Lewis River Case Study Final Report

A decision-support tool for assessing watershed-scale habitat recovery strategies for ESA-listed salmonids

Appendix D: Action Models

May 2007

Introduction

In this appendix, we describe how each type of restoration or preservation action was modeled. First, we selected stream reaches to be modified by a given restoration, protection, or degradation actions (Appendix C). Only stream reaches selected for an action were changed. Then, we modified the appropriate base datasets to account for the effects of actions in the selected reaches. Table D-1 provides an overview of what data are changed by each type of action. We then ran models on the modified datasets and summarized resulting metrics. Table D-2 details which models are affected by each type of action. After all actions for a particular strategy were modeled, it was then possible to evaluate the potential future landscape using the suite of landscape evaluation models described in the *Landscape Evaluation Models* section of this report.

Barrier removal

We used a two-step procedure that updated the amount of habitat accessible to anadromous fish based on the anthropogenic barriers selected for restoration or improved passage. The baseline barrier dataset contained information about whether each barrier was blocking or passable, and identified the next barrier downstream. When a barrier was restored, it was coded as passable, and the procedure recursively recoded all barriers that previously pointed to the newly restored barrier (Figure D-1). This information was then used to reclassify stream reaches as accessible, provided that all downstream barriers are passable. Only stream reaches that were historically accessible to a species were candidates for becoming accessible. Reaches with gradients over 20% or above natural barriers were considered inaccessible reaches.

Floodplain Restoration

Restoring connectivity between the main channel and side channels within the floodplain was modeled by increasing the length of the affected stream reach by 39.4%. This value was calculated as the average maximum change in length of channel versus associated side channels as measured from aerial photographs for 18 reaches from current (1990) to historical (1854, 1928, and 1955) conditions (Appendix M). We applied this action before any other strategy actions, so that the effects of any other actions would be reflected on the entire restored reach length (i.e., old reach length plus newly added length). The new reach length inherited habitat condition values from the original reach. This action could only be applied in reaches where floodplains were present historically.

Riparian Restoration and Protection

For riparian restoration and protection actions, we assumed a 50-yr time step. Benefits over 50 years were estimated and applied to the reach when the reach was restored or protected using the riparian model (Appendix H). To estimate the impact of protection over 50 years, we simply improved the riparian function scores (Table D-3) and seral stage values (Table D-4) by one value. If scores were already at the maximum value, there was no effect of protection. To estimate the impact of restoration over 50 years, riparian function scores and seral stage values were increased to the best possible level. If scores were already at the maximum value, there was no effect of restoration.

Additionally, riparian actions were reflected as changes in the riparian portions of the vegetation/land cover dataset. If protected or restored, the data code for riparian meta-polygons associated with the reach was improved to 20-yr forest for all classes except shrub, grass, or naturally bare ground, which we did not expect to become forested. Upland meta-polygon codes were not altered for these actions. In the rare case where restoration and protection actions were selected to occur on a single reach, protection occurred first and then restoration.

Instream Habitat Improvement

This action was designed to mimic placement of spawning gravel, and was the only static habitat improvement method directly employed. We reasoned that other habitat improvements (i.e., recruitment of wood and formation of pools) would be reflected by improvements in watershed processes affected by other actions (i.e., riparian restoration). Improvement of spawning habitat acted only on data inputs used to estimate spawner capacity (Appendix I). For small streams (≤25 m bankfull width), we improved mean redds/km on the affected portion of a reach to the 90^{th} percentile value. New 10^{th} (and 90^{th}) percentile values were calculated as the new mean minus (or plus) the range from the old mean to the old 10^{th} (or 90^{th}) percentiles. For example, if we restored 4 m of a 6-m reach, of which mean redds/km was previously predicted to be 36.40 (7.97 to 61.30), new redds/km was calculated as follows: 2 m at old values, and 4 m at 61.30 (32.87 to 86.20) redds/km. The new redds/km for the entire reach was then 53.00, and ranged from 24.57 to 77.90 (10^{th} to 90^{th} percentiles). For large streams (>25 m bankfull width), we increased the area spawnable by 32%. Spawner capacity was then calculated based on these adjusted data values.

Road Improvement

We employed two levels of road restoration: decommissioning and improvement. This action was modeled by reducing the length of roads in the GIS layer. Decommissioning reduced length of roads by 95% (i.e., there was only 5% of road length remaining after restoration), whereas road improvements reduced road length by only 50%. Because actions acted on a reach-by-reach basis, the amount of roads remaining in the lateral drainage area of a stream reach was calculated as: (length of reach affected * level of restoration) + (length of reach unrestored). For example, if there were 5 km of roads decommissioned in the drainage area of a reach containing 7 km of roads, the resulting amount of roads in the reach was (5*0.05) + 2 = 2.25 km. Roads maintained their existing surface type (paved or unpaved) and underlying geology.

Table D-1. Data that are changed when modeling alternative conservation strategies. Actions (restoration, protection, or degradation) are in the left column. Data that change under each action type are listed in succeeding columns; actions happen only to reaches marked for conservation actions. See *Virtual Restoration and Degradation* section for details on specific changes made to data under each action category. All data not shown here do not change under modeled alternative strategies. Note that degradation only happens for strategies based on potential future conditions.

DATA→ ACTIONS↓	BARRIERS	RIPARIAN VEGETATION	VEGETATION/ LAND COVER	ROADS	STREAM REACH
upgrade or remove migration barriers	Changed to "passable," and corresponding fish distributions are updated to include newly opened habitat				
restore/protect riparian buffer		Modeled riparian function scores and seral stage values ↑ where possible to improve	In riparian areas, 20-year and 5-year forests ↑, clearcut and agriculture ↓		
restore/protect upland vegetation			In upland areas, 20-year and 5-year forests ↑, clearcut and agriculture ↓		
decommission or remove roads				Length of roads in marked drainage wings are decreased	
restore spawning gravels and instream large woody debris					Increased spawning capacity estimates (acts directly in model)
floodplain restoration (increase off-channel habitat by connecting to old channels)					Increased stream length available to fish
convert to urban or agriculture		Total tree cover and average conifer size ↓ in 75% of stream reach (25% automatically protected at existing value)	20-year and 5-year forests ↓, urban or agriculture ↑ (only on reaches without riparian protection measures)		

Table D-2. Models that are affected by data changes (see Table D-1) due to actions in conservation strategies. Actions (restoration, protection, or degradation) are in the left column. Models affected directly (or indirectly) by each action are listed in succeeding columns. See Appendix C through Appendix J for details on model development and parameters. Note that degradation only happens for strategies based on potential future conditions.

MODELS→ ACTIONS↓	**RIPARIAN**	**SEDIMENT**	**HYDROLOGY**	**FISH MODELS**
upgrade or remove migration barriers	Riparian Functions or Seral Stage (via opened habitat)	Sediment input and deposition (via opened habitat)	Runoff, Flood Discharge, and Scour (via opened habitat)	Accessibility, Suitability, Spawning Capacity, and Survival (all via opened habitat)
restore/protect riparian buffer	Riparian Function, Seral Stage	Surface Sediment, Road Sediment, Routed Fine Sediment	Runoff, Flood Discharge, Scour Potential	FishEye Suitability (via Riparian Function, Fine Sediment, and Scour Potential), Puget Suitability and Spawning Capacity (via Seral Stage), Survival (via Fine Sediment)
restore/protect upland vegetation		Surface Sediment, Mass Wasting, Routed Fine Sediment	Runoff, Flood Discharge, Scour Potential	FishEye Suitability (via Riparian Function, Fine Sediment, and Scour Potential), Survival (via Fine Sediment)
decommission or remove roads		Road Sediment, Routed Fine Sediment	Flood Discharge, Scour Potential)	FishEye Suitability and Survival (via Fine Sediment)
restore spawning gravels and instream large woody debris				Spawning Capacity
floodplain restoration (increase off-channel habitat by connecting to old channels)				Accessibility, FishEye Suitability, Spawning Capacity, and Survival (all via increased accessible reach length)
convert to urban or agriculture	Riparian Function, Seral Stage	Surface Sediment, Road Sediment, Routed Fine Sediment	Runoff, Flood Discharge, Scour Potential	FishEye Suitability (via Riparian Function, Fine Sediment, and Scour Potential), Puget Suitability and Spawning Capacity (via Seral Stage), Survival (via Fine Sediment)

Table D-3. New riparian function scores assigned to reaches that were protected or restored. If the existing score was naturally poor, the score did not change. If the existing score was already the highest possible, there was no change. Changes occurred in the poor and fair categories. Generally, protect actions increased scores by one level and restore actions increased scores to the highest potential where possible. The amount to which a score could be elevated depended on local conditions such as bankfull width, stream gradient, and existing percent of trees that are coniferous or deciduous; these are the same constraints used in the riparian function models used to create scores for current conditions.

Existing	Shade		Pool-forming conifers		LWD recruitment	
	Protect	**Restore**	**Protect**	**Restore**	**Protect**	**Restore**
naturally poor (0)	nat. poor	nat. poor	nat. poor	nat. poor	nat. poor	nat. poor
poor (1)	fair	good	fair	good	fair	good
fair (2)	good	good	good	good	good	good
good (3)	good	good	good	good	good	good
Exceptions	none		- ≤30% coniferous trees *or* - ≥40m bankfull width *or* - gradient >0.04 *or* - (gradient 0.02-0.04 *and* bankfull width 20-40m)		- >70% deciduous trees *and* ≥20m bankfull width	
Score for exceptions	n/a		naturally poor		fair	

Table D-4. New seral stage codes assigned to reaches that were protected or restored. Cottonwood-dominated areas were reaches designated as falling in floodplains or having Rosgen ratings of C; all other reaches were designated as conifer-dominated areas. Codes in bold represent changes; those in parentheses do not change. Naturally non-forested areas cannot change.

Existing	Protect		Restore	
	Cottonwood-dominated areas	**Conifer-dominated areas**	**Cottonwood-dominated areas**	**Conifer-dominated areas**
L (late seral conifer)	(L)	(L)	(L)	(L)
M (mid seral conifer)	(M)	**L**	(M)	**L**
E (early seral conifer)	**MIX**	**M**	**MIX**	**L**
MIX (mixed con/dec)	**D**	**E**	**D**	**E**
D (deciduous-dom.)	(D)	**MIX**	(D)	**MIX**
O (non-forested)	**D**	**E**	**MIX**	**E**

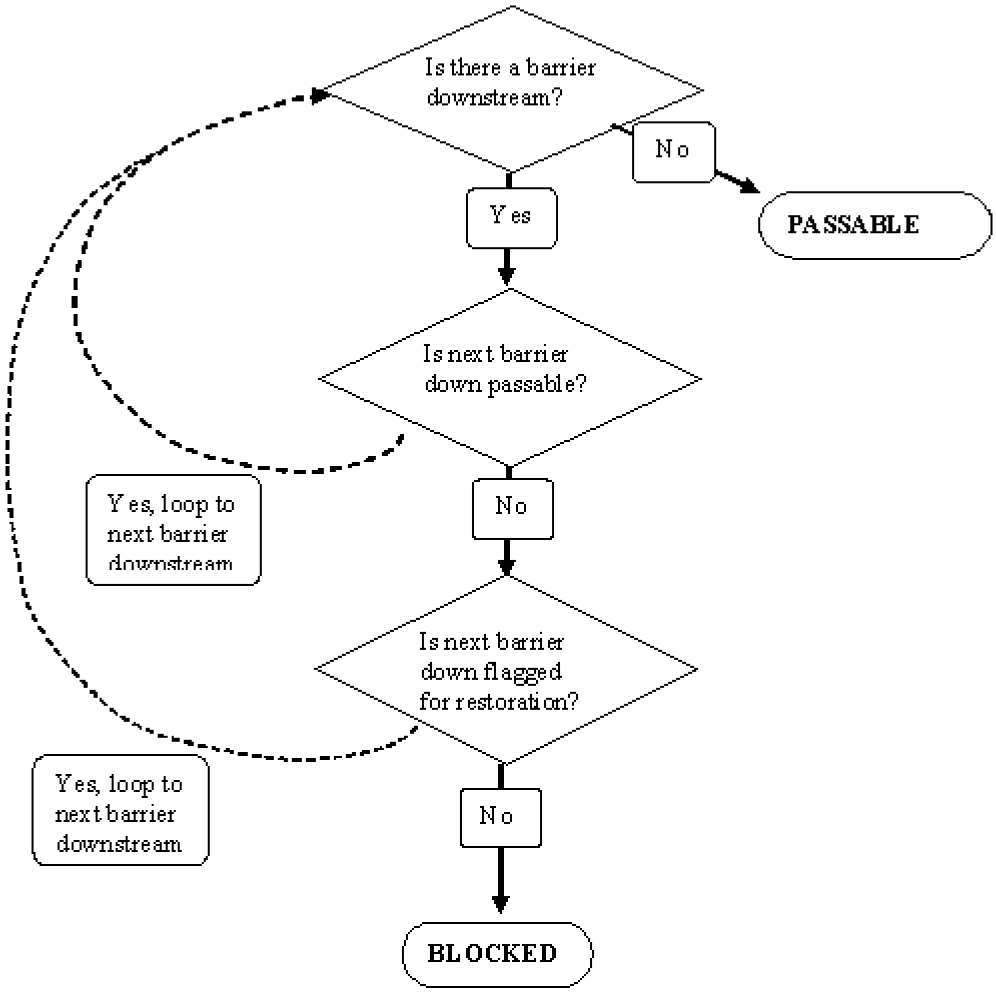

Figure D-1. Effect of barrier removals on accessibility of reaches to fish. After this barrier update procedure was completed, stream reaches were coded as currently accessible to fishes if all barriers in a reach were considered passable. Only reaches that were historically accessible to a given species were candidates for becoming accessible to that species.