

Stephen C. Newbold and Juha V. Siikamäki. 2009. Prioritizing conservation activities using reserve site selection methods and population viability analysis. *Ecological Applications* 19:1774–1790.

Calibration to current and historic conditions

First, we assume that the pollution intensity factors for each land use type, ω , are proportional to the relative effects of land use types on average spawner densities as estimated by Pess et al. (2002). Pess et al. examined the relationships between watershed land use characteristics and coho salmon (*Oncorhynchus kisutch*) abundance in the Snohomish River in northwest Washington, and estimated the following regression equation to relate different land use types and spawner abundance: $spawners = \exp(6.49 - 0.011[\%tilled] - 0.029[\%bedrock] - 0.32\ln[\%ag] - 0.13\ln[\%urban])$, where *spawners* is the number of returning spawners observed per stream kilometer per day [fish/km/day]; *%tilled*, *%ag*, and *%urban* denote the percent of the watersheds in tilled agricultural land, other agricultural land, and urban uses; and *%bedrock* denotes the percent of riverbed that is bedrock. With this model structure the constant term captures the average influence of all other unmeasured factors on the number of returning spawners, including the effects of forest degradation.

We isolate the relative effect of forest degradation on the number of spawners by assuming that the constant term in the Pess et al. regression includes the effects of existing forest conditions, i.e., $6.49 = a + b_0 \ln[\% forest]$, where *a* isolates the effect of pristine watershed conditions on habitat productivity and *b₀* determines the effect of forest degradation on spawner

density. Thus, the average historic spawner density is $\exp(a - 0.029[\%bedrock])$. Haas and Collins (2001) estimated that historic production levels for Coho salmon in the main stem of the Snohomish watershed were roughly 50% greater than current estimates. Assuming that $\%bedrock$ has not changed, this means

$$1 = 1.5 \times \exp(b_0 \ln[\%forest] - 0.011[\%tilled] - 0.32 \ln[\%ag] - 0.13 \ln[\%urban]). \quad (B.1)$$

Purser et al. (2003) report the following land use shares for the Snohomish watershed: 17% tilled agriculture, 1% other agriculture, and 6% urban, which leaves 74% for forest. With these data with the parameter estimates reported by Pess et al. (2002), we can use Eq. B.1 to solve for the pollution loading factor for existing forest land, which gives $b_0 = 0.00334$.

Next, to calibrate ρ we first must estimate the ratio of the average abundance of returning spawners for each stock under pristine watershed conditions to current conditions. According to Mullan et al. (1992), historic spawner abundances in Methow, Entiat, and Wenatchee were 24000, 3400, and 41000, or about 18-, 10-, and 15-times the current average spawner densities (over the years 1960-2002). The reduction of spawner densities from historic levels has resulted from a combination of factors in the upstream watersheds, where the protection measures that are the main subject of this paper would have an effect, as well as conditions in the main stem of the Columbia River and the estuaries and ocean where the fish spend most of their lives, which are outside of our model and therefore treated as constant. We assume that 50% of the reductions from historic abundances are associated with habitat degradation in the upstream watersheds. With this assumption, removing all human disturbances in the upstream watersheds would therefore result in about 9-, 5-, and 7.5-fold increases in average spawner densities of the Methow, Entiat, and Wenatchee stocks. Denoting these ratios as γ , and recognizing that the steady state spawner abundance is proportional to β , we can

calculate the habitat productivity under pristine conditions using $b = \gamma\beta / \sum_i h_i$ (this is the b in Equation (4) of the main text), and then we can plug this into our equation for β to get $\sum_i h_i = \gamma \sum_i h_i \exp(-\rho \bar{C}_i)$ and then solve numerically for ρ for each stock.

The calibration strategy used here is conditional on the pollution decay parameters, μ and η , so we cannot simultaneously calibrate ρ and both decay parameters with the few aggregate data we use on current and historic average spawner abundances. To calculate μ and η , we assume that the associated half-lives of pollution in runoff in streams and pollution in rivers is 1 km and 10 km, respectively. With all parameters specified, the model can be used to predict changes in survival probabilities for each stock, for any combination of stocks, or for the ESU as a whole from changes in human disturbances (as represented by human land use shares) in each watershed.

Literature cited

Haas, A, and B. Collins. 2001. A historical analysis of habitat alterations in Snohomish River Valley, Washington since the mid-19th century: implications for chinook and coho salmon. A report prepared for the Bureau of Indian Affairs, the Tulalip Tribes, and Snohomish County.

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