisturbed, natural areas, were strongly considered for refugia status.

| Study Area | Mean GIS Score |
|---|---|
| **Kitsap County** | **65%** |
| East Kitsap WRIA-15 | 58% |
| West Kitsap WRIA-15 | 72% |
| **East Jefferson County** | **68%** |
| East Jefferson WRIA-16 | 77% |
| East Jefferson WRIA-17 | 65% |

*Table 25: Refugia GIS Model Score Summary*

Tables 18-20 summarize the combined refugia model scores for the combined East Jefferson (WRIA-16 & 17) and Kitsap (WRIA-15) study areas. In general, salmonid habitat conditions are better in East Jefferson County (see Table 25) than in Kitsap County. In addition, habitat conditions in Hood Canal watersheds are generally better than in those draining to the central Puget Sound region (see Table 25). This is likely due to the lower human population levels and resultant lower levels of watershed development found in the western portions of the study area (farther from the commercial-industrial centers of Puget Sound). However, even at relatively low, rural levels of watershed development, human impacts on salmonid habitat quality can be significant. Examples of this include the impacts of timber harvest and agriculture outlined in previous sections of this report.

The relationship between landscape parameters that measured human land-use and those that measure natural land-cover are quite interesting (see Figures 44 through 49). Generally, as development progresses in a watershed, native forest and other natural land-cover features (e.g. wetlands) are lost and replaced with agricultural fields, residential development, roads, and other land-use features. These human land-use features generally have impervious surfaces associated with them (i.e. pavement, rooftops, lawns, pastures, and other non-forested areas). Research has found that the percent total impervious area (%TIA) is a good measure of the cumulative impact of human development within a watershed (Booth, 1991; Booth and Reinelt, 1993; May et al., 1997; Horner et al., 1997; Horner and May, 1999; Booth et al., 2002).

Figure 44 shows the relationship between watershed development (as measured by %TIA) and natural land-cover (as measured by percent forest cover) for all the watersheds analyzed in the combined Kitsap and East Jefferson study area. In analyzing the data displayed in Figure 44, it can be seen that, in general, as watershed development increases, impervious surface area (%TIA) increases and native forest cover is lost. The relationship between the loss of natural forest cover and the increase in impervious surface area is quite strong, especially when development moves from the rural (< 10% TIA) to the suburban and urban ranges (> 30 %). This is the range of development where residential, commercial, and industrial land-uses begin to dominate the landscape and natural land-cover (forests and wetlands) is lost.

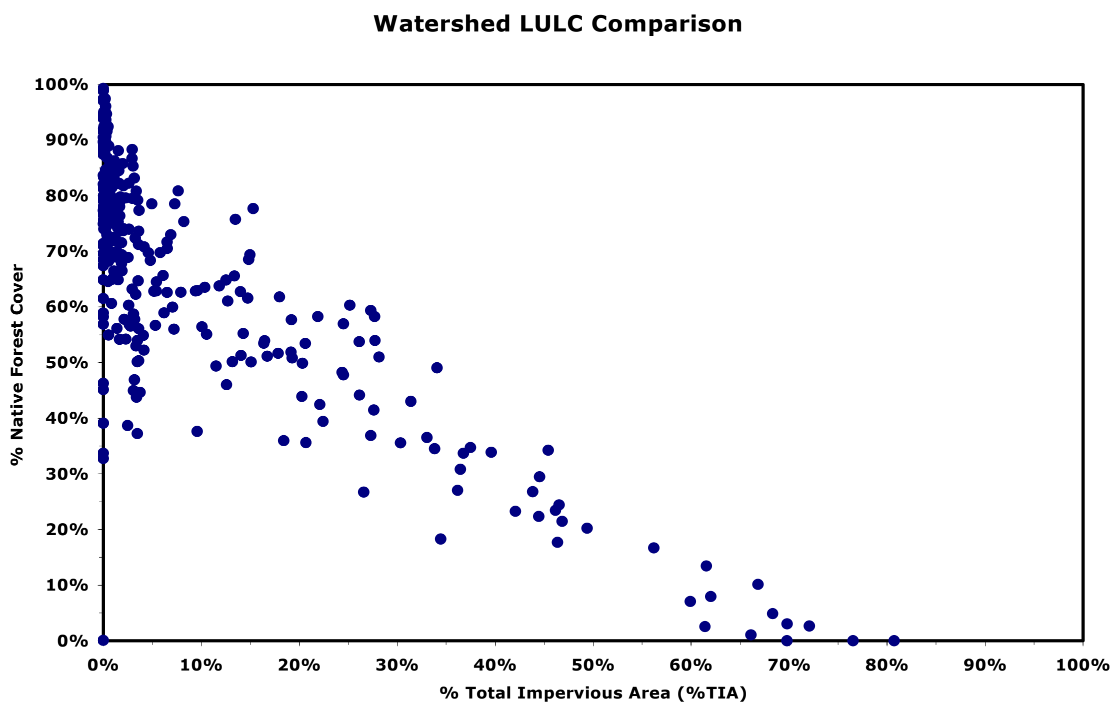


*Figure 44: Relationship between Watershed Land-Use and Land-Cover*

In the lower end of the impervious spectrum (<5%TIA), there is a great deal more scatter in the data. This reflects the impact of land-use activities that do not introduce a significant amount of imperviousness, yet do remove natural forest cover. This is primarily agricultural activities (farming or grazing), timber harvest, and rural residential land-uses. The difference between Kitsap County and Jefferson County can be seen in Figure 45, which displays data from both study areas, but differentiates between counties. This shows that Kitsap County is, in general, much more developed than East Jefferson County. A line has been drawn at the 5%TIA level to distinguish the two ranges of land-use discussed above. It can be seen that there is a number of watersheds in both counties with low imperviousness. Within this group, most also have a majority of their native forest land-cover remaining, while a smaller number have lost forest cover to agriculture and timber harvest activities. Another line has been drawn at the 65% forest cover level. This is generally recognized as the level (60-70% forest cover range) at which the natural hydrologic regime of a watershed begins to unravel and instream hydrologic impacts become significant (May et al., 1997; Horner et al., 1997; Horner and May, 1999; Booth et al., 2002). Research in the Puget Sound lowlands (Booth et al., 2002) indicates that at low levels of development (such as the rural levels found throughout Kitsap County), the retention of forest cover is much more significant than the increase in impervious surfaces in maintaining the natural hydrologic regime within a watershed. These results point to the importance of maintaining native vegetation and minimizing imperviousness on the sub-watershed scale. Currently, Kitsap County has several watersheds where stormwater runoff impacts, that tend to result from increased development, have had a significant impact on the natural hydrologic regime or aquatic ecosystems. These include Annapolis, Blackjack, Ross, Wright, Clear, Barker, Mosher, Steele, Bjorgen, and Dogfish Creeks. Retention of natural land cover (native forests and wetlands) is the key to reducing hydrologic impacts at rural levels of development (May et al., 1997; Horner and May, 1999; Booth et al., 2002).

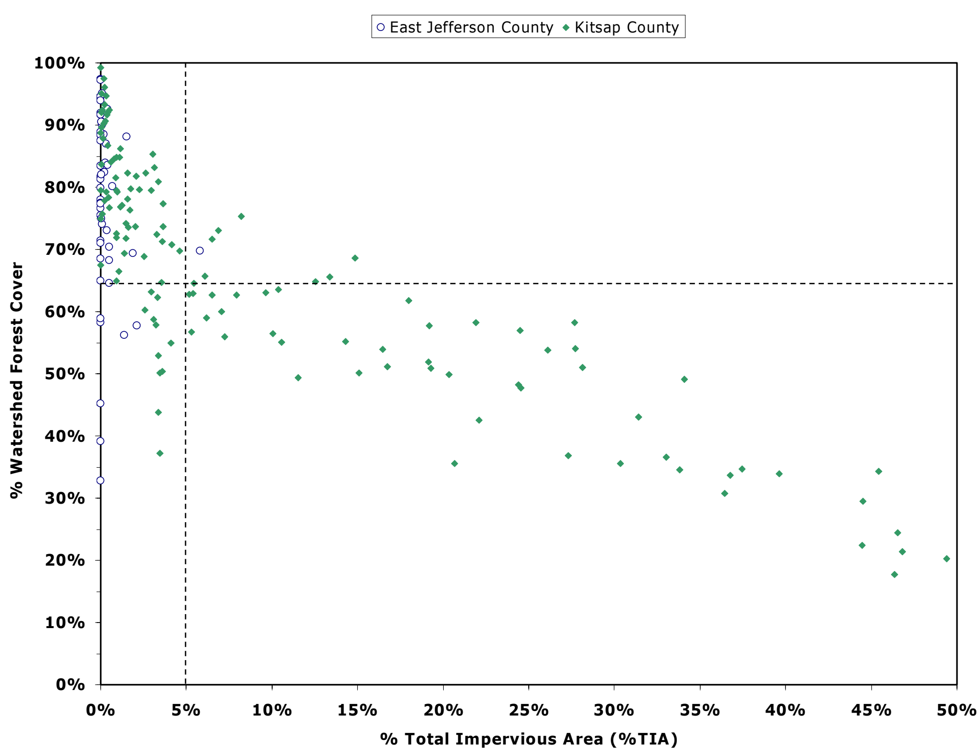


*Figure 45: Relationship between Forest Cover and Land Use.*

Another interesting relationship is that between imperviousness (%TIA) and the road network within a watershed. Roads are typically a major component of the overall level of imperviousness within a watershed, often exceeding 60% of the total impervious surface area (May et al., 1997; Horner et al., 1997; Horner and May, 1999; Booth et al., 2002). Figure 46 shows this relationship. This points to the importance of limiting the number of roads (paved and unpaved) constructed in a watershed, if impervious surface area is to be controlled and the natural hydrologic regime maintained.

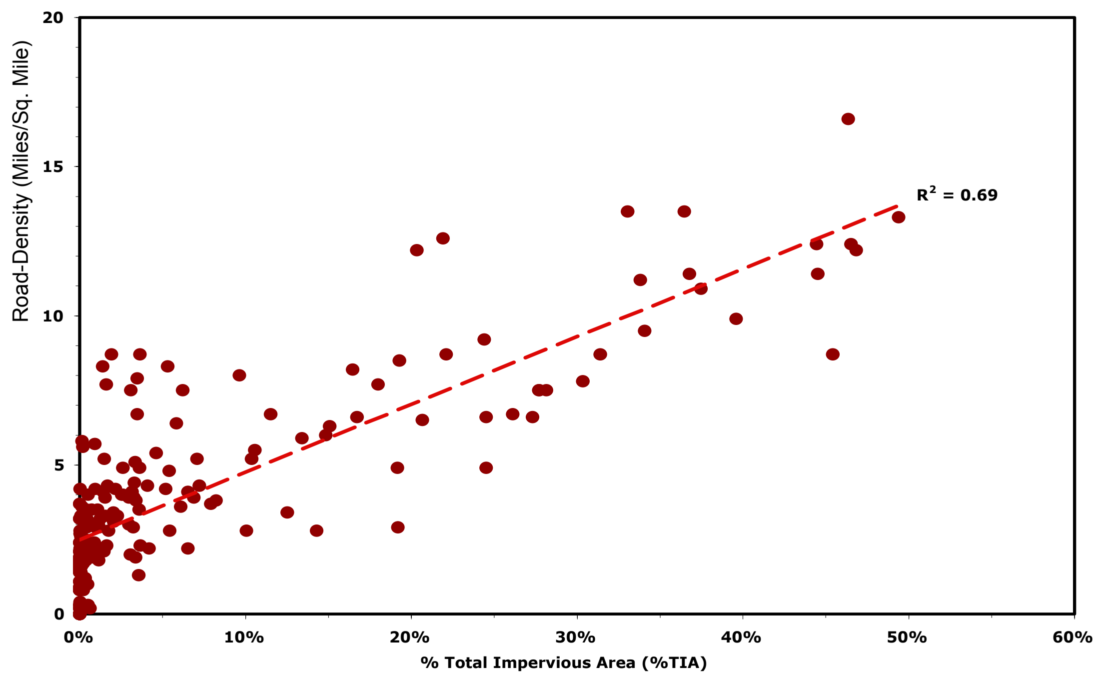


*Figure 46: Relationship between Watershed Land-Use and Road Density*

Roads also have other impacts on stream systems when they cross a stream or river. These impacts include fragmenting the stream-riparian ecosystem corridor, causing migration barriers (improperly installed culverts), and providing a conduit for fine sediment and other pollutants to enter the stream system with stormwater runoff. Figure 47a-d shows the number of road-crossings per channel length for streams in the Kitsap County study area. In general, a good target for maintaining natural stream-riparian function is to limit stream-crossing frequency to less than 2 per km (May et al., 1997). Numerous Kitsap County streams are well over this target and are highly fragmented. This can lead to hydrologic problems (localized flooding) as well as ecological impacts such as migration barriers.

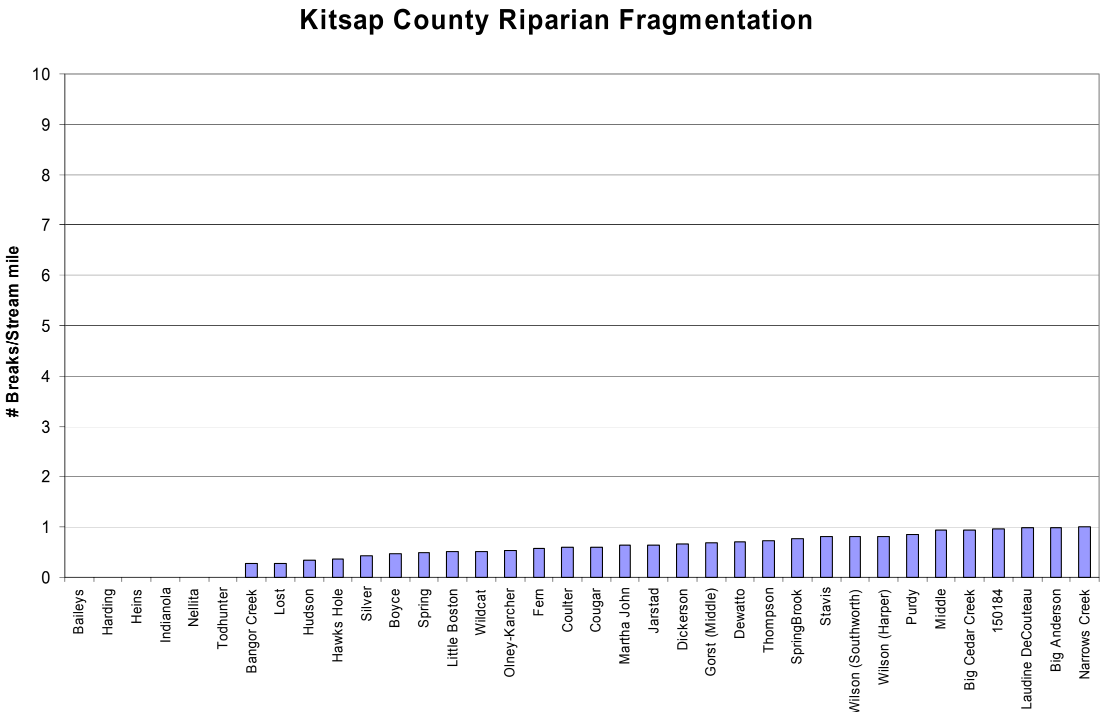


*Figure 47a: Stream-Riparian Fragmentation in Kitsap County.*

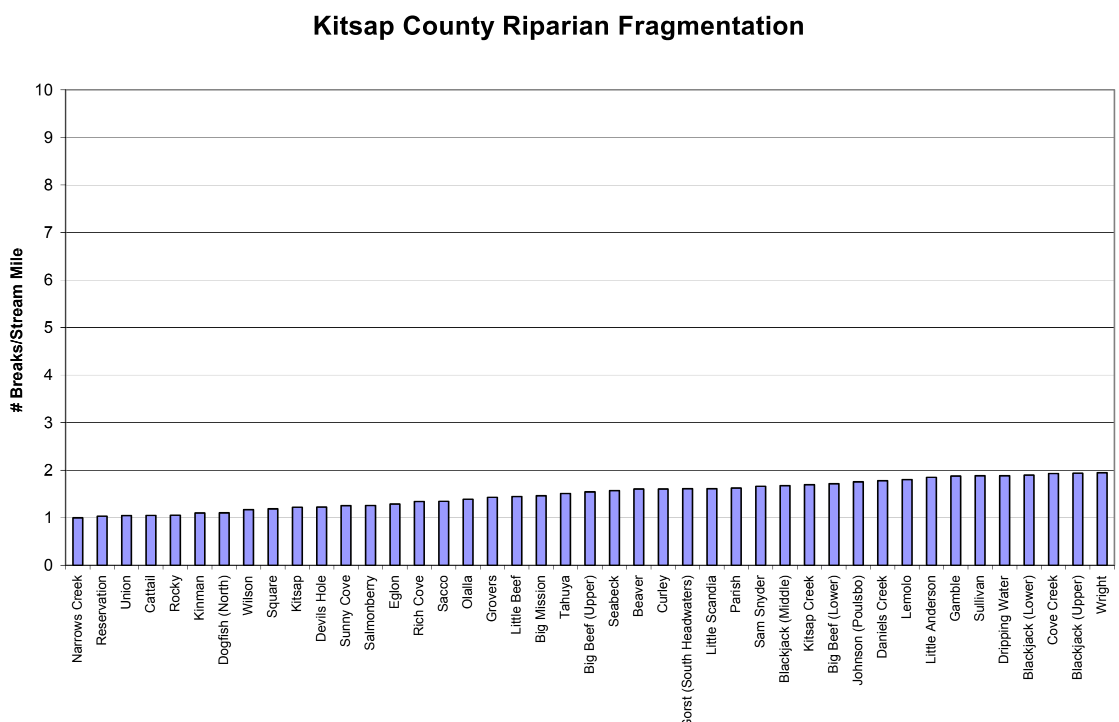


*Figure 47b: Stream-Riparian Fragmentation in Kitsap County.*

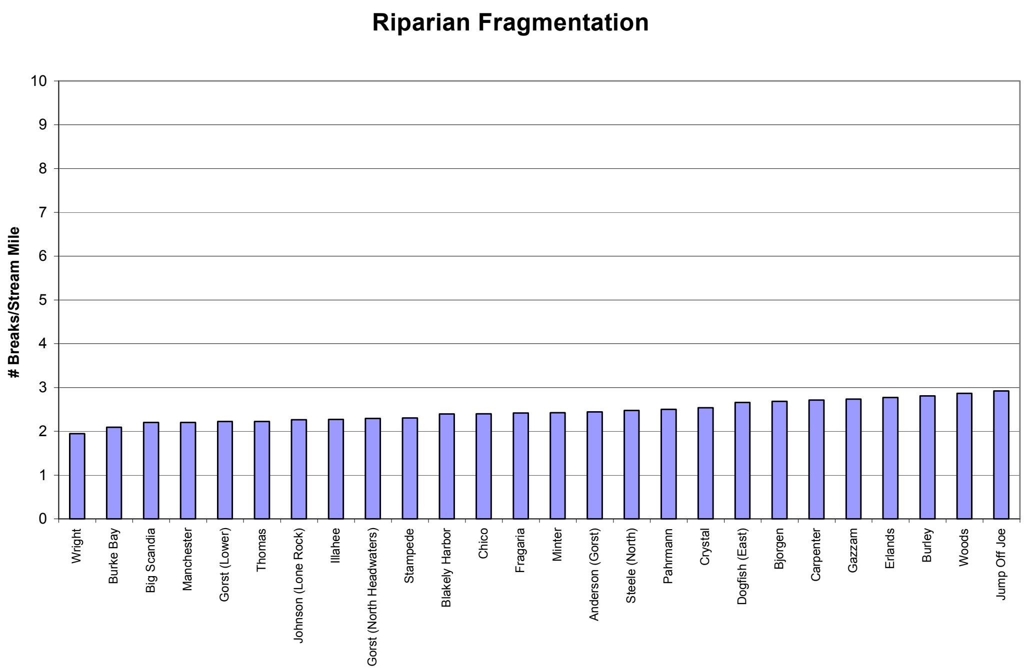


*Figure 47c: Stream-Riparian Fragmentation in Kitsap County.*

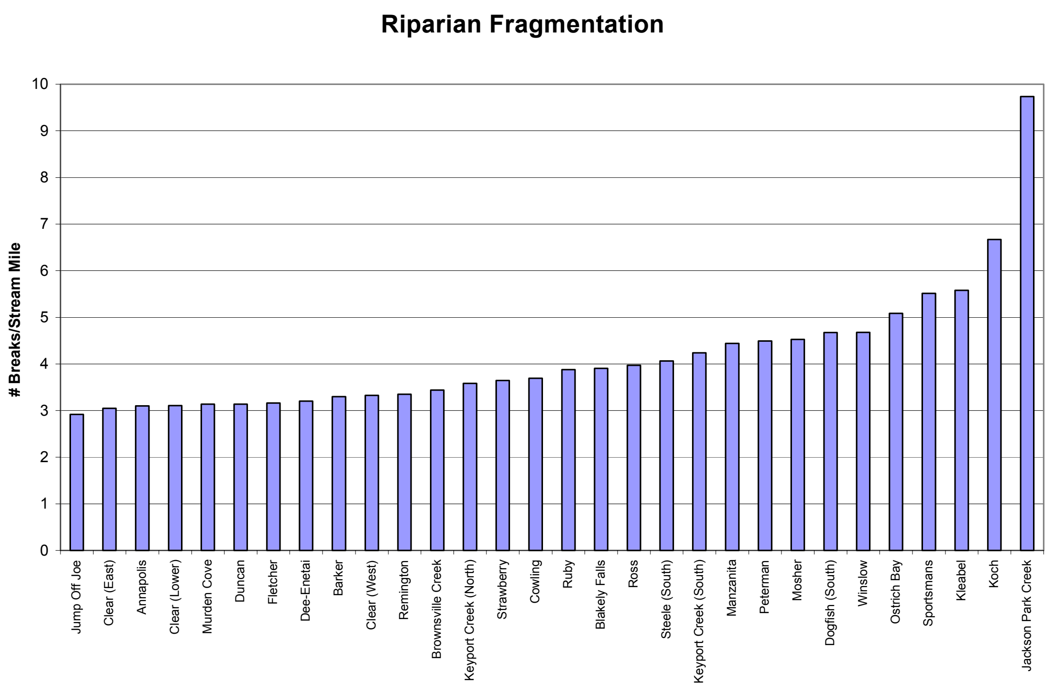


*Figure 47d: Stream-Riparian Fragmentation in Kitsap County.*

Agricultural (pasture grazing and crop production) is relatively low, but is still a common component of the overall land-use pattern of Kitsap County. Figure 48 shows the level of agricultural land-use found in the study area. In general, hobby farms and horse farms are the major agricultural-related activities, primarily located in the lower valley bottoms of the major stream watersheds (Burley, Olalla, Salmonberry, Blackjack, Dogfish, Steele, Big Scandia, Grovers, Martha John, Kinman, Eglon, Carpenter, and Gamble). Agricultural activities can have several negative impacts on streams, including polluted runoff from fields and pastures, loss of floodplain habitat and ditching of stream channels, and loss of riparian vegetation (NRC, 1996).

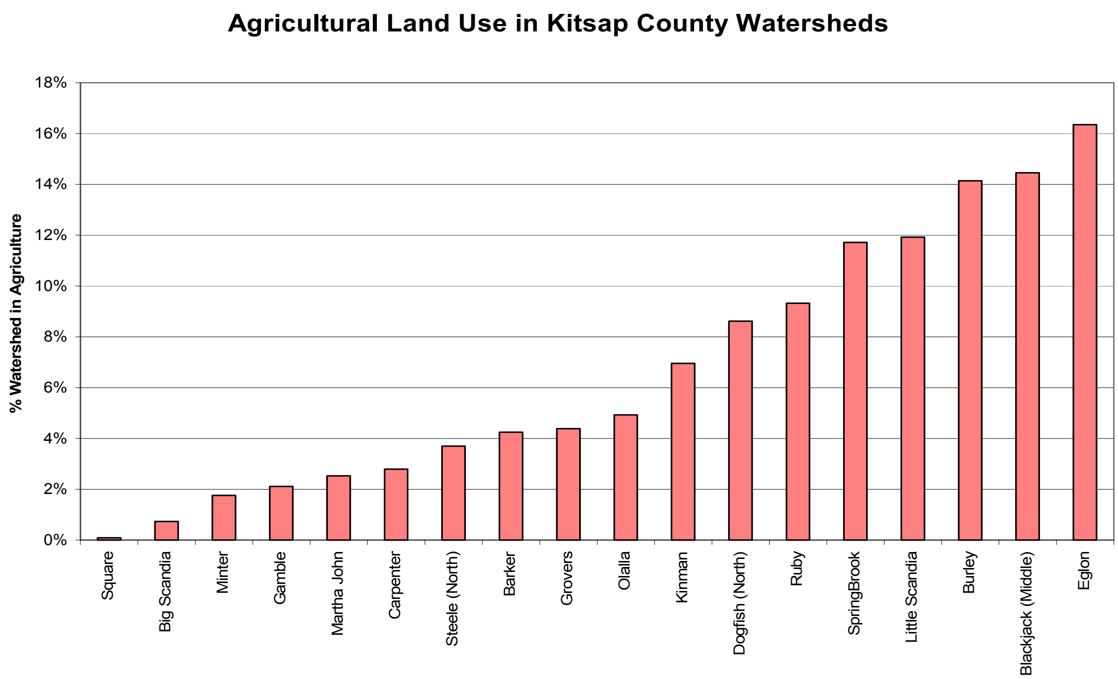


*Figure 48: Agricultural Land Use in Kitsap County Watersheds (other watersheds equal 0%).*

As has been discussed, the urbanization process has numerous impacts on watershed hydrology, water quality, and ecological integrity (May et al., 1997). Floodplain modification is one of those impacts associated with development within floodplain or flood-prone areas (see Figure 49a-b).

Figure 50a-d shows the distribution of impervious cover within the Kitsap study area, indicating that a significant number of watersheds are already at suburban levels of development. In spite of the impacts discussed above, many streams in the Kitsap County study area have retained much of their native forest cover and natural riparian integrity (see Appendix E for details on riparian issues), however a significant number of watersheds have lost much of their native forest cover and riparian integrity. Figure 51a-d shows the distribution of coniferous, deciduous, and mixed forest cover within the study area. Figure 52a-d shows the level of riparian quality (as measured by the percent of the riparian corridor that is composed of native forest cover) for streams in the Kitsap County study area.

The overall GIS landscape scores for the Kitsap County study area are shown in Figure 53a-d. In general, the scores for the Kitsap County study area good, reflecting the low level of watershed development and retention of native forest cover in most watersheds.

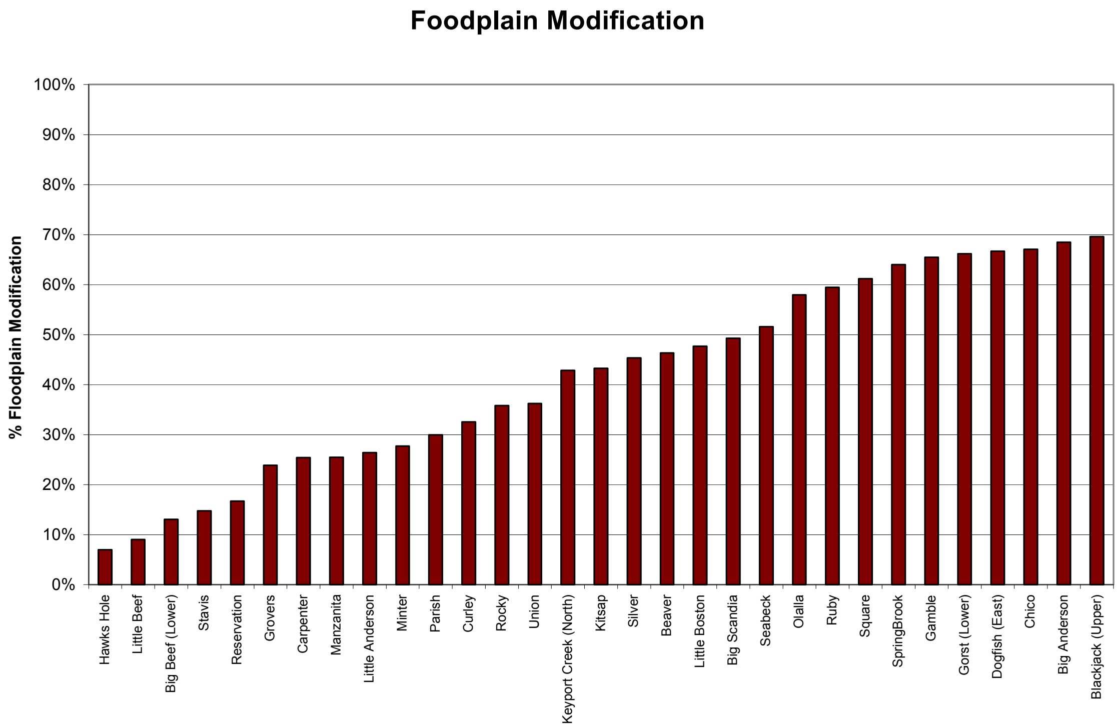


*Figure 49a: Floodplain Modification in Kitsap County Watersheds (watersheds not shown have a value of 0%).*

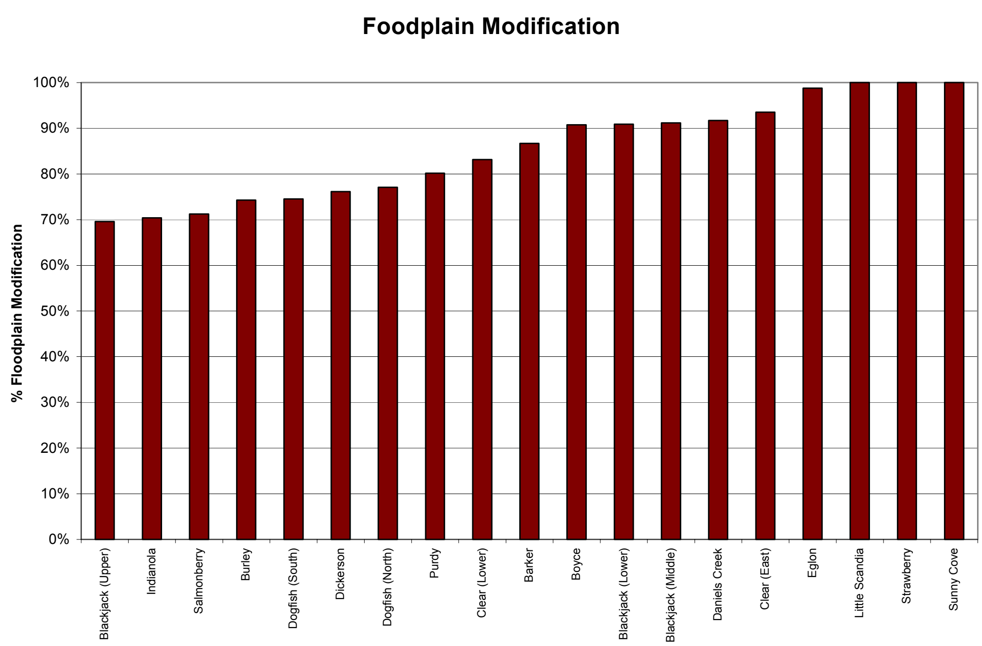


*Figure 49b: Floodplain Modification in Kitsap County Watersheds (watersheds not shown have a value of 0%).*

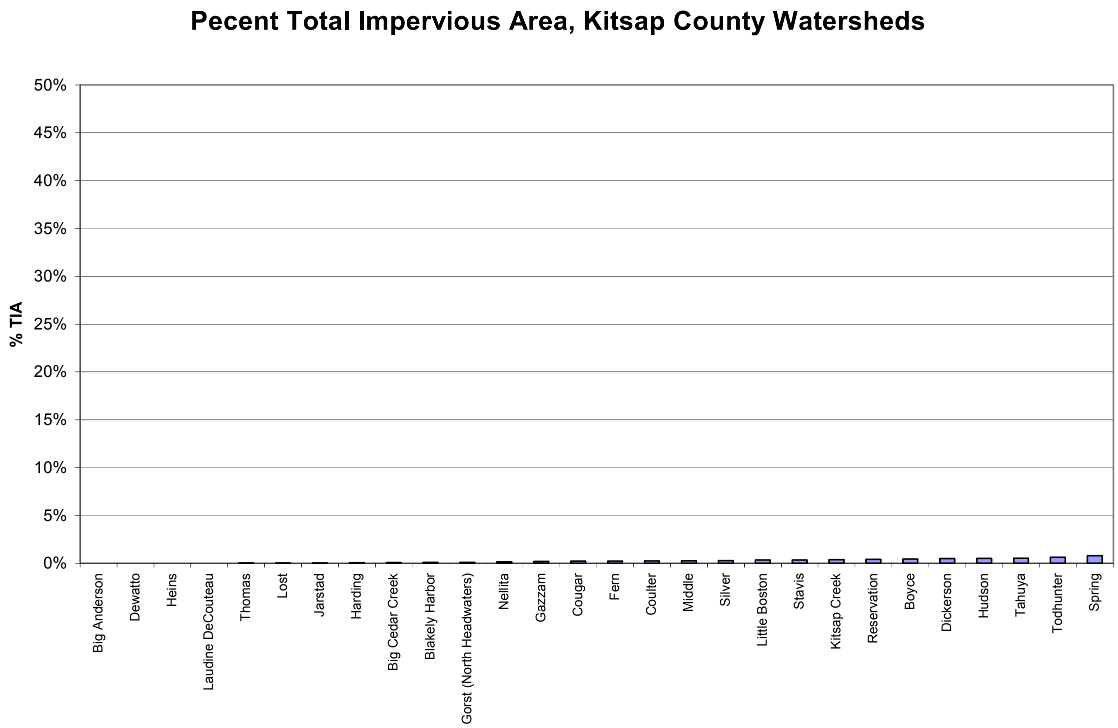


*Figure 50a: Percent Total Impervious Area of Kitsap County Watersheds.*

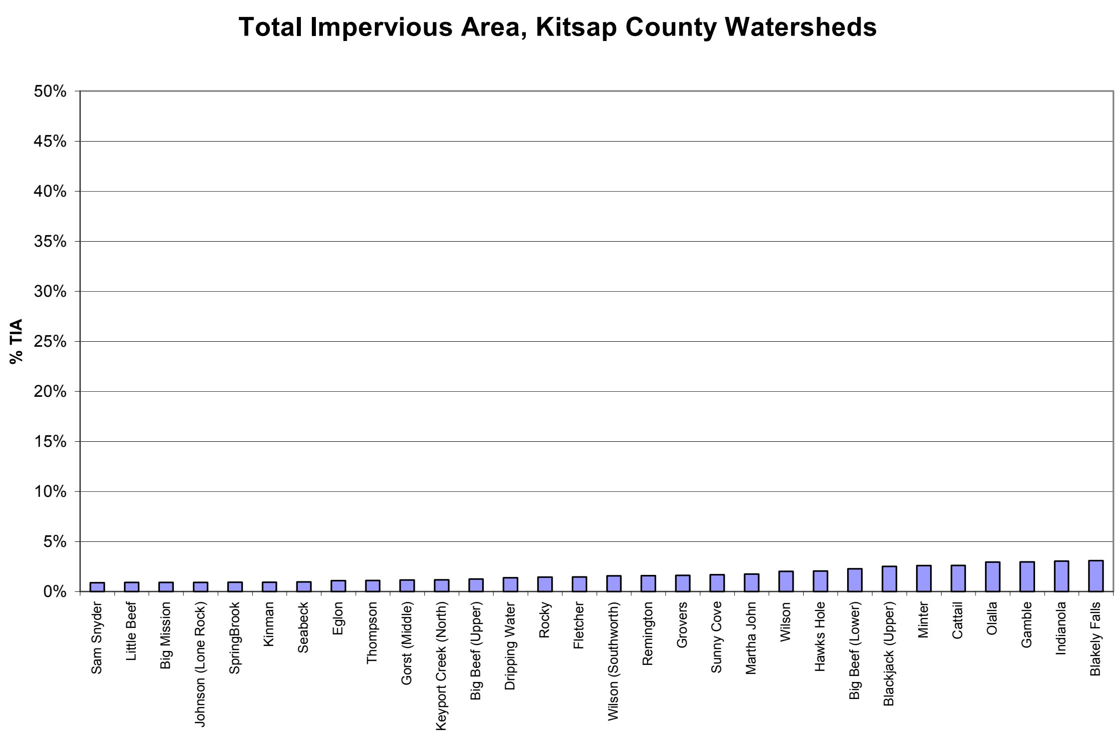


*Figure 50b: Percent Total Impervious Area of Kitsap County Watersheds*

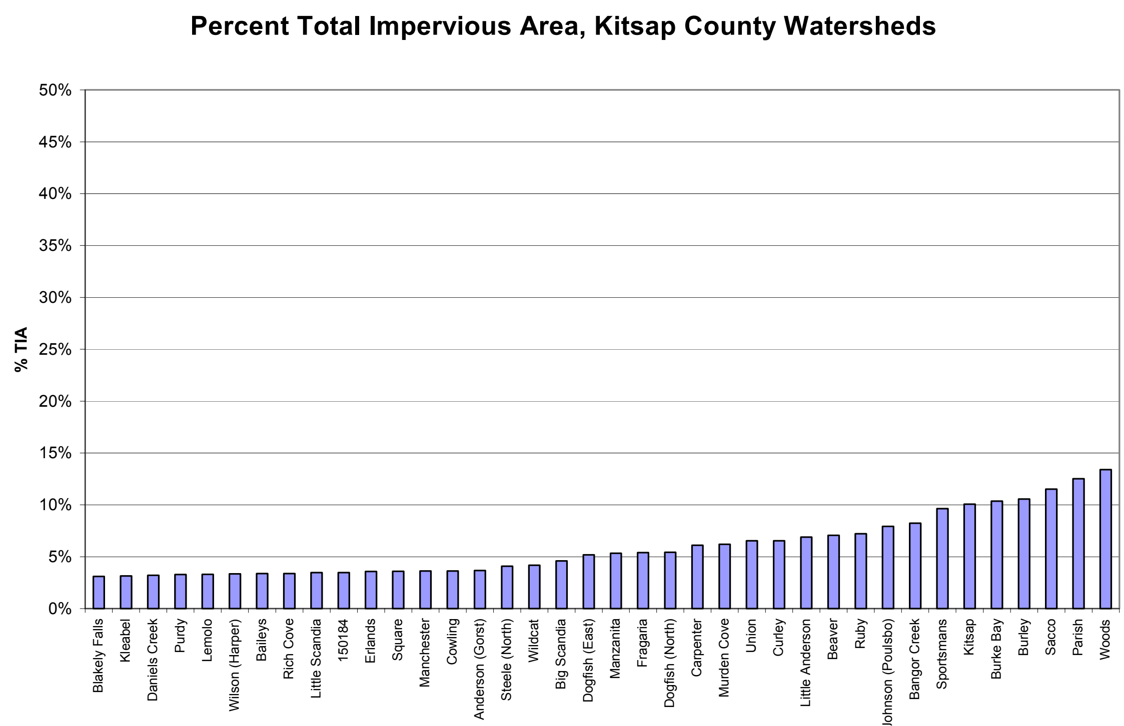


*Figure 50c: Percent Total Impervious Area of Kitsap County Watersheds*

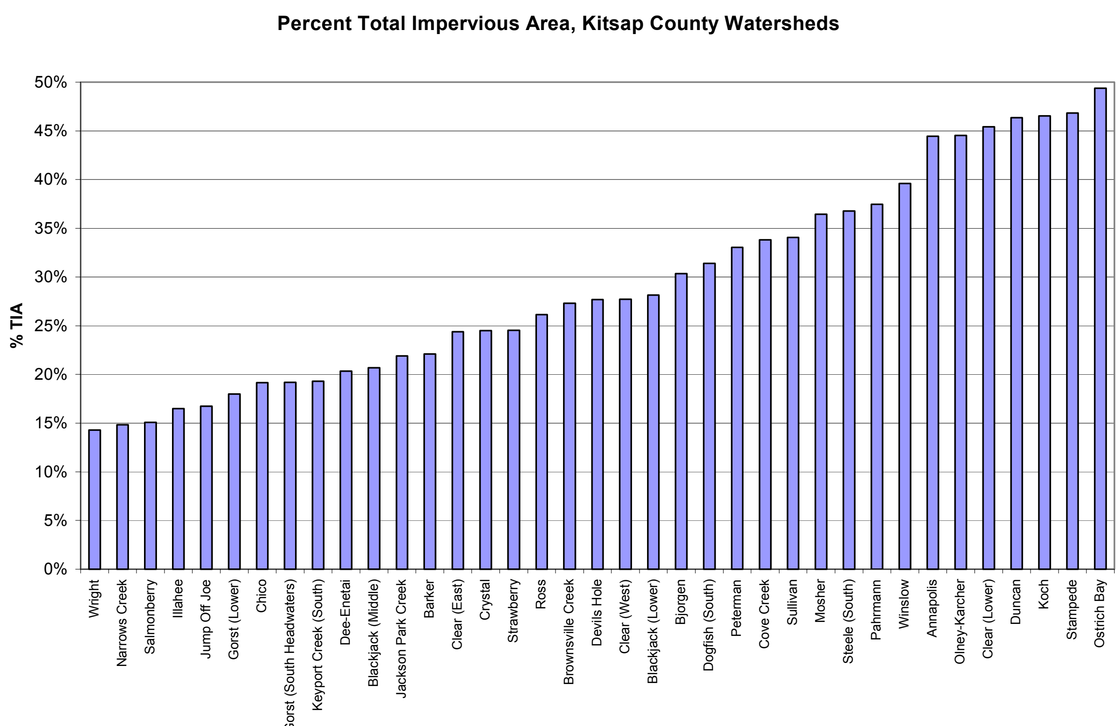


*Figure 50d: Percent Total Impervious Area of Kitsap County Watersheds*

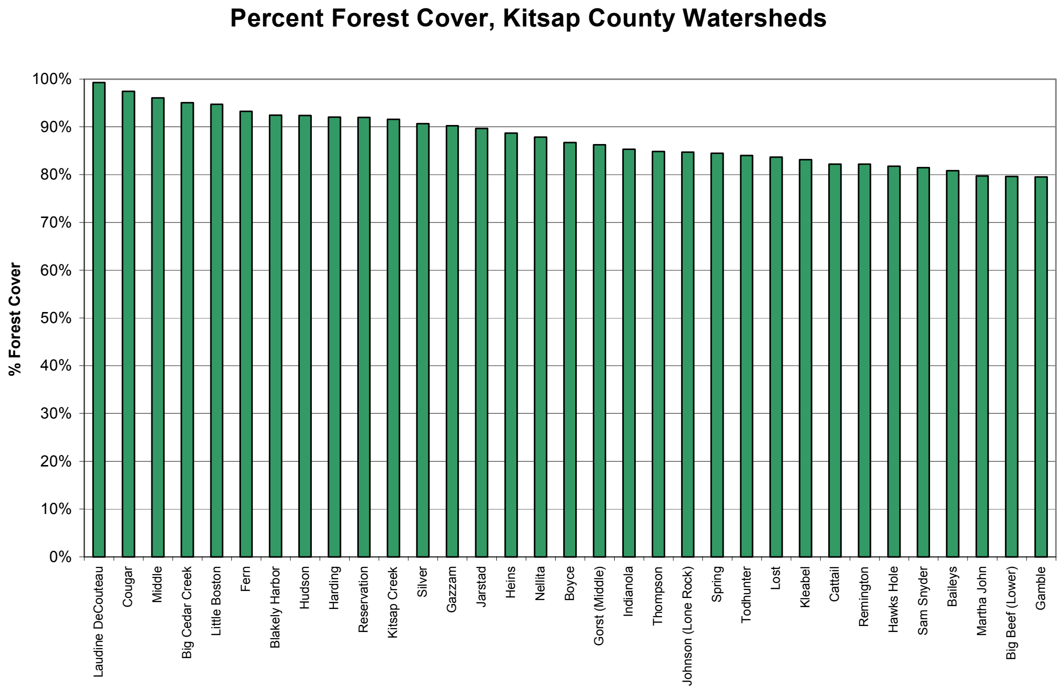


*Figure 51a: Percent Forest Cover, Kitsap County Watersheds*

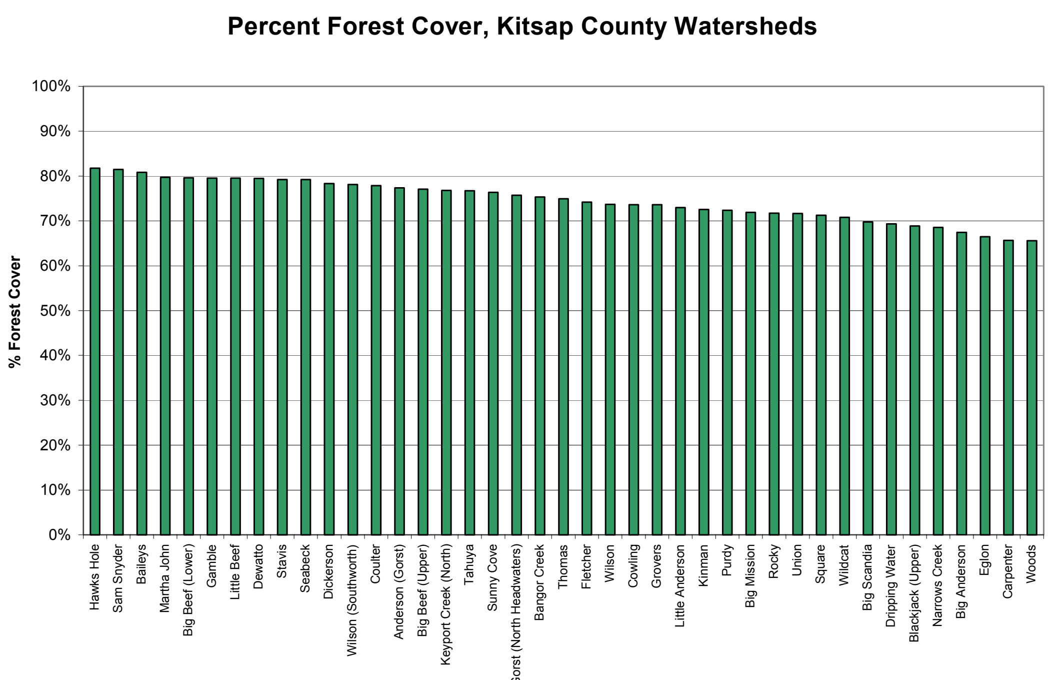


*Figure 51b: Percent Forest Cover, Kitsap County Watersheds*

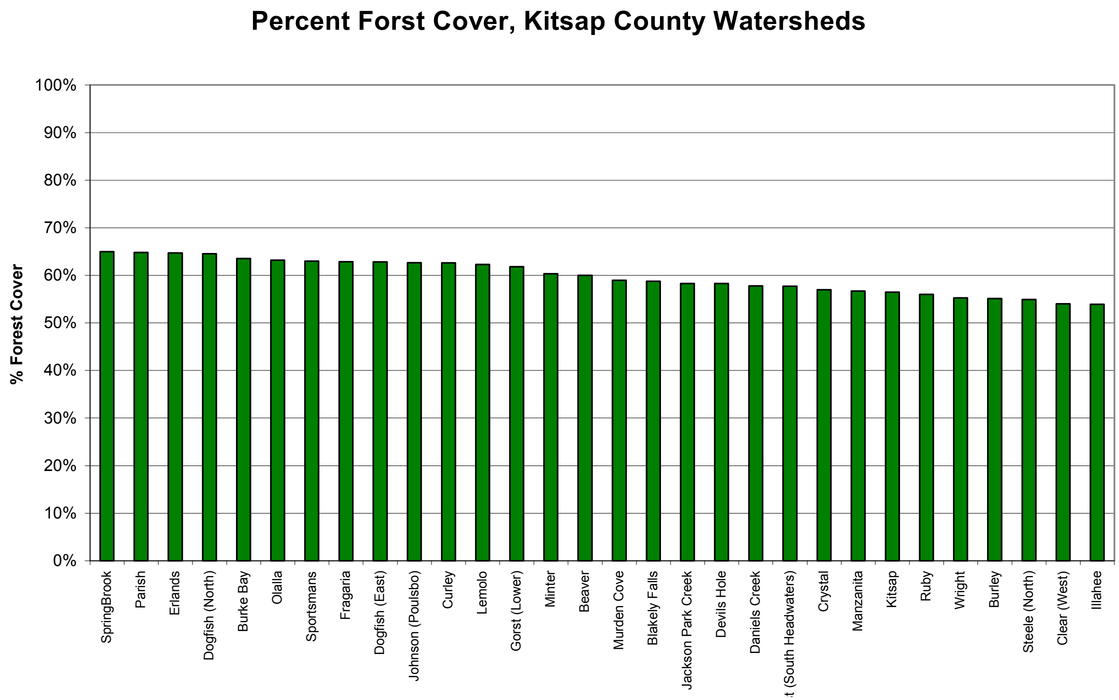


*Figure 51c: Percent Forest Cover, Kitsap County Watersheds*

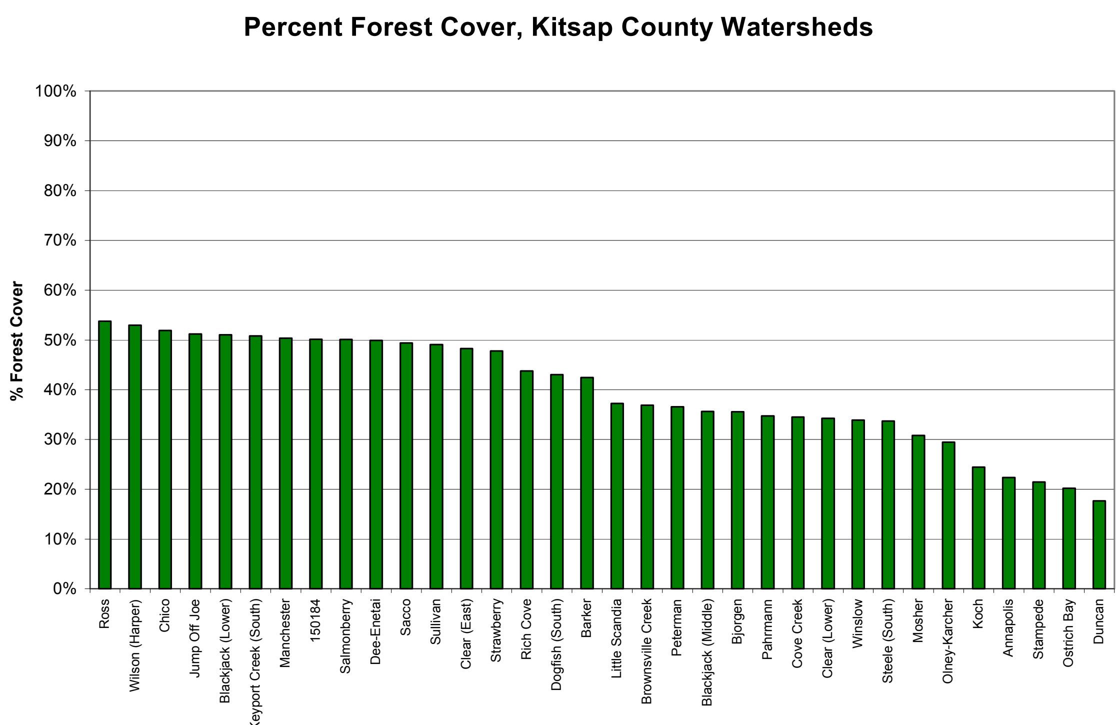


*Figure 51d: Percent Forest Cover, Kitsap County Watersheds*

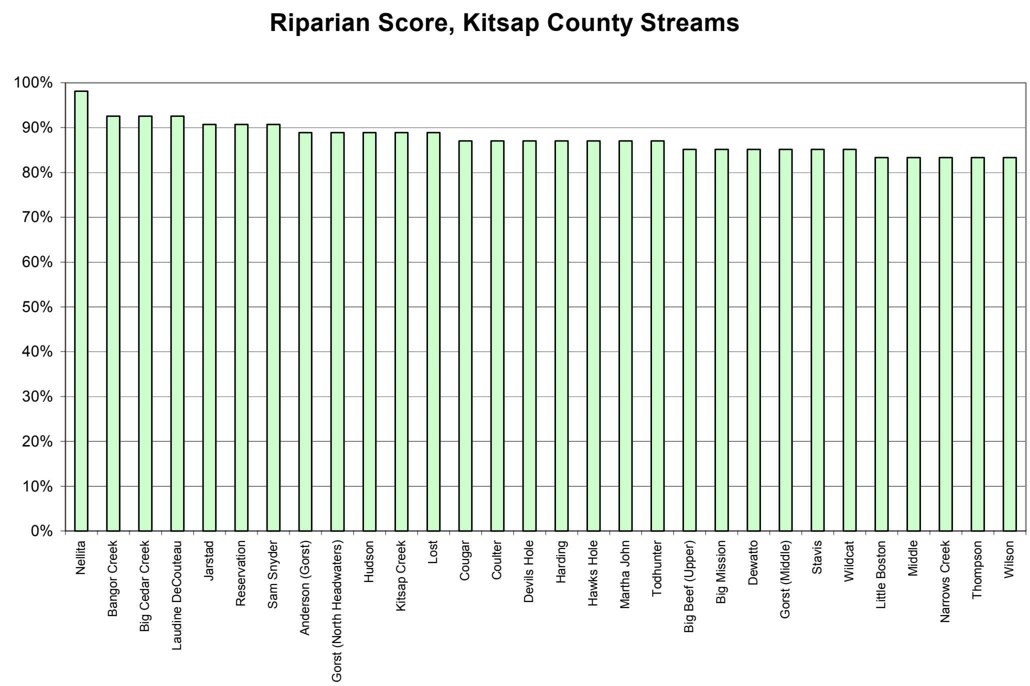


*Figure 52a: Riparian Score, Kitsap County Watersheds*

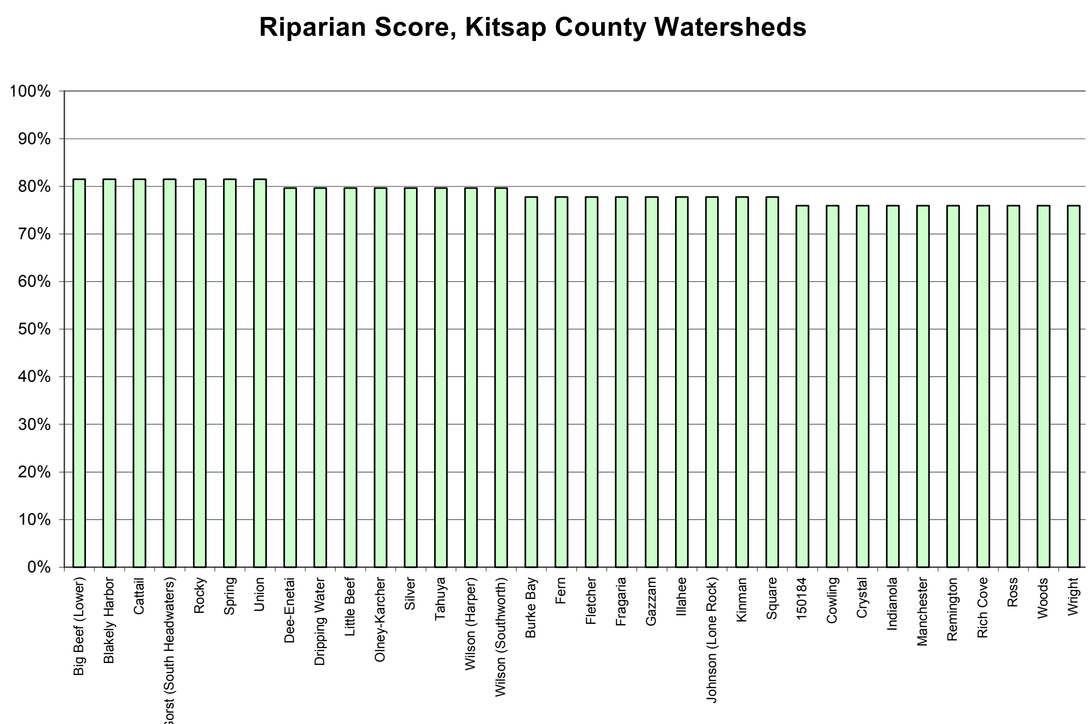


*Figure 52b: Riparian Score, Kitsap County Watersheds*

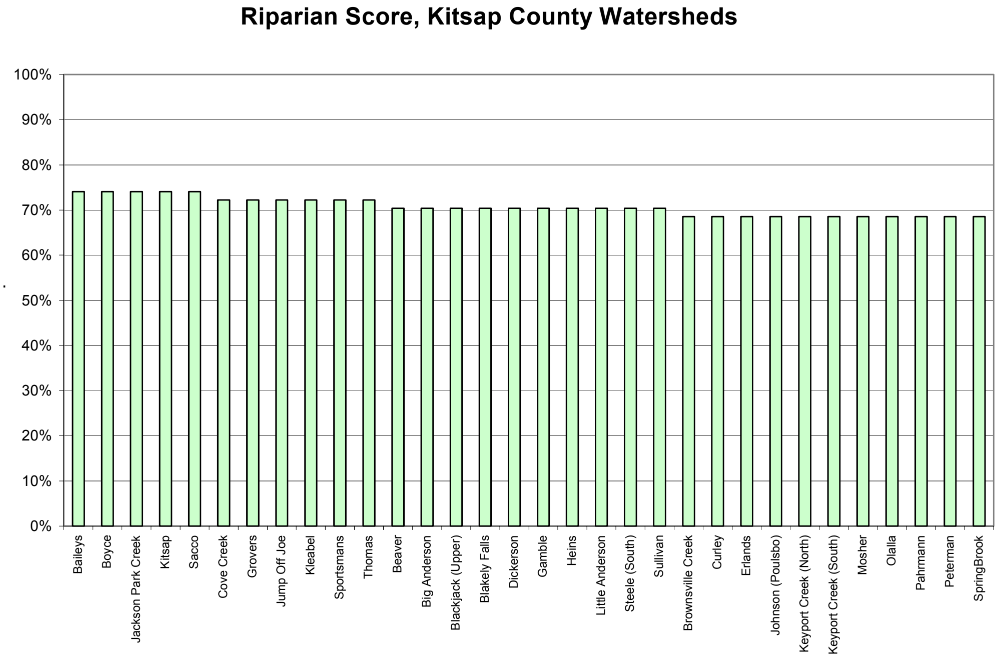


*Figure 52c: Riparian Score, Kitsap County Watersheds*

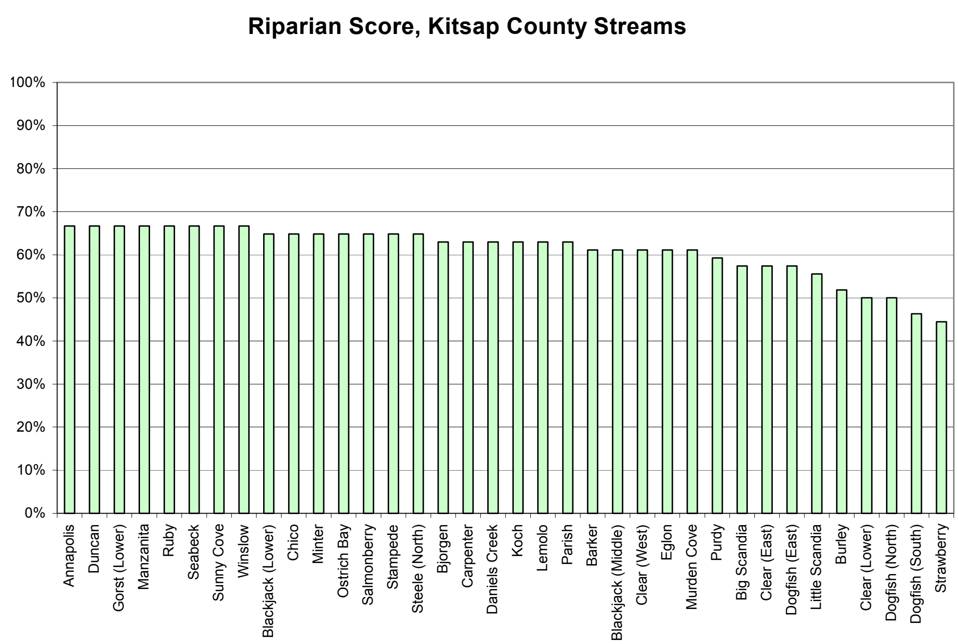


*Figure 52d: Riparian Score, Kitsap County Watersheds*

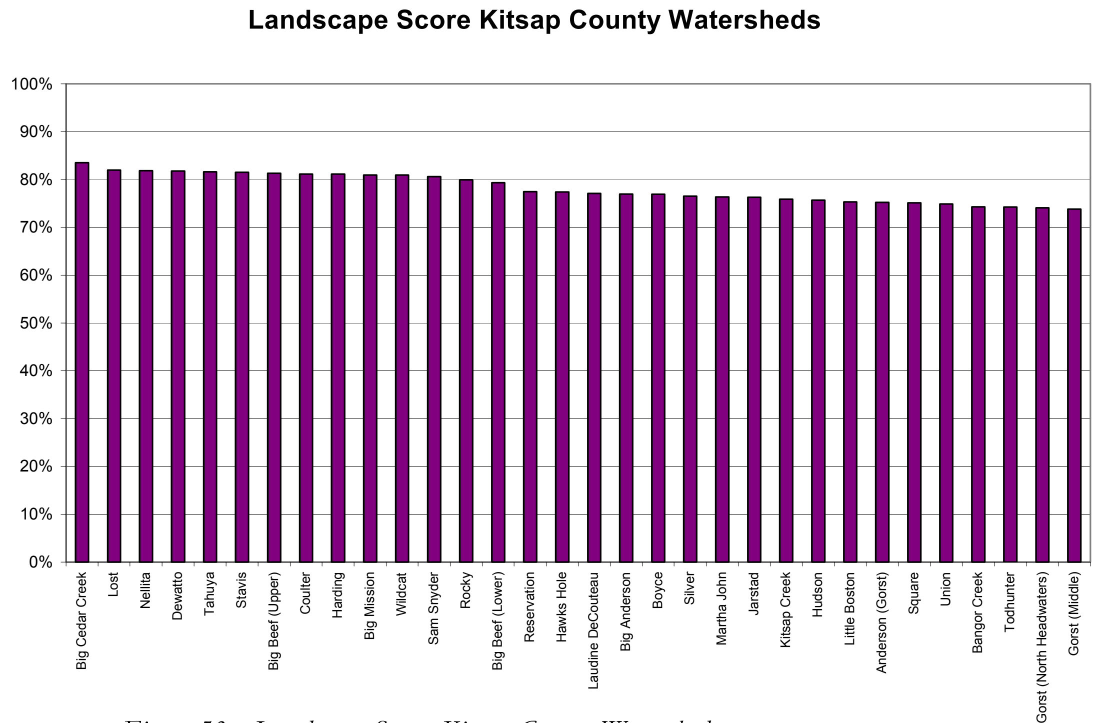


*Figure 53a: Landscape Score, Kitsap County Watersheds*

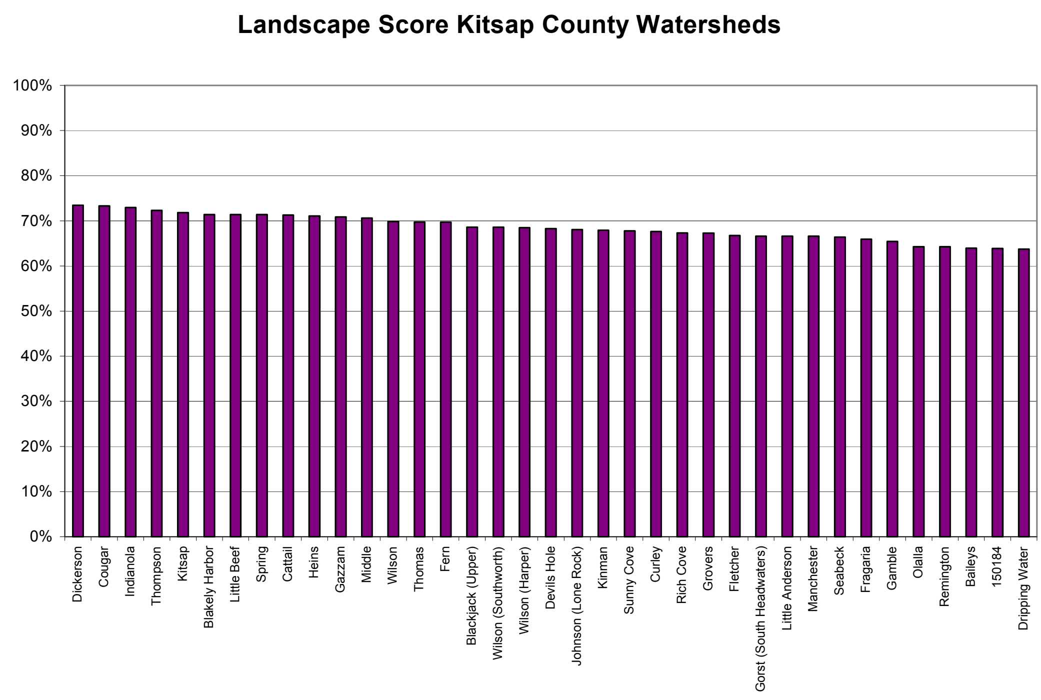


*Figure 53b: Landscape Score, Kitsap County Watersheds*

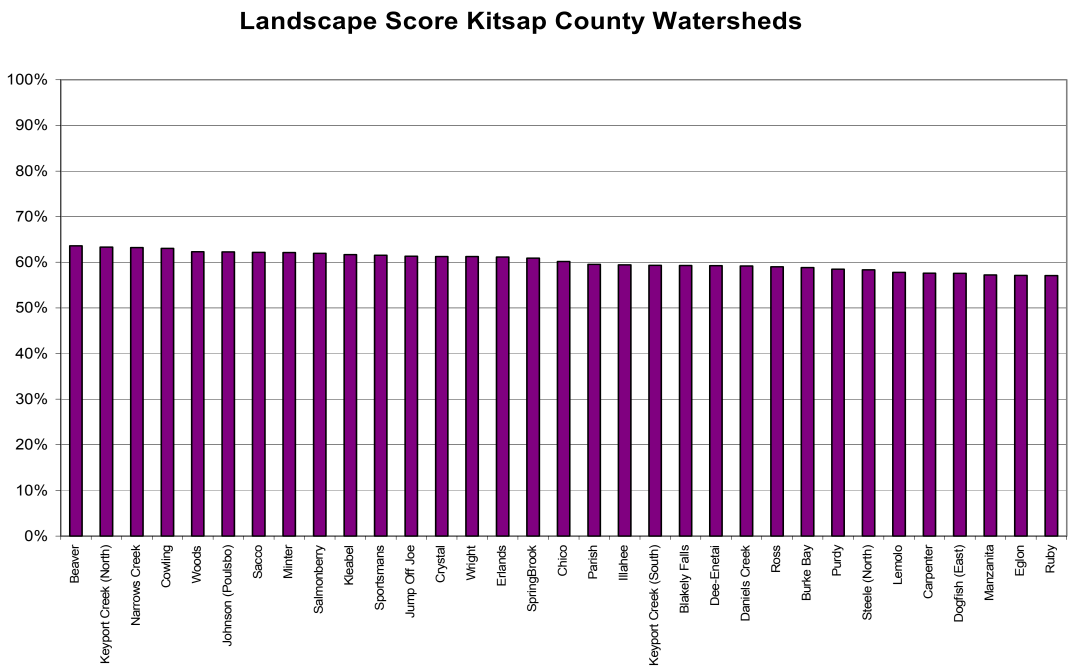


*Figure 53c: Landscape Score, Kitsap County Watersheds*

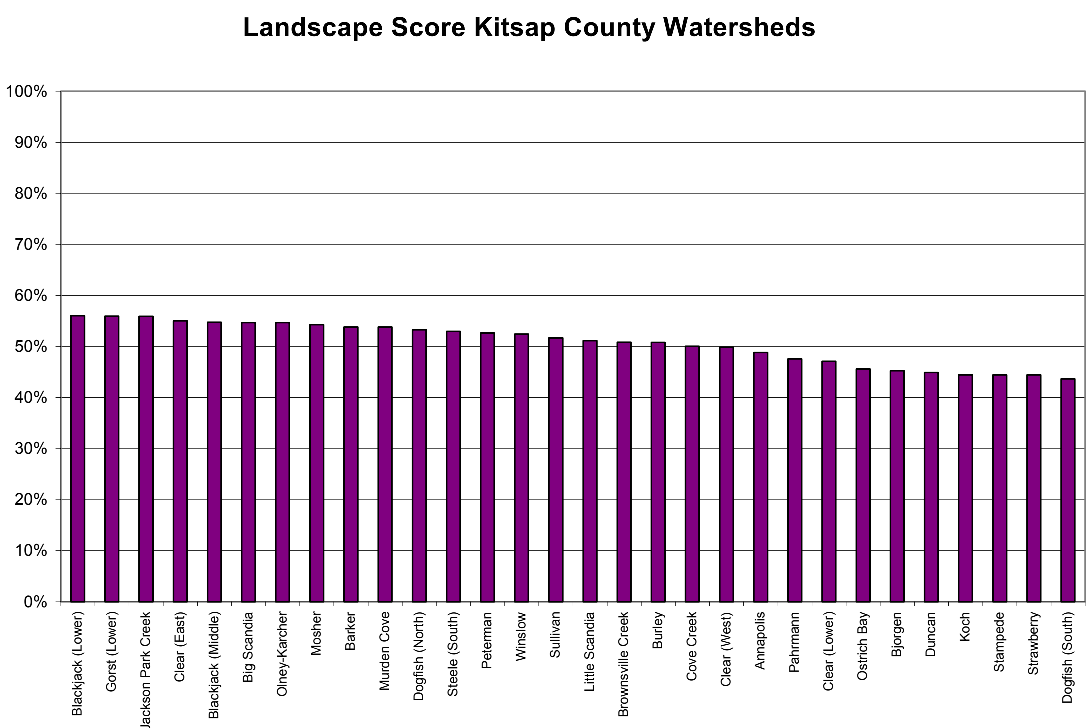


*Figure 53d: Landscape Score, Kitsap County Watersheds*

## GIS LANDSCAPE MODEL NEARSHORE RESULTS

The identification, delineation, and assessment of potential nearshore refugia was based on best available scientific data. There is still a great deal we do not understand about salmonid utilization of the nearshore environment, but the body of knowledge is growing (Williams and Thom, 2001). Other jurisdictions are in the process of conducting detailed nearshore assessments (see King County State of the Nearshore Draft Report and Bainbridge Island Nearshore Assessment Draft Report for examples). The quantity and quality of scientific data available on the nearshore environment within the study area is significantly less than the data available for freshwater salmonid habitat. Therefore, the results of the nearshore refugia analysis should be considered as "interim" until a more thorough and rigorous nearshore assessment can be conducted.

The identification of potential nearshore refugia areas was based on field surveys conducted as part of the refugia project, interviews with local nearshore "experts" (this was primarily conducted in parallel with the WCC limiting-factors nearshore analysis process), and aerial-photo analysis using the most current WDOE shoreline photos (http://apps.ecy.wa.gov/shorephotos/). The selection and delineation of nearshore refugia areas was based on the following criteria:

- Known salmonid utilization for juvenile rearing and migration
- Known salmonid utilization for adult migration or feeding
- Presence of aquatic vegetation habitat supportive of salmonids

In addition, the estuaries of major streams and rivers were also included as nearshore refugia areas because of their critical importance in salmonid adult, juvenile, and smolt life history stages for multiple species.

Figure 54 shows a map of nearshore refugia areas in the combined Kitsap County and Kitsap County study area. The results of the GIS nearshore analysis for Kitsap and Jefferson Counties are shown in Figures 55 and 56. In general, nearshore areas in Hood Canal were in a more natural condition than nearshore areas on the east side of the Kitsap Peninsula on Puget Sound. Also, the west shore of the Hood Canal (Jefferson County) has generally more natural nearshore areas than the east shore, with the exception of the Dewatto and Tahuya areas in Mason County, which are among the most natural in the study area. The most significant negative impacts on the nearshore environment were the modification of the shoreline (including bulkheads, docks, marinas, and shoreline roads), the loss of native riparian vegetation, and the filling of estuarine areas for shoreline development.

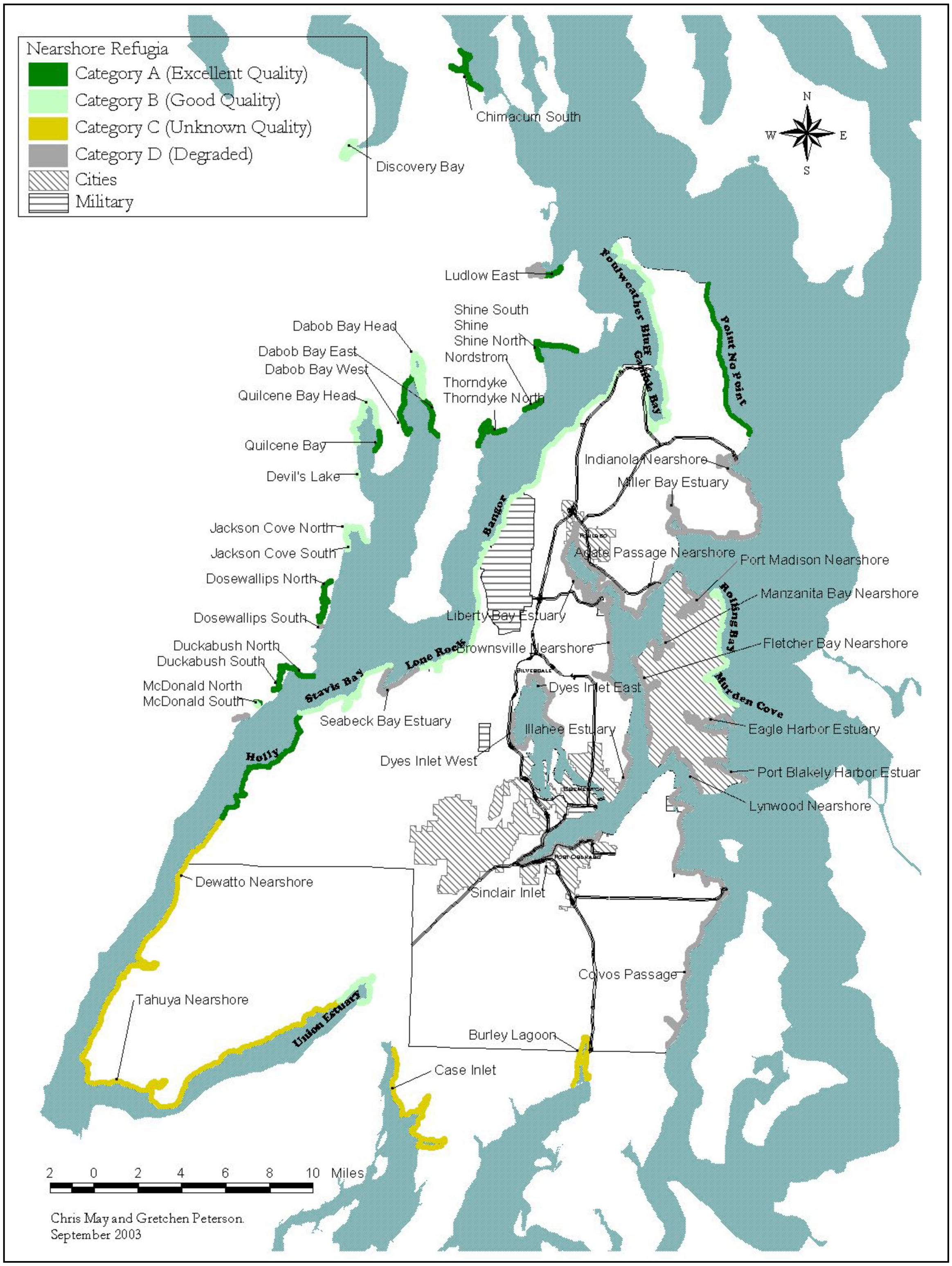


*Figure 54: Map of Nearshore Refugia Areas.*

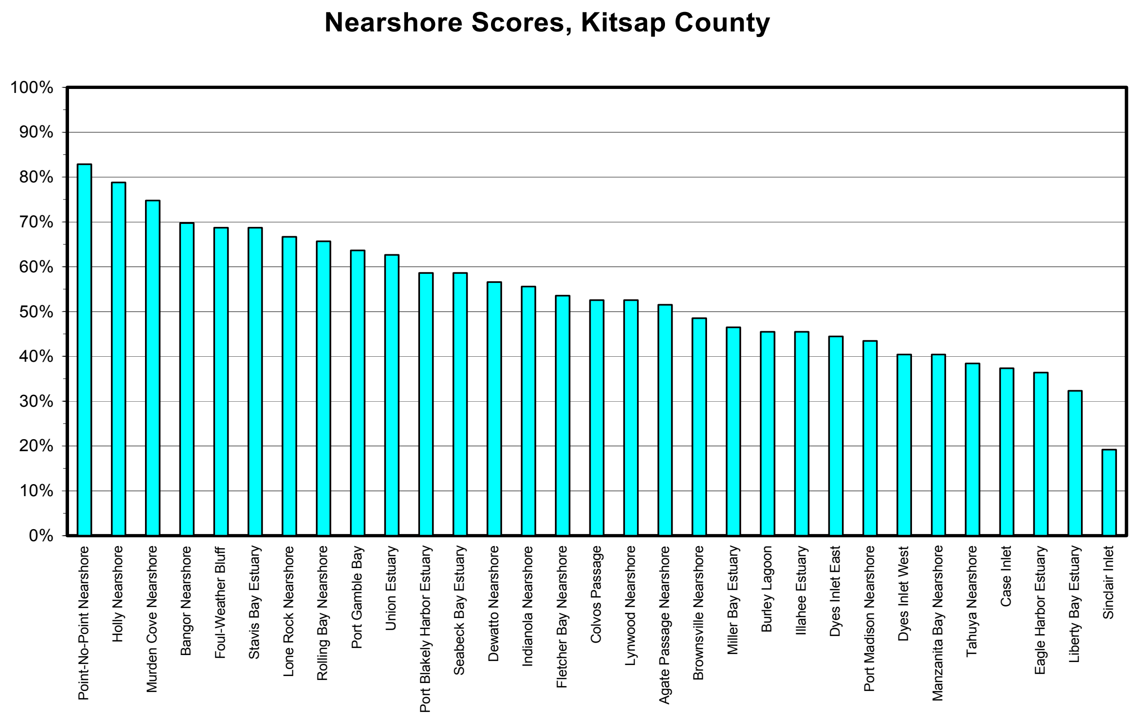


*Figure 55: Nearshore Refugia Scores for Kitsap County*

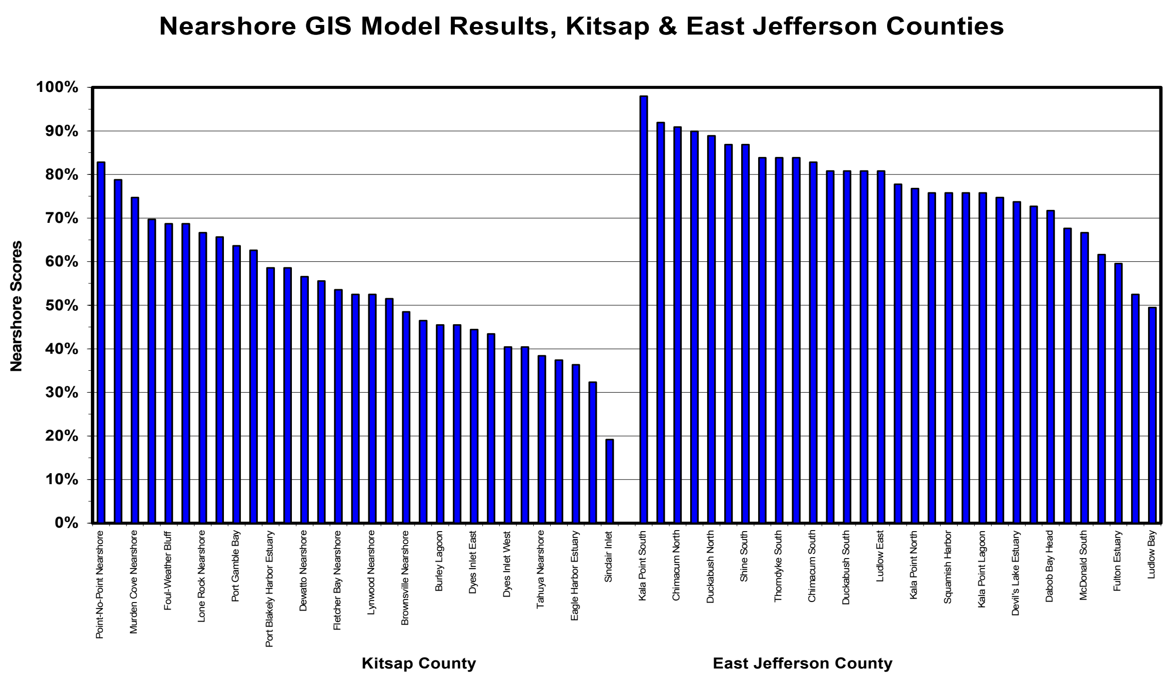


*Figure 56: Nearshore Refugia Scores for Kitsap and East Jefferson Counties.*