Limiting Factors Assessment
and Restoration Plan

Elkhorn Creek

A Tributary to Beaver Creek in the Beaver Creek Basin
(Ona Beach)

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Introduction

This document provides watershed restoration actions proposed to enhance the Coho Salmon population within the Elkhorn Creek sub-watershed in Lincoln County, Oregon. Elkhorn Creek is a 4th order contributor to Beaver Creek, which enters the Pacific Ocean at Ona Beach, located eight miles south of Newport City. The stream contributes to the Beaver Creek Marsh, a large and relatively undisturbed Oregon coast wetland that provides rearing habitat for multiple salmonid species, as well as resident and migratory birds and other wetland species. The wetland receives flow from several Beaver Cr tributaries that flow through the confinement created by the construction of the Hwy 101 bridge crossing. This crossing has influenced the successional trajectory of the Beaver Cr Marsh and expanded its influence on adjacent lowland habitats (spruce forest).

The goal of the restoration effort is to identify the dominant processes and habitat characteristics that currently limit the production of Coho salmon smolts in the watershed, and to develop a prioritized list of actions ("prescriptions") for removing the limitations in ways that help normalize landscape and stream channel function.

Central to this goal is the identification of Coho "Core Areas" and "Anchor Sites", which are sections of the stream channel that support the remnant Coho population. By Core Area we mean a contiguous section of stream channel or channel system where juveniles rear on a consistent (year to year) basis. The term Anchor Site is used to specify a portion of the Core Area which provides all essential habitat features necessary to support the complete Coho freshwater life history.

For a more detailed description of these concepts as well as the restoration, assessment, and prioritization protocols used in developing the plan, please refer to "*Midcoast Limiting Factors Analysis, A Method for Assessing 6th field subbasins for Restoration*". This document is available at www.midcoastwatershedscouncil.org/GIS or by contacting the Midcoast Watersheds Council.

The following questions exemplify the types of issues addressed in the assessment process.
How well and in what mode is the current system functioning for Coho production (what part does each of the habitat subdivisions play)
What temperature problems are apparent?
Where are temperature refugia located?
Where are the barriers?
What are the sediment issues in the system?
Where are the spawning areas, and how are they integrated with the summer and winter rearing sites?
What needs to be done to make the Core habitat function for all life phases, and to function at a higher level?
What work should be done in each area to facilitate a more completely functional whole?
What is the best upslope work that supports the instream work?
How are the fish currently using the system?
What problems are generated by the current habitat configuration (e.g., temperature dependant movements that expose juveniles to predation)
How and when are the greatest losses generated to the population?
Within the Core habitat, what are the dominant limiting factors?
Within the 6th field, what are the dominant limiting factors?
Within the 4th field, what are the dominant limiting factors?
Does the presence or absence of adequate winter habitat outside the spatial boundaries of the 6th field suggest or preclude the need for expanding the quantity or quality of winter habitat?

Resources used in developing the plan

The following resources were used in preparing the restoration plan:

- Aquatic habitat inventories: Elkhorn Creek was surveyed by the United States Forest Service in 1994.

- Summer snorkel surveys: These "Rapid Bio Assay" fish inventories identify the species, age class, density and distribution of salmonids in pools based on fish counts made in randomly selected pools of a stream reach. Elkhorn Creek was surveyed by Bio-Surveys on July 7, 1999.
- Field assessment: This identifies the location and functionality of the sub-watershed's Core Area and Anchor Site(s). The field assessment of Elkhorn Creek was conducted on June 3, 2005.
- Oregon Department of Forestry slide assessment mapping: This procedure evaluates failure-prone headwater slopes as potential sources of wood and substrate to the aquatic corridor. The evaluations help identify Critical Recruitment Areas within the sub-watershed.
- Habitat Limiting Factor Model (HLFM): This analytical model, also referred to as the Nickleson Model, evaluates estimates of spawning gravel, egg deposition rates, and abundance of aquatic habitat to identify which seasonal habitat, and thus which Coho life stage, currently limits smolt production within a watershed. The model is described in ODFW Information Report 98-4.

Watershed overview

The Elkhorn Creek sub-watershed is a 1,350 hectare drainage that lies on the west face of the Oregon Coastal Mountain range. The stream originates at about 1,250 ft elevation, and flows west to become a major contributor to Beaver Creek at approximately RM 6.

The drainage pattern is generally pinnate and simple, most tributaries flowing through short, steep, narrow valleys. The primary exception to this is Tributary H, the largest tributary drainage and flow contributor (50%). Tributary H is a north-facing dendritic drainage located midway on the mainstem corridor. This drainage, along with those of N Fork Elkhorn Creek #2[1], and Tributary G comprise the only valley morphologies outside the mainstem able to provide significant Coho rearing habitat.

Near the stream mouth, the mainstem valley is narrow (100 to 330 ft) and flat-floored, with a very low gradient. Above RM 0.5, the valley narrows providing floodplains less than 100 ft. The gradient increases slowly upstream, reaching 8% near RM 4.

Substrates of both channel bottom and banks are almost entirely sand and silt dominated throughout the system. The quality and location of limited gravel deposits are therefore critical factors in Coho production. Substrate cover is extremely limited.

The 1994 habitat survey defined four reaches up to RM 4.9. Transition points are at RM 0.5 (narrowing valley floor and change from agricultural to non-agricultural land use), RM 1.5 (increasing gradient and change from trench pool to pool:riffle aquatic habitat structure), and RM 2.5 (flow increase due to Tributary H).

All aspects of terrestrial and aquatic habitat within these reaches have been severely impacted by decades of clearcut harvest, debris torrent flows, homesteading, livestock grazing, and rural residential use. These impacts are observable in reduced hillslope and riparian wood resources, accumulations of soft sediments low in the system, entrenched, simplified stream channels, and reduced beaver activity. These effects are progressively evident downstream, where the stream channel is deeply entrenched (up to 10 ft vertical channel walls) in a soft, alluvial plain. Channel conditions of this kind favor the development of pasture trench pools inhabited by aquatic vegetation, which provide good summer but only moderate winter rearing habitat for Coho.

Although the majority of the stream lies within the Siuslaw National Forest, multiple private parcels exist. Most of this private ownership lies within Reach 1, where livestock grazing continues to prevent riparian regeneration. Above Reach 1, the riparian zone is recovering from harvest, but this is primarily naturally generated alder. The potential for recruitment of coniferous LWD to the stream channel is therefore extremely low throughout and above the rearing system.

[1] USGS quad maps identify two tributaries as "N Fork Elkhorn Creek".

A major consideration in evaluating the Coho rearing capacity of the Elkhorn Creek sub-watershed is its functional relation to the Beaver Creek Marsh and other watersheds that drain to this wetland. Of principle interest in this respect are the North Fork Beaver Creek and South Fork Beaver Creek sub-watersheds. The position is taken in this assessment that aquatic habitats within all three drainages combine with the marsh to form an integrated rearing system, and that Coho are likely to move about within this system to find favorable conditions during both summer low flows and winter high flows. This possibility specifically suggests that attempts to identify the limiting seasonal habitat of one of the sub-watersheds must consider the wetland as a common rearing system used by fish produced within all of the sub-watersheds.

Current status of Coho

The status of Oregon Coast Natural (OCN) Coho has been well documented in the Beaver Cr basin as a whole by ODFW's Stratified Random Sampling Program for adult spawners. In addition, the Midcoast Watershed Council has conducted one year of Rapid Bio-Assessment Inventory for an estimate of the summer standing crop of juvenile Coho. The adult data gives us a sense of the basin wide trends in abundance and the juvenile data gives us a snapshot of how Elkhorn Cr. performed in relation to the 5^{th} field for the single inventoried year, 1999.

A 15 year review of basin wide trends in Beaver Cr indicates that adult escapement hovered at very low levels from 1990 to 1998 exhibiting a range of estimated escapement (ODFW) between 23 and 1,340. During the productive ocean conditions observed between 2001 and 2004 escapement increased radically to vacillate between 5,000 and 9,000 adult Coho. This adult estimate is a combined assessment of Beaver Cr and Rock Cr of Devils Lake and does not represent the Beaver Cr basin alone. This ODFW analysis of combined watersheds is utilized to add statistical power to adult estimates that are the result of a small sample size.

The status of Oregon Coast Natural (OCN) Coho in the Elkhorn 6^{th} field was reviewed in 1999 by the Midcoast Watershed Council using the Rapid Bio-Assessment snorkel inventory. This survey observed only minor escapement (approximately 18 adults back calculated from the abundance of summer parr) in an abbreviated distribution that extended only 2.4 miles in the mainstem. The total expanded juvenile population for the 6^{th} field subbasin in 1999 was 1,944 (this figure utilizes a 20% expansion for visual bias associated with the snorkel methodology). This was only 5% of the total of all summer parr observed for the Beaver Cr basin that included NF Beaver and Elkhorn Cr. during the summer of 1999. The 1998 adult estimate for the whole Beaver Cr basin utilizing the RBA estimate of summer parr to back calculate adults was 325. The ODFW estimate for the combined complex of Rock Cr (Devils Lake) and Beaver Cr for 1998 was 1,041. The RBA estimate of adult Coho escapement for the Devils Lake basin in 1998 was 99 (back calculation from the abundance of summer parr). The ODFW adult estimate for the 1998 brood year may significantly overestimate (146%) adult escapement to the Beaver Cr / Devils Lake complex when compared to actual juvenile abundance.

The abundance of juvenile Coho during the summer of 1999 was the lowest on record for many mid Oregon Coast streams. The back calculated adult estimates from summer parr abundance probably underestimates the actual adult escapement to the Beaver Cr basin as a whole because the juvenile inventories did not completely bracket summer distribution and its certain that some level of spring fry migration to adjacent lowland habitats occurred. This spring fry migration would result in the unquantified rearing of summer parr in the lower Beaver Cr mainstem and its associated marsh and wetland habitats.

Limiting seasonal habitat analysis

Using the Nickelson model

A primary goal of the assessment process is to identify which seasonal habitat most restricts smolt production. Restoration work then focuses on improving those aquatic, riparian, and upslope conditions that contribute to the restriction.

A principle, but not the only, tool used to identify the limiting seasonal habitat is the Nickelson Model. The analysis requires estimates of the amount of Coho spawning gravel in the sub watershed, and the amount of each type of pool, riffle, glide, and rapid habitat present during each season of the year.

The Assessment phase of the current study supplies estimates of spawning gravel, while previously conducted habitat inventories provide habitat data. Most of the habitat inventories have been conducted by ODFW. USFS, BLM and occasionally private landowners and watershed councils also commission inventories.

Model limitations

Several factors can limit the usefulness of this analysis:

- Typically, only summer data are available. Winter, and spring inventories are almost never conducted.
- Habitat inventories may be lacking altogether within a sub watershed, or may miss important Coho-bearing reaches.
- Inventory protocols often vary among agencies (e.g., trench pools may be identified in one survey, but not in another).
- Variable surveyor experience and point of view can generate variable data sets (e.g., one surveyor may see a glide where another sees a pool tail out).
- Habitat conditions can change year to year, sometimes dramatically. High water years can change habitat structures. Beaver can move into or out of a drainage, or be removed for management purposes. Slope failures, natural timber recruitment, logging and similar events can introduce large amounts of soil and wood into a channel.
- The model relies on a highly simplified view of the Coho life cycle and the forces that control season to season survival.
- Model results depend heavily on assumptions made about season to season survival rates, and these rates are both evasive and debatable.

We attempt to address these problems in the following ways:

- To estimate winter rearing capacity, we use an empirical polynomial regression equation provided by ODFW that predicts smolt rearing density based on summer inventory data describing channel gradient, % pools, number of beaver ponds, active channel width, and reach length.
- The spring season is ignored in the analysis.
- Where possible, we approximate missing reach habitat data with information collected in nearby reaches, or with habitat sub samples collected during RBA surveys.
- We run the model using two sets of survival rates. One set is provided in ODFW Information Report 98-4, and the other set is based on the unpublished data of James Hall at Oregon State University. The two sets of rates vary in their assumptions about survival, and thus provide outputs that express alternative views of seasonal rearing potentials. More specifically, the ODFW survival rates are higher than those of the OSU study because they assume that only density independent mortalities occur, while the OSU rates are based on population studies where all forms of mortality occurred.

Combining model results with other resources

Clearly, the model's output should be seen as just one guideline in a decision making process that necessarily relies heavily on the professional judgment of the biologists conducting the assessment as other information is reviewed.

As part of this process, summer habitat conditions and distribution (based on habitat inventories) are compared to the summer distribution of juvenile Coho (RBA surveys). This comparison shows how the fish respond to physical habitat variables, and is generally very informative.

Some very important habitat conditions which are not adequately evaluated during physical habitat surveys must also be considered. These include sediment loading and elevated summer temperature. Information on these topics is generally sparse, and usually must be augmented by observations made during the Limiting Factors field assessment. A typical examination of elevated temperature effects would review the few temperature measurements provided by survey crews and possibly some DEQ temperature monitoring records, consider the sources and locations of cold water inputs, and assess the level of shading provided by the riparian canopy.

The assessment process therefore is not a fixed methodology that relies strictly on data tabulation and model outputs. Rather, it is an informed use of diverse and incomplete resources that change from system to system.

Data sources

Field assessment

Migration barriers

There have been four barriers to adult migration identified in the Elkhorn 6th field. At least two of these barriers are currently classified as ephemeral and the result of natural accumulations of woody debris. In addition, there are several ephemeral barriers to the potential upstream temperature dependant migrations of juvenile salmonids.

1) On the mainstem at RM 3.4 is a steep (6%) and narrow gorge with boulder cascades and remnant debris torrent jams. The zone contains many 3ft pours and there were no Coho observed above this point in either of the inventories conducted in 1994 or 2005. Surveyors have consistently described this gorge as passable to adult Coho and not a definitive barrier. In addition, the 1979 survey by Marston and Demming documented juvenile Coho rearing above the location of this gorge.

2) On the mainstem a definitive natural barrier to adult migration exists at RM 4.8 at the site of a 3 tiered bedrock falls with 4ft, 3ft and 2 ft vertical drops stacked on top of each other.

3) Tributary G exhibits a definitive adult barrier at its confluence with mainstem Elkhorn that is caused by an impassable concrete culvert underneath an abandoned forest road.

4) Tributary H exhibits an ephemeral barrier at a natural cascade that has accumulated a woody debris jam approximately 300 ft above its confluence with Elkhorn Cr.

Temperature issues

No temperature limitations were apparent in the mainstem above RM 0.75 with a summer high of 57 deg documented in the 1994 AQHI. This inventory however, did not collect values for mainstem Elkhorn in Reach 1 (pasture trench) and it is probable that temperatures exceed 57 deg in this lower mainstem zone of increased solar exposure. Juvenile distribution patterns support this conclusion and suggest that there may be a temperature barrier developing below RM 0.4 (appendix 6). Juvenile Coho densities continually decline below RM 0.4.

In addition, Temperatures collected in mainstem Beaver Cr in 1994 at the confluence of Elkhorn Cr. recorded sustained daily maximums that exceeded the 64deg threshold for salmonids for 37 consecutive days between July 14 and August 20. There were large diurnal fluctuations ranging from 4-7 deg F that helped mitigate the condition for salmonids but the lower mainstem of Elkhorn is exposed and susceptible to solar radiation.

Aquatic habitats overview

Core Area

Describe the Core Area and its location.

The Core area describes the potential summer distribution of Coho within the 6th field. The last documentation of juvenile distribution was conducted in a 1999 RBA snorkel Inventory conducted by Bio-Surveys. During that survey, Coho utilized only 2.4 miles of mainstem Elkhorn Cr to a point 1,730 ft upstream of the confluence of Trib H. There was no definitive adult barrier identified at this terminus, only a zone of gorge habitat with increased gradient (6%). The 1998 brood year that produced this summer distribution was one of the lowest coast wide adult escapements for Coho on record. Historical observations of juvenile Coho above this point (Marston and Demming, 1979) suggests that the Core actually extends to a bedrock falls at RM 4.1 In addition, Coho have been observed as high as RM 0.2 in the NF Elkhorn #2 and RM 0.1 in Trib H. The end of distribution in Trib H is an ephemeral log jam barrier in a narrow gorge and consequently the Core area extends to RM 0.7 in Trib H and to RM 0.3 in Trib 1 of Trib H.

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

Gravel abundance was limited with only 235 sq. meters of mixed quality gravels observed in 2005 throughout the Elkhorn 6th field. The 1994 AQHI inventory conducted by the USFS documented only 84 sq. meters of high quality spawning gravel within the 6th field. Gravels of marginal or lower quality were not quantified within this inventory. The inventory of gravel quality conducted in 2005 by Bio-Surveys documents 147 sq. meters of high quality spawning gravel. The highest abundances of high quality gravel were located in reaches 2 and 3 from approximately NF Elkhorn #1 to the confluence of Trib H. This zone contained 57% of the total available spawning gravel.

Supplemental spawning gravel data was also available from the Lincoln Co. SWCD for the 2002 brood year. Their total spawning gravel inventory for reach 2 and 3 of mainstem Elkhorn ranged from 94 – 132 sq. meters in 3 separate inventories. This value is very similar to the quantity observed by Bio-Surveys for the same two reaches in 2005 (134 sq. meters).

The intent of this limiting factors analysis is to continually test the hypothesis that a certain life history stage limits smolt production. Therefore our approach for the incubation component of that life history is to develop robust estimates of potential spawning gravels while asking the question, even at this robust assessment of gravel abundance, could the availability of gravel potentially limit smolt production.

Juvenile distribution patterns suggest that 30% of the spawning gravels observed in the Elkhorn 6th field are currently not being utilized by adult Coho even during moderate adult escapement years (No Coho were observed above RM 2.4 in the 2005 inventory). This may influence current production capacity but the modeling developed in this analysis will include its full future potential.

Summer juvenile distribution

Describe the summer distribution of Coho juveniles. Include a description of the resources used.

There has been only 1 year of summer juvenile snorkel survey completed for the Elkhorn Cr 6th field (1999). This survey included the full extent of juvenile Coho distribution within the mainstem and all of its tributaries. During brood years of low adult abundance (1998) juvenile distribution may have been truncated within the 6th field. Spawning and rearing was occurring only in mainstem Elkhorn and a few hundred feet of Trib H.

There were no sites within this limited distribution that exhibited rearing densities that approached the capacity of the available habitats. There was however some indication near the confluence of mainstem Beaver Cr that distribution may be affected by the existence of elevated stream temperatures. This response is portrayed in the distribution graphic included as appendix 6. Rearing densities increase at approximately the confluence of Trib A at RM0.35. This is the zone that transitions into a forest canopy. In addition, the decline towards the mouth indicates that no upstream temperature dependant migration from the mainstem of Beaver Cr is likely to be occurring.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Summer cover for juvenile salmonids is often expressed in quantitative inventories as the abundance of woody debris that provides the foundation for complex cover. LWD densities for mainstem Elkhorn Cr as portrayed in the 1994 USFS inventory are extremely low in reaches 1, 2 and 3 at 6-10 pieces / mile of both large and small wood. In reach 4, above the confluence of Trib H, wood densities increase substantially to 55 pieces of wood/mile >24" dia. Even though the lower reaches lack any substantial key log structure to provide a foundation for trapping transient woody debris the abundance of wood stored in debris flow jams in reach 4 is substantial. Each of the 5 documented full spanning debris flow jams was retaining large amounts of transient canopy litter and mobile substrate. Only 1,700 ft of Reach 4 has exhibited rearing summer Coho parr in both 1999 and 2005.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Only 39 % of the mainstem of Elkhorn Cr. (1.85 miles) exhibits the fundamental channel morphology that provides high quality winter habitat (cover) in the form of low velocity pool surface area that interacts with low floodplain terraces. In addition, the densities of LWD for providing channel roughness and aquatic cover on these interactive terraces is extremely low in these primary production zones for Coho. These zones of functional morphology exist in three locations.
1) Site 1 is classified as low gradient pasture trench pool habitat that extends from the mouth to RM 0.8.
2) Site 2 has been termed Anchor Site #1 (0.75 miles).
3) Site 3 is the low gradient headwater beaver flat a RM 3.3 Classified as Anchor Site #2 (0.3 miles).

The remainder of the mainstem corridor (2.9 miles) displays channel morphologies that provide very limited winter cover potential. Channel conditions vary from narrow gorge habitats with bedrock dominated substrates and a debris torrent legacy to steep cascade habitats with large boulder / cobble substrates.

There is an abundance of winter habitat outside the 6th field that is easily accessible to downstream migrants that will be discussed in depth in the *Lowland Habitats* section of this document.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction..

There are several progressions of channel form as you proceed upstream on the Elkhorn mainstem. These are listed below with their associated attributes.

Pasture Trench: <1% gradient, sinuous, deep entrenchment, no floodplain interaction, 0.8 miles
Broad active channel: 2% gradient, sinuous, highly interactive floodplain, 0.75 miles
Gorge reach: 3% gradient, no sinuosity, no floodplain interaction, narrow VWI, 1mile
Cascade: 4% gradient, no sinuosity, no floodplain interaction, narrow VWI, 0.3 miles
Beaver flat: <1% gradient, highly interactive floodplain, broad floodplain valley, 0.3 miles

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

Within the Elkhorn mainstem channel types described above, there are only 3 channel types that could develop the complex attributes of meander, braiding and backwater. These are the pasture trench, the broad active channel and the beaver flat designations. Each of these sites exhibits the potential for increasing the abundance of these complex characteristics. The beaver flat designation is a low priority for restoration because the current conditions provide the highest quality attributes of complexity naturally through impoundment. The pasture trench habitats are also lower priority because deep entrenchment by definition trends towards simplification of the channel and not the development of complex characteristics. However, in lower Elkhorn, there is currently extensive sinuosity and natural channel meander because the pasture trenches have never been manipulated to facilitate agriculture. The third channel form exhibiting by far the greatest potential for restoration is the 0.75 miles of broad active channel in Anchor Site #1. Because of the low floodplain terraces this section exhibits exceptional potential for the development of interactive backwater habitats, side channel development and increased sinuosity.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

For stream reaches 1-3, the primary limitation is the lack of wood complexity within the active channel that functions as a catalyst for the development of habitat diversity. Secondarily, morphological characteristics in reaches 1 and 3 also limit the development of channel complexity. These are deep entrenchment in reach 1 and a narrow VWI (Valley Width Index) in reach 3. Wood placement in reaches 1 and 3 would have a reduced impact on the development of channel complexity when compared to the observed response of wood placement in reach 2.

Reach 4 currently contains good densities of instream LWD and therefore its complexity is limited more specifically by morphological characteristics. The reach is dominated by a steep gradient and a narrow VWI with no potential for the development of off channel habitat characteristics. There is a divergence from this condition within the reach that begins at approximately RM 3.3 at the confluence of Trib J on the left. At this point a broad, low gradient terrace exists that extends for approximately 0.3 miles. This flat has an extended legacy of beaver colonization and exhibits premier complex aquatic habitats.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

In general, limitations to the development of channel complexity that are morphological in origin have reduced potential for restoration. This does not suggest that restoration will not be beneficial but that an analysis of cost / benefit would describe restoration efforts in these locations as less effective if monitored for results. With that said, the limitations documented for reach 2, low aquatic wood densities, is the limitation and the location, with the greatest potential of generating quantifiable results from a restoration prescription.

Increasing wood densities in reach 1 could have some long term impact on floodplain interaction if the wood placement consisted of well anchored full spanning structures designed to lift the entrenched active channel up to achieve floodplain connectivity. This prescription could have an impact on the adjacent terrace of small private ownerships.

Increasing wood densities in reach 3 also could have some long term beneficial impact for habitat complexity. This benefit would exist primarily in edge oriented micro habitats of low velocity, some summer and winter cover for juvenile salmonids and some minor increase in the storage of mobile substrates (gravels) on channels currently scoured to bedrock.

Anchor Site 1

Location and length

Anchor site #1 begins at approximately RM 0.75, just upstream of the confluence of NF Elkhorn #2. The anchor then extends 0.75 miles to approximately the confluence of Trib D. At the upper end of the anchor is a definitive restriction in the Valley width that defines the transition to reach 3.

Sinuosity

The anchor has a moderate amount of sinuosity (1.1) and exhibits potential for increasing this attribute with the addition of large wood complexity. It is significant that the low interactive terrace within the anchor is approximately 150 ft wide. The terrace is depositional sands and sediments and easily erodible for the development of channel meander and the resultant increase in sinuosity.

Terrace structure

There is a single terrace within the anchor that is approximately 2 ft above the active summer channel elevation. Terraces are very uniform in elevation and composed of depositional substrates. The terrace is currently dominated by an even aged stand of Alder in the 10-20 inch DBH range. There are some large Spruce remaining on the floodplain terrace.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This 3/4 mile segment of Elkhorn contains all of the attributes necessary to complete the Coho life cycle from spawning gravel to winter habitat. The quality of these habitats is compromised by the low wood abundance and sediment deposition, but the zone can function independently to provide year round incubation and rearing. The anchor contains 34% of all of the high quality gravel identified in the subbasin and 40% of the total gravel. If these gravels were fully utilized they would be producing approximately 5,058 summer parr. Inventories conducted in 1999 documented a summer parr estimate of only1,620 Coho for the entire 6th field. Unfortunately, the 1999 abundance of juvenile salmonids did not test the anchors carrying capacity because of the lack of adult escapement to the subbasin.

Using the results of the Aquatic Habitat Inventory data available for Elkhorn, it is apparent that reach 2 provides the greatest potential for increasing the abundance of both summer and winter habitat through restoration. This is primarily a function of the underlying channel and floodplain morphologies that exhibit extensive unutilized floodplain surface areas because of the lack of significant wood complexity.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The anchor is limited by the abundance of large key wood pieces that can function to trap and retain the transient deciduous wood component that is abundant within the system.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Within Anchor site #1 the most effective restoration prescription would include the placement of large wood complexes to enhance floodplain connectivity and utilize the rearing potential that exists on low floodplain terraces. These structures would be designed to trap and sort gravel, create deflection and scour and provide complex cover for juvenile salmonids.

2) Removal of the stream side forest rd that parallels a portion of the anchor would reduce the potential of fill failures from plugged cross drains and restore the floodplain meander belt to it's full potential.

Anchor Site 2

Location and length

Anchor Site #2 exists in the headwaters of mainstem Elkhorn at approximately RM 3.3 and extends 0.3 miles upstream. The site is a morphological anomaly that exhibits a broad (200ft) floodplain and a flat gradient (<1%).

Sinuosity

There was no measurable sinuosity within the active channel during the 2005 inventory by Bio-Surveys or during the 1994 inventory conducted by the USFS. This is primarily because the majority of the lineal channel distance is consistently dominated by beaver dams and their associated impoundments. If the beaver community were to abandon the site, there would be extensive sinuosity because of the broad meander belt that exists as floodplain.

Terrace structure

Most beaver impoundments were broad resulting in narrow bands of floodplain terrace near the toe slope. Existing terraces are low (1ft) and uniform in elevation and composition. Narrow terraces contain standing snags from a legacy of high water tables. These snags also indicate the ephemeral pattern of beaver colonization.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

The anchor provides exceptional potential rearing habitat during both summer and winter. 35 % of the pool surface area in reach 4 was >3 ft deep (the highest deep pool ratio in the system) and was contained primarily in a series of 6 active beaver ponds.

This anchor site was not accessed by spawning adults in either 1994 or 2005. The combination of the collapsed log stringer bridge at the junction of Trib H and the debris torrent jams above this Trib confluence have contemporarily frustrated adult escapement. The anchor was rearing juvenile Coho during the 1979 survey by Marston and Demming and natural blockages accumulated after the 1979 surveys are decaying and ephemeral. Most of the spawning gravels documented in reach 4 were observed just above or in association with this anchor site that exhibited the correct gradient for depositing and sorting salmonid gravels.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The site is currently limited only by access. All other high quality attributes are being maintained by an active beaver colony. These are, vast quantities of low velocity impounded habitats for the provision of spring , summer and winter rearing and an accumulation of well sorted spawning gravels.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

The log stringer bridge at the confluence of Trib H from the left was historically a barrier to adult migration. This site is currently not an adult barrier and in fact juvenile Coho were observed rearing above this point in the 2005 inventory. The old bridge crossing does limit the upstream migration of juveniles but temperature dependant upstream migrations are unlikely at this point in the system (2.4 miles above the mouth). No recommendation for alteration is currently appropriate for this location.

The primary factor compromising adult access to Anchor Site #2 is a series of debris jams and associated cascades between the confluence of Trib I and Trib J. These are natural accumulations of harvest legacy wood that are slowly migrating through the mainstem. It appears that these may only be significant barriers at low winter flows or low adult escapement years when adequate spawning locations are targeted before reaching the headwaters.

Anchor site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) Anchor Site #2
2) Anchor Site #1

Restoration potential

Rank the identified anchor sites in terms of restoration potential (1= greatest potential).

1) Anchor Site #1
2) Anchor Site #2

Secondary Branch 1

Location and length

Secondary branch #1 is listed as NF Elkhorn on USGS quads. This analysis has classified the site as NF Elkhorn #2 to distinguish it from the downstream tributary of the same name. The stream enters just below Anchor Site #1 from the north at approximately RM 0.72. the stream is accessible to large anadromous spawners for approximately 700 ft.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

An inventory of available spawning gravel was conducted during the 2005 inventory by Bio-Surveys. There was 30 sq. meters of high quality gravel documented in the tributary. This represents 20 % of all of the high quality gravel within the entire Elkhorn 6th field. The tributaries confluence with the mainstem of Elkhorn is low in the system making this gravel highly accessible regardless of winter flow regime.

This stream was not surveyed during the 1994 USFS Aquatic habitat Inventory. Therefore, no habitat data exists to assess the tributaries summer and winter rearing potential. Professional judgment suggests that the absence of any significant pool habitat reduces the tributaries summer rearing potential to less than could be easily seeded by a single successful redd. In addition, the abundance of low velocity winter habitat is near zero.

Clearly this is an important tributary for high quality spawning gravels to seed the lower mainstem of Elkhorn and Beaver Cr that are pasture trench dominated and devoid of gravels for incubation. In addition, this tributary delivers high quality flow to the mainstem during summer flow regimes for the maintenance of mainstem temperatures.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The stream is limited by its small size for the production of Coho. Low summer flows limit the available pool surface area for rearing. The Tribs most important contributions are its high quality gravels as a terminal spawning destination and its cold water contribution to the mainstem during low summer flows.

Addressing the limitations

The stated limitations are not feasible to address with restoration prescriptions. Any attempt to provide structure for pool development would meet with limited success because of the lack of hydraulic potential for creating scour and transporting mobile wood components.

Secondary Branch 2

Location and length

This secondary branch enters the mainstem at approximately RM2.4. The branch is identified as Trib H in this Assessment and as Trib 14 of the 1994 USFS Inventory. This is a major contributor of flow and extends approximately 0.6miles on the left fork and 0.3 miles on the right fork. The forest rd that has paralleled the mainstem of Elkhorn to the confluence of Trib H, crosses Elkhorn and extends first up the left side of Trib H and then crosses to continue up the right fork of Trib H (Trib 1 of Trib H).

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Trib H was inventoried by Bio-Surveys in 2005. There was 15 sq. meters of spawning gravel identified with 11 sq. meters documented as high quality. There were no juvenile Coho observed above the debris jam / falls that exists 400 ft above its confluence with the mainstem of Elkhorn. This barrier was classified as ephemeral and not a permanent barrier.

Trib H contains a total of 1,090 sq. meters of pool surface area with 36 % of that surface area quantified in beaver pond habitats in 1994. The 2005 inventory also documented abundant beaver ponds in the system (surface area not quantified). This rearing surface area is capable of producing approximately 1,635 summer parr at fully seeded summer densities. In addition the Tributary exhibits excellent winter potential in impounded beaver ponds for approximately 700 pre-smolt Coho (refer to the Limiting Habitat Analysis in appendix 4). The beaver ponds are winter stable and exhibit extensive longevity.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The majority of this spawning and rearing potential is currently inaccessible because of the ephemeral natural jam / falls 400 ft above the confluence of the mainstem of Elkhorn. This is currently the primary limitation to the secondary branches production potential. This is not a definitive permanent barrier and adult passage could be realized on high fall / winter flow events.

There are two additional log stringer bridge crossings (one on Trib H and the other on T1 of Trib H). At this juncture neither of these crossings blocks anadromous migration. There is however, a slight chance that these could develop into unnatural barriers in the future as these structures collapse into the active channel. No prescription is recommended at this time because the contribution of these stringers could emulate naturally recruited wood components.

Addressing the limitations

No recommendations are proposed for addressing the current limitations to production (access).

Secondary branch site rankings

Function

Rank the identified branch sites in terms of current function (1= best).

1) Secondary Branch #2
2) Secondary Branch #1

Restoration potential

Rank the identified branch sites in terms of restoration potential.

1) Secondary Branch #2
2) Secondary Branch #1

Lower mainstem area

Winter habitat potential

Previously reviewed near top of aquatic habitats section. This is the lowest 0.8 miles of pasture trench habitat just above the confluence with the mainstem of Beaver Cr.

Summer habitat potential

Previously reviewed near top of aquatic habitats section. This is the lowest 0.8 miles of pasture trench habitat just above the confluence with the mainstem of Beaver Cr.

Lowland habitats

Describe lowland habitats and locations outside the 6th field.

Estuarine Marsh Habitat
There is a portion of the Beaver Cr lowlands that is definitively influenced by salt water. We have not attempted to assay the saltwater marsh environments in this assessment except to recognize them as very important winter rearing habitats (when salinities are low) for juvenile salmonids. The salt water marsh exists outside the physical boundaries of the Elkhorn 6^{th} field.

Freshwater Marsh Habitat (Winter Potential)
The vast majority of the Beaver Cr marsh would be classified as fresh water habitat. Because the upstream end of this marsh is only approximately 1.5 miles below the confluence of Elkhorn and NF Beaver, we are considering its habitats easily accessible to juveniles during both summer and winter flow regimes.
To facilitate a limiting factors analysis it was paramount for us test the hypothesis that the abundance of potential winter habitat reasonably accessible to salmonid juveniles during winter flow regimes could be limiting. It is important to understand that a very conservative estimate of winter surface area available in the Beaver Cr marsh was the objective of this analysis. The surface area estimate grossly underestimates the actual winter rearing surface area intentionally. If the abundance of winter habitat is not limiting with this conservative estimate of surface area, we have guarded the analysis from the very real potential of over estimating its true abundance. To calculate this low end surface area estimate of available fresh water marsh habitat, we have measured the circumference of the wetland marsh surface during winter water tables from the confluence of NF Beaver to the crossing of Hwy 101 and assumed a 1 meter wide band of vegetatively complex low velocity habitat for each bank within the pasture trench section and a 4 meter wide band for the flooded pasture / marsh habitats. This resulted in an estimate of 66,948 sq. m of high quality backwater habitat. Again, this is an extremely conservative estimate of rearing potential because it is certain the much greater surface area exist in the flooded marsh for rearing Coho beyond a 4 meter wide edge oriented band.

Freshwater Marsh Habitat (Summer Potential)
This same fresh water habitat also offers extensive summer rearing potential. The obvious concerns for summer habitat are water quality issues (temperature and dissolved oxygen). The information required to assess the physical conditions of the mainstem below the confluence of Elkhorn Cr were not available. In addition, no population distribution data is available because of the poor visibilities in the estuary and lower mainstem that have frustrated snorkel inventory efforts. We can safely assume that density independent (as a life history strategy) and density dependant (as a function of adult abundance) nomadic Coho fry originating from the Elkhorn and NF Beaver Cr 6^{th} fields utilize this lower mainstem and freshwater marsh during summer flow regimes. However, no data exist to quantify their distribution and abundance. For limiting factors purposes we will assume that density dependant downstream summer migrations of older age class parr probably do not occur because of temperature barriers that may exist in the 2.7 miles of mainstem between the confluence of NF Beaver and the head of the Fresh water marsh habitat.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.
The riparian corridor in Reach 1 is uniquely different than the remainder of the surveyed reaches. There is a legacy of livestock grazing that has kept the riparian in an early seral stage of grass and forbs. The lack of vegetative diversity (complexity) within the riparian has caused a failure in the natural process that traps and retains mobile sediments maintaining floodplain connectivity. Because of the lack of advanced seral species such as willow, beaver have been unable to colonize the reach resulting in an active channel that has continued to entrench and simplify.

The riparian corridor above the confluence of NF Elkhorn #2 at RM enters a forested canopy recovering from harvest impacts. It is Alder dominated and maintains a lack of species diversity throughout most of the mainstem.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The 1994 Aquatic Habitat Inventory conducted by the USFS summarizes the riparian recruitment potential as follows; A range of 0.25 – 7 conifers / 100 ft throughout the entire mainstem. The lowest conifer densities exist in Reach 1 and the highest exist in reach 4. These levels are extremely low and the result of a long legacy of homesteading and harvest. The long term potential for the recruitment of large conifer to the aquatic corridor is low from conifers from stream adjacent riparians. There is however very high recruitment potential upslope in the form of debris torrent materials.

The ODF slide risk assessment (appendix 5) indicates that there are many tributaries that exhibit the potential of delivering resources (wood and gravel) directly to the mainstem of Elkhorn throughout the distribution of Coho. Some of the highest potential appears to exist in Tribs C,D,E and F that enter from the south directly above anchor site #1. These tributaries exhibit physical evidence of a torrent legacy and future upslope management strategies should prioritize these streams for the retention of site potential trees in the torrent track and on initiation sites.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The riparian condition is excellent for the provision of shade above the confluence of NF Elkhorn #2. No temperature limitations were apparent in the mainstem above RM 0.75 with a summer high of 57 deg documented in the 1994 AQHI. This inventory however, did not collect values for mainstem Elkhorn in Reach 1 (pasture trench) and it is probable that temperatures exceed 57 deg in this lower mainstem zone of increased solar exposure. Juvenile distribution patterns support this conclusion and suggest that there may be a temperature barrier developing below RM 0.4 (appendix 6). Juvenile Coho densities continually decline below RM 0.4.

In addition, Temperatures collected in mainstem Beaver Cr in 1994 at the confluence of Elkhorn Cr. recorded sustained daily maximums that exceeded the 64deg threshold for salmonids for 37 consecutive days between July 14 and August 20. There were large diurnal fluctuations ranging from 4-7 deg F that helped mitigate the condition for salmonids but the lower mainstem of Elkhorn is exposed and susceptible to solar radiation.

Critical Contributing Areas (CCA)

Description and relation to core site

Identify the CCA's and describe the spatial relationship between each CCA and the Core Area and Anchor Site(s). Identify CCA's that contribute directly to specific Anchor Sites.
There have been 12 separate non fish bearing tributaries identified in the ODF slide risk assessment as potentially critical contributing areas for resource delivery. All of these tributaries have varying potential for delivering directly to the high intrinsic habitat for Coho. Those subbasins ranked from 9-12 in appendix 5 have a much lower chance of delivering resources to the mainstem of Elkhorn. These are the larger subbasins where debris flow run out is unlikely to extend to the mainstem. Those tributaries ranked from 1-8 are smaller upslope drainages with high direct delivery potential. Within this group of potential critical contributing areas, the streams identified in areas 1,4,5 and 7 have the potential of delivering directly into a designated anchor site for Coho. Within this group of priority subbasins, the streams in areas 1 and 7 deliver directly to anchor site #1, which will always be the greatest single producer of Coho smolts because of it location in the basin and its underlying channel morphology that provides the potential for extensive floodplain interaction. Because of this direct delivery potential, the management of the upslope riparian corridors in these CCA's should maximize the retention of mature conifer species within 1 site potential of the torrent corridor and on high risk initiation sites.

Ranking

Rank the CCA's in order of importance to the Core/Anchor Site system. This ranking should consider the contribution of substrate, wood, flow, and temperature maintenance to the Anchor Site system.
Trib H
Trib G
NF Elkhorn #2
Trib F
Trib J
Trib E
Trib D
Trib I

Restoration analysis

Nickelson Model results

Confining the Limiting Habitat Analysis to the Elkhorn subbasin clearly indicates that the abundance of summer pool surface area is the primary habitat limitation to the production of Coho smolts. Both the Nickelson and the Alsea Watershed Studies agree with this conclusion when their varied seasonal survival rates are utilized.

However, because lowland habitats located below the confluence of Elkhorn Creek in the mainstem of Beaver Cr are easily accessible to spring or winter downstream migrants from Elkhorn, it seems appropriate to attempt to model habitat limitations on the 5^{th} field scale (Beaver Cr basin as a whole). To facilitate this analysis we have developed an Excel summary of all of the contributing habitats to entire basin and ran the model to identify the seasonal limitation on the basin scale (appendix 4).

This approach was necessary to determine if the abundance of lowland habitats could limit production given that 3 major 6th fields were contributing juveniles to these same lowland habitats during both summer and winter.

If the lowland habitats (below the confluence of Elkhorn and NF Beaver) are not considered as viable summer rearing habitats because of the known temperature limitations, then the calculations produced by both of the carrying capacity models (Nickelson / Alsea Watershed Study) utilized in this analysis suggest that the abundance of summer habitat continues to limit Coho production when modeled on the basin scale. However, if the lowland habitats are included as viable summer habitats, then we would have to conclude that the abundance of spawning gravel and not summer habitat is the primary limiting factor on the basin scale. The validity of the seasonal limitation being spawning gravel abundance rests on the assumption that these lowland habitats are accessible to both volitional and density dependent spring migrants and that summer temperatures do not prevent effective use of the habitats up to fully functional seeding levels.

Clearly, stream temperatures must remain suitable during summer low flow regimes for juvenile salmonids to successfully utilize these lowland habitats. We have conflicting and incomplete information on temperature effects in the lowland habitats of Beaver Cr:

1) In 2003, a summer snorkel survey in NF Beaver Cr. found high juvenile Coho densities as far downstream as the confluence of Elkhorn Creek. Due to poor visibility, no reliable snorkel observations were made below this point.
2) Extensive temperature monitoring conducted in 1994 at the confluence of Trib B, Elkhorn and Simpson Creeks found that temperatures began to exceed the 64 deg threshold for extended periods somewhere between the confluence of Trib B and Elkhorn Creek.
3) Although excedance of the threshold continued at the lower basin Simpson Cr site, peak temperatures were reduced from those observed higher in the basin.

The majority of the wetland/marsh habitat lies close to the coast and is therefore influenced by both the cool marine air mass and the incursion of marine water. Although fish and temperature data are lacking for this area, we believe that it is highly probable that spring migrants are overcoming the apparent temperature barriers that develop in the pasture trench habitats from Trib B to the head of the wetland / marsh habitat by either passing through early enough (prior to July 15) or by simply spending little time in route to cooler rearing areas.

Please review the results of the basin scale model run in Table F (appendix 4). This provides a numerical estimate of seasonal smolt production without the lowland habitats being factored in as potential summer rearing habitat. Based on this assumption, the Alsea Watershed Study produced summer smolt estimates (17,179) that are close to smolt estimates generated by the available gravel estimates (20,087). Utilizing the Alsea Watershed Study coefficients of survival, the abundance of gravel could easily become the habitat limitation if lowland habitats were effectively providing significant summer rearing potential.

We conclude that the two primary habitat factors controlling the production potential of the Beaver Cr basin and the Elkhorn 6th field in order of importance are, 1) elevated summer mainstem stream temperatures that limit the productivity of summer rearing surface areas and 2) a lack of high quality spawning gravel that begins to function as the seasonal limitation as soon as lowland habitats recover to function as effective summer rearing habitat. We recommend that both of these factors be considered in the development of restoration prescriptions.

Defining the production bottleneck

Does the seasonal bottleneck identified by the Nickelson Model remain the primary limiting habitat when each of the other issues identified in the assessment process are factored in? Explain.

As discussed above, we have factored in the potential influence of mainstem temperatures that exceed DEQ standards for salmonids. This has led to the conclusion that the quality (not the abundance) of summer habitats is the primary seasonal habitat limitation influencing Coho smolt production.

Potential for lowlands contribution

If the abundance of winter habitat has been determined as the primary factor limiting Coho production, discuss how lowland habitats existing outside the boundaries of the 6th field might function to provide winter habitat for smolts produced in the 6th field.

This discussion is not applicable because the abundance of lowland winter habitats exceeds all of the other habitat attributes on the basin scale.

Ownership issues

To what degree would land use and ownership allow restoration work?

Recent acquisitions by the USFS in the Elkhorn subbasin have cleared the path for access for future restoration. On the basin scale issues of solving temperature limitations, there are excellent private property opportunities and willing landowners.

Channel complexity potential

What is the potential to increase channel complexity in the long term through natural recruitment processes, with and without restoration?

Channel complexity becomes an immediate concern for restoration activities in the Elkhorn 6th field because it is that complexity that will support the accumulation and sorting of mobile gravel resources for additional incubation potential. Within the high priority areas for restoration (Anchor Site #1) there is very limited potential for the natural recruitment of coniferous species exhibiting longevity in the active channel. The riparian is alder dominated and not effectively retaining the deciduous component that is being recruited regularly. This is a zone that will benefit greatly from the restoration of channel complexity with LWD from outside the native riparian zone.

Restoration prescriptions

Potential restoration sites

1) Anchor Site #1
2) North side Forest Rd that parallels stream channel
3) Culvert on Trib G
4) Knot weed locations
5) Lower 0.5 miles of private property

Location

1) Anchor site #1 begins at approximately RM 0.75, just upstream of the confluence of NF Elkhorn #2. The anchor then extends 0.75 miles to approximately the confluence of Trib D. At the upper end of the anchor is a definitive restriction in the Valley width that defines the transition to reach 3.

2) The north bank forest rd. that parallels the mainstem of Elkhorn begins at RM 1.0 at the confluence of Trib B and extends upstream 1.4 miles to the confluence of Trib H. The road crosses Elkhorn just above Trib H and continues up the trib H corridor on the east bank.

3) The culvert on Trib G crosses the north bank forest rd at approximately RM 1.9 or 0.9 miles from the beginning of the forest rd.

4) The Knot weed infestation extends from approximately the confluence of NF Elkhorn #1 upstream to the confluence of NF Elkhorn #2. This is a 3,400 ft section of documented presence with some sections exhibiting extensive maturity and abundance.

5) The lower mainstem of Elkhorn from the confluence with Beaver Cr to a point approximately 0.5 miles upstream.

Issue

1) Anchor site #1 (reach 2) exhibits the underlying channel morphology conducive to the development of complex aquatic habitats that interact effectively with off channel floodplain habitats during both summer and winter flow regimes. The anchor however is not currently functioning to its full potential because of the lack of large full spanning wood to initiate floodplain interaction and trap and sort migratory substrates for spawning (a high priority for addressing one of the two probable habitat limitations). The fundamental reason for this limitation is the deciduous dominated riparian condition and the lack of a conifer component that has a greater potential for retention within the active channel during winter flow regimes.

2) The forest road that parallels the mainstem of Elkhorn on the north bank is functioning to confine the active stream channel and promote channel simplification. In addition, inadequate maintenance of the drainage system on this abandoned road bed has a long legacy of triggering fill failures that have transported large volumes of side cast material into the mainstem of Elkhorn Cr. There are currently 8 stream crossings on the rd bed that range from 1^{st} order corridors to 3^{rd} order fish bearing tributaries (Trib G). One culvert has been pulled and 7 remain plugged, collapsing or only partially functional. These crossings are at high risk for initiating additional fill failures.

3) The culvert the crosses the above mentioned forest rd on Trib G is currently terminating anadromous passage to significant spawning substrates identified as a limiting habitat within the Elkhorn 6^{th} field. The pipe is a series of 3 ft concrete culvert sections that have become under mined and collapsed on the downstream side. The pipe is also undersized for the crossing and a high risk site for initiating a large debris flow event.

4) The Knot weed is an invasive plant species that is compromising riparian vegetative function and has developed into the dominant inner riparian canopy within the identified reach. The removal of this species does not directly address a limiting habitat factor, but it would help restore proper function to the riparian and truncate a problem that could get significantly worse within the Beaver Cr basin as a whole.

5) This section is typified by deep channel entrenchment (10 ft), a legacy of extensive livestock grazing, an early seral stage of vegetative development, and Reed Canary Grass. Historical livestock use has reduced riparian vegetative diversity and resulted in the elimination of woody shrub species (Willow, Nine bark). This has led to channel simplification from sloughing banks, deep entrenchment and a lack of deep pool scour.

Goal

1) Restoration activities in Anchor site #1 would target the reconnection of the active channel with its floodplain. This is the one reach within mainstem Elkhorn where restoring this functionality is a realistic goal. Low terraces would eventually exhibit interactive backwater habitats during both winter and summer flow regimes.

2) Addressing the issues on the forest road that parallels the mainstem of Elkhorn would restore historical drainage patterns and prevent cataclysmic road fill failures that are inevitable given the current status of this abandoned road bed.

3) Removal of the failed road culvert on Trib G would provide access for anadromous salmonids to habitat that has been inaccessible since construction of the road. In addition, removal of the artificial crossing could likely prevent a potentially devastating dam break flood event emanating from Trib G.

4) Addressing the Knot weed problem in Elkhorn Cr. reduces the risk of transport of the species into a highly productive wetland / marsh ecosystem downstream. The long term ramifications of allowing this invasive to spread to these downstream habitats is unknown, however, reduction in vegetative diversity is a known consequence with implications for complex invertebrate communities.

5) Initiating the colonization of shrub species to the riparian in this reach would result in improving root mat complexity for bank stability, provide channel roughness that would trap transient wood and result in pool scour and eventually provide shade and cover that would directly address the habitat limitations of high quality summer habitat identified in this analysis.

Method

1) The restoration of floodplain interaction within anchor site #1 would most successfully be completed with the implementation of a large wood placement project utilizing a heavy lift helicopter for implementation. This approach would facilitate the use of large diameter, tree length conifers that would be capable of maintaining a full spanning placement during winter runoff events.

2) The forest road restoration would ideally be a complete decommission that would restore slope contour and remove perched side cast and fill material from unstable stream side platforms. A complete decommission would remove all stream crossings to restore natural drainage patterns and in the case of Trib G, would restore anadromous passage. This would be accomplished with an excavator and potentially a subsoiler.

3) The restoration of natural flow at the road crossing on Trib G is a high priority that should be completed with or without the complete implementation of Item #2 (road decommission). This site is still easily accessible by track excavator and the barrier culvert and associated fill could be efficiently removed and recontoured in a ½ day effort.

4) The restoration effort surrounding the eradication of Knot weed in the Elkhorn subbasin can be labeled as controversial because of the identified methods of treatment. Two primary approaches are currently utilized, manual removal and herbicide treatment. The manual removal is an 8-10 year commitment of replicate effort because of the rhizome sprouting that continues to occur. In addition, success is not guaranteed after this long regime of manual release. The herbicide treatment is a 2 year commitment with the second year virtually guaranteeing elimination of the plant from the site. In the case of Elkhorn, direct application of herbicide to individual stems appears to be the most effective approach that yields the highest opportunity for success. The presence of the high quality wetland ecosystem downstream of this site raises the level of concern and priority for the swift and complete eradication of this species.

5) There are multiple options for addressing the restoration of this zone. Livestock could be excluded permanently from this narrow corridor without ever building a fence by approaching the landowner with a CREP partnership agreement. If grazing continues to be required by the landowner, a fence could be constructed to exclude livestock from the inner riparian only and develop a planting prescription for the buffer behind the fence. The total exclusion option would be the preferred option because its compensation to the landowner would be more significant and likely more attractive and the treatment would be more likely to have a positive long term impact on the condition of the lower Elkhorn mainstem.

Potential complications

1) There are private properties within the confines of identified anchor site #1. Access for a large wood placement project remains to be negotiated.

2) The road is so close to the active channel in multiple locations that additional precautions may be necessary in a decommission strategy to protect water quality and restore vegetative complexity rapidly before the onset of winter rains.

3) No complications to the removal of this culvert have been identified.

4) Controversy over the preferred strategy of herbicide treatment may require extensive local education and participation. The organization of a local partnership committee would be highly recommended.

5) Options for livestock exclusion have not been addressed with the landowner.

Expected results

1) The results of large wood placement would be easily quantifiable in terms of channel complexity and roughness within year 1 from a simple inventory of the woody debris associated with the active stream channel. Floodplain interaction would be quantifiable with a post project Aquatic Habitat Inventory some time after a significant flow event such as occurred in 1996 or 2005.

2) The road decommission would restore upslope drainage patterns and essentially prevent the initiation of future slope failures. In addition, we would expect the active channel of mainstem Elkhorn to regain some of its original floodplain foot print that was utilized to build this road bed. The long term view would include a slight increase in channel meander and accessible floodplain habitats during winter flow.

3) The removal of the culvert at the road crossing on Trib G would restore access to anadromous salmonids to a approximately 0.3 miles of spawning and rearing habitat. This directly addresses a primary habitat limitation for the 6th field.

4) The eradication of invasive Knot weed would protect the long term functionality of habitats downstream of the Elkhorn site that include highly productive wetlands and marshes in lower Beaver Cr.

5) Livestock exclusion and the establishment of later seral stage vegetation would begin to restore the functionality to this portion of Elkhorn that has been locked in a trajectory of channel simplification since early homesteading removed the vegetation for the pursuit of rural agriculture (grazing).

Restoration rankings

From the recommendations listed above, list and rank the restoration work that most effectively stabilizes the population at a higher base level and prioritizes the recovery of ecosystem function.

Short Term (Prioritized)
1 – 3 – 2 – 4 – 5

Long Term (Prioritized)
3 – 4 – 2 –5 – 1

Combined Prioritization
3 – 1 – 2 – 4 – 5

APPENDICES

Appendix 1. Habitat features and survey status of Elkhorn Creek reaches that have Coho bearing potential

Current Reach ID	Stream	Description	River Mile			Survey Resource			Valley Morphology			Aquatic Habitats			
			Beg	End	Len	Type	Year	Surv Rch ID	Grad (%)	Valley Width	Constraint	Pools (%)	Bvr Pnds (#)	Wood (pcs/mi)	
														Total	Key
1	Elkhorn	Agricultural lands, chan dominated by trench pools	0.0	0.5	0.5	USFS	1994	1	1.0	Broad	Terrace	77	1	23	2
2	Elkhorn	Non-agricultural lands, chan dominated by trench pools	0.5	1.5	1.0	USFS	1994	2	2.0	Narrow	Terrace	71	3	44	1
3	Elkhorn	Chan changes to typical pool/riffle structure	1.5	2.5	1.0	USFS	1994	3	3.0	Narrow	Hillslope/ Terrace	42	1	31	4
4	Elkhorn	Above Trib H	2.5	4.9	2.4	USFS	1994	4	4.0	Narrow	Hillslope	50	12	96	23
1	NF Elkhorn #2	(see Appendix 2)	0.0	0.3	0.3				6.2	Narrow	Hillslope				
1	Trib G	(see Appendix 2)	0.0	0.3	0.3	USFS	1994	1	4.0	Narrow	Hillslope	18	0	19	8
1	Trib H	(see Appendix 2)	0.0	0.6	0.6	USFS	1994	1	7.0	Narrow	Hillslope	22	5	48	7
1	Trib H/Trib 1	(see Appendix 2)	0.0	0.3	0.3	USFS	1994	1	5.0	Narrow	Hillslope	25	0	62	2

1) Two tribs on USGS quad maps are identified as "NF Elkhorn". This is the upstream trib, located at RM 0.71.
2) The 1994 survey identified some Trench Pools as Glides. This table combines glides and pools to estimate Pool %.
3) Trib G gradient increases sharply after the first 0.3 mile (R1).

Appendix 2. Elkhorn Creek drainages

Drainage	River Mile	Enters from	Slope faces	Relative size	Valley description	Comments
NF Elkhorn #1	0.2	Left	SW	Small	Flat, broad	Cutthroat potential
Trib A	0.3	Right	NE	Very small	Steep, narrow	Cold contribution, but no Coho potenial
NF Elkhorn #2	0.7	Left	SW	Small	Moderate, moderate	High quality Coho spawning
Trib B	1.0	Left	W	Very small	Steep, narrow	Cold contribution, but no Coho potenial
Trib C	1.1	Right	NE	Very small	Steep, narrow	Limited potential all spp
Trib D	1.4	Right	N	Very small	Steep, narrow	Limited potential all spp
Trib E	1.5	Right	N	Very small	Steep, narrow	Limited potential all spp
Trib F	1.6	Right	N	Very small	Steep, narrow	Limited potential all spp
Trib G	1.9	Left	S	Small	Moderate, moderate	First 0.3 mile provides excellent spawning for Coho and Cutthroat; currently inaccessible
Trib H	2.3	Right	NW	Large	Moderate, moderate	Excellent spawning and rearing for Coho and Cutthroat; narrow gorge complicates access
Trib I	2.7	Left	S	Very small	Steep, narrow	No potential
Trib J	3.1	Left	S	Very small	Steep, narrow	No potential
Trib K	4.0	Left	S	Very small	Steep, narrow	No potential
Trib L	4.2	Right	NW	Very small	Steep, narrow	No potential
Headwaters		N/A*	W	Very small	Steep, narrow	No potential

* Mainstem

Appendix 3. Elkhorn Creek spawning gravel estimates

Stream	Reach	Poor	Fair	Good
Elkhorn Cr	1			
Elkhorn Cr	2	10	33	50
Elkhorn Cr	3		2	39
Elkhorn Cr	4	12	16	1
NF Elkhorn #2	1			30
Trib G	1		8	
Trib H	1		4	11
Trib H 1	1		3	16
Total		**22**	**66**	**147**

Appendix 4. Elkhorn Creek limiting habitat analysis based on the Nickelson model

The following text and tables are extracted from an Excel workbook that implements the Nickelson model. The analysis was performed three times for the purpose of estimating smolt production and identifying the seasonal limiting habitat under varied scenarios:

1) Scenario 1: Elkhorn (6^{th} field): Habitats within Elkhorn Creek subwatershed only are evaluated.
2) Scenario 2: Basin (5^{th} field) without summer lowlands: Habitats within the Elkhorn Creek, S Fk Beaver Creek, and N Fk subwatersheds, as well as winter lowland habitats (i.e., only summer lowland habitats are excluded).
3) Scenario 3: Basin (5^{th} field): All basin habitats are included.

The text and the first set of tables (Tables A and B) are descriptive of the analytic process conducted in each scenario, and therefore are presented just once. Below this are the results of each scenario analysis. Note that the table numbers are repeated for each scenario (Tables C through F appear under each scenario).

GENERAL TEXT AND TABLES

Worksheet function

This sheet accumulates the results of the calculations performed on the other sheets to estimate the number of coho that can be supported by the rearing system under analysis.

The specific goals are to: 1) Estimate the number of coho that can be supported during each season of the year, and 2) Rank the seasonal habitats in terms of their ability to generate "potential smolts"; this identifies which seasonal habitat most limits the production of smolts from the system.

Ideally, this evaluation would utilize spawning gravel data along with habitat data describing spring, summer and winter rearing conditions. However, physical habitat surveys are almost always conducted during the summer. In practical terms, winter and spring survey data are not available.

To accommodate these deficiencies, we use a work-around to estimate winter rearing capacity, and are unable to estimate the spring rearing capacity.

The work-around method for estimating winter rearing capacity utilizes a polynomial regression equation that relates winter rearing capacity to summer habitat conditions. This equation is provided by ODFW research. No such work-around exists for estimating spring capacity, and it is not estimated.

The current evaluation thus aims at determining whether spawning gravel, summer conditions, or winter conditions are most limiting in the rearing system.

The model used to identify the limiting seasonal habitat is "Version 5.0. Coho Salmon Carrying Capacity Model", provided by Tom Nickelson of ODFW Research Division. This model uses season-to-season survival rates to estimate potential smolt production for each seasonal habitat. We have two sets of survival rates, one provided by ODFW research and the other by Jim Hall's Alsea watershed study. We compare model results using both sets of rates.

Results presented

Five tables are presented.:

Table A lists the summer rearing density for each stream habitat type. This table is included to illustrate how strongly reach habitat structure affects rearing capacity.

Table B lists the two sets of survival rates used to evaluate potential smolt production.

Table C lists spawning, summer and winter rearing capacities for each upland stream and lowland habitat.

Table D lists potential smolt production for each upland stream and lowland habitat based on ODFW survival rates.

Table E lists potential smolt production for each upland stream and lowland habitat based on Alsea study survival rates.

Table F lists habitat capacity and potential smolt production for each seasonal habitat. This table comprises the primary product of the analysis.

Table A. Stream summer rearing densities

Table A. Coho rearing density for each summer stream habitat type.

Habitat type	Fish/sq m
Cascades	0.24
Rapids	0.14
Riffles	0.12
Glides	0.77
Trench Pools	1.79
Plunge Pools	1.51
Lateral Scour Pools	1.74
Mid Chan Scour Pools	1.74
Dam Pools	1.84
Alcoves	0.92
Beaver Ponds	1.84
Backwaters	1.18

Data of Tom Nickelson based on ODFW reseach.

Table B. Survival rates to smolt

Table B. Season (life stage) to smolt survival rates.

ODFW Reseach		Alsea study data	
Life stage	Survival rate	Life stage	Survival rate
Egg to smolt	0.3200	Egg to smolt	0.0270
Spring to smolt	0.4600	June to Smolt	0.0644
Summer to smolt	0.7200	Fall to smolt	0.1110
Winter to smolt	0.9000	Winter to smolt	0.2870

Rates used by Tom Nickelson (ODFW) Rates provided by Jim Hall (OSU Dept of F

SCENARIO 1: Elkhorn (6th field).

Table C. Rearing capacities

Table C1. Upland rearing capacities.

Stream ID		Rearing capacity (# eggs or fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	154,583	19,404	35,997
Stream 2	S Fk Beaver			
Stream 3	N Fk Beaver			
Stream 4				
Stream 5				
Stream 6				
	Totals	154,583	19,404	35,997

Table C2. Lowland rearing capacities.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		
Wetland channels		
Flooded wetlands		
Total		

Table D. Potential smolt production based on ODFW survival rates

Table D1. Upland potential smolt production based on ODFW survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	49,467	13,971	32,397
Stream 2	S Fk Beaver			
Stream 3	N Fk Beaver			
Stream 4				
Stream 5				
Stream 6				
	Total	49,467	13,971	32,397

Table D2. Lowland potential smolt production based on ODFW survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		
Wetland channels		
Flooded wetlands		
Total		

Table E. Potential smolt production based on Alsea study survival rates

Table E1. Upland potential smolt production based on Alsea study survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	4,174	2,154	10,331
Stream 2	S Fk Beaver			
Stream 3	N Fk Beaver			
Stream 4				
Stream 5				
Stream 6				
	Total	4,174	2,154	10,331

Table E2. Lowland potential smolt production based on Alsea study survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Total		

Table F. Overall rearing and smolt production capacities.

Table F. Combined upland and lowland rearing capacity and potential smolt production. Smolt production is estimated using both ODFW and Alsea watershed survival rates.

Life stage (season)	Rearing capacity (# fish)	Potential smolt production (# fish)	
		ODFW rates	Alsea rates
Spawning (# eggs)	154,583	49,467	4,174
Spring (# fish)	no data	no data	no data
Summer (# fish)	19,404	13,971	2,154
Winter (# fish)	35,997	32,397	10,331

No estimate of spring capacity or potential smolts produced is possible with current data.

Calculation of Spawning (# eggs) is based on the assumptions of 2500 eggs/redd and 3 m2/redd

SCENARIO 2: Basin (5th field) without summer lowlands

Table C. Rearing capacities

Table C1. Upland rearing capacities.

Stream ID		Rearing capacity (# eggs or fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	154,583	19,404	35,997
Stream 2	S Fk Beaver	59,167	51,871	48,047
Stream 3	N Fk Beaver	530,208	83,493	91,740
Stream 4				
Stream 5				
Stream 6				
	Totals	743,958	154,768	175,784

Table C2. Lowland rearing capacities.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		28,195
Wetland channels		11,974
Flooded wetlands		
Total		40,169

Table D. Potential smolt production based on ODFW survival rates

Table D1. Upland potential smolt production based on ODFW survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	49,467	13,971	32,397
Stream 2	S Fk Beaver	18,933	37,347	43,242
Stream 3	N Fk Beaver	169,667	60,115	82,566
Stream 4				
Stream 5				
Stream 6				
	Total	238,067	111,433	158,205

Table D2. Lowland potential smolt production based on ODFW survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		25,376
Wetland channels		10,776
Flooded wetlands		
Total		36,152

Table E. Potential smolt production based on Alsea study survival rates

Table E1. Upland potential smolt production based on Alsea study survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	4,174	2,154	10,331
Stream 2	S Fk Beaver	1,598	5,758	13,789
Stream 3	N Fk Beaver	14,316	9,268	26,329
Stream 4				
Stream 5				
Stream 6				
	Total	20,087	17,179	50,450

Table E2. Lowland potential smolt production based on Alsea study survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
		8,092
		3,436
Total		11,528

Table F. Overall rearing and smolt production capacities.

Table F. Combined upland and lowland rearing capacity and potential smolt production. Smolt production is estimated using both ODFW and Alsea watershed survival rates.

Life stage (season)	Rearing capacity (# fish)	Potential smolt production (# fish)	
		ODFW rates	Alsea rates
Spawning (# eggs)	743,958	238,067	20,087
Spring (# fish)	no data	no data	no data
Summer (# fish)	154,768	111,433	17,179
Winter (# fish)	215,953	194,357	61,978

No estimate of spring capacity or potential smolts produced is possible with current data.

Calculation of Spawning (# eggs) is based on the assumptions of 2500 eggs/redd and 3 m2/redd

SCENARIO 3: Basin (5th field)

Table C. Rearing capacities

Table C1. Upland rearing capacities.

Stream ID		Rearing capacity (# eggs or fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	154,583	19,404	35,997
Stream 2	S Fk Beaver	59,167	51,871	48,047
Stream 3	N Fk Beaver	530,208	83,493	91,740
Stream 4				
Stream 5				
Stream 6				
	Totals	743,958	154,768	175,784

Table C2. Lowland rearing capacities.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat	15,990	28,195
Wetland channels	22,210	11,974
Flooded wetlands		
Total	38,200	40,169

Table D. Potential smolt production based on ODFW survival rates

Table D1. Upland potential smolt production based on ODFW survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	49,467	13,971	32,397
Stream 2	S Fk Beaver	18,933	37,347	43,242
Stream 3	N Fk Beaver	169,667	60,115	82,566
Stream 4				
Stream 5				
Stream 6				
	Total	238,067	111,433	158,205

Table D2. Lowland potential smolt production based on ODFW survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat	11,513	25,376
Wetland channels	15,991	10,776
Flooded wetlands		
Total	27,504	36,152

Table E. Potential smolt production based on Alsea study survival rates

Table E1. Upland potential smolt production based on Alsea study survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Elkhorn	4,174	2,154	10,331
Stream 2	S Fk Beaver	1,598	5,758	13,789
Stream 3	N Fk Beaver	14,316	9,268	26,329
Stream 4				
Stream 5				
Stream 6				
	Total	20,087	17,179	50,450

Table E2. Lowland potential smolt production based on Alsea study survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
	1,775	8,092
	2,465	3,436
Total	4,240	11,528

Table F. Overall rearing and smolt production capacities.

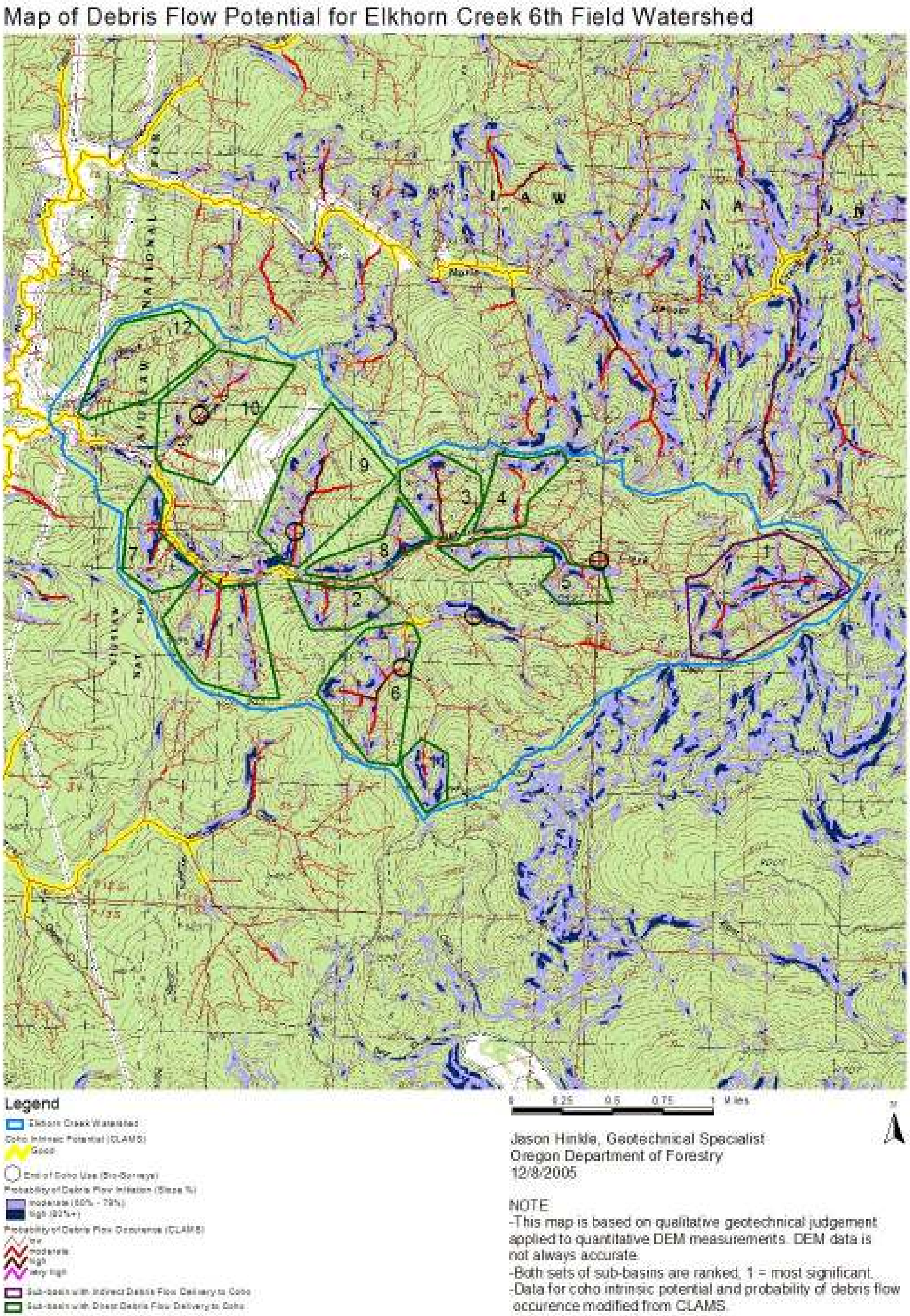
Table F. Combined upland and lowland rearing capacity and potential smolt production. Smolt production is estimated using both ODFW and Alsea watershed survival rates.

Life stage (season)	Rearing capacity (# fish)	Potential smolt production (# fish)	
		ODFW rates	Alsea rates
Spawning (# eggs)	743,958	238,067	20,087
Spring (# fish)	no data	no data	no data
Summer (# fish)	192,968	138,937	21,419
Winter (# fish)	215,953	194,357	61,978

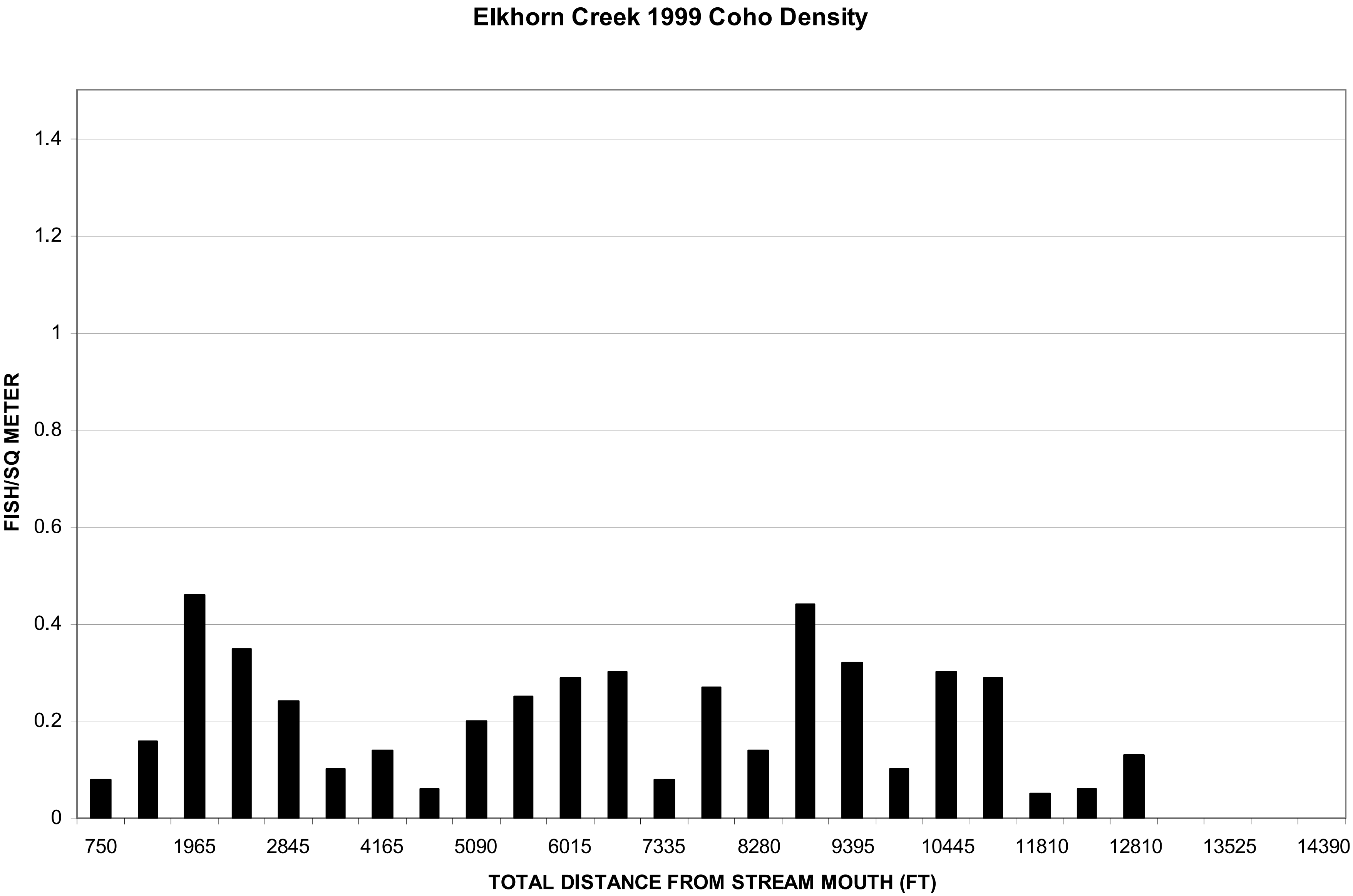
No estimate of spring capacity or potential smolts produced is possible with current data.

Calculation of Spawning (# eggs) is based on the assumptions of 2500 eggs/redd and 3 m2/redd

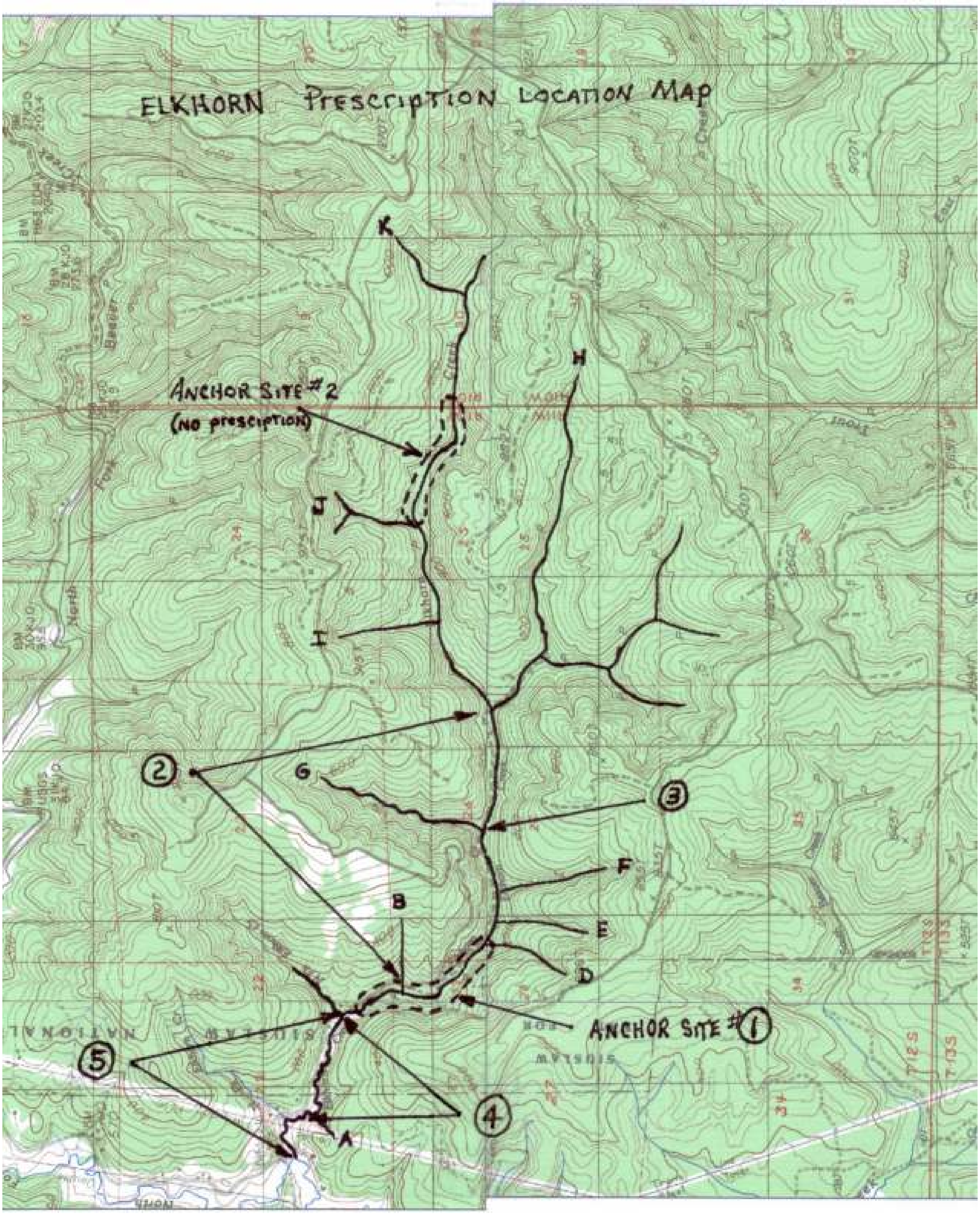
Appendix 5. Elkhorn Creek ODF slope risk analysis map



Appendix 6. Elkhorn Creek summer Coho distribution chart



Appendix 7. Elkhorn Creek prescription location map



Appendix 8. Elkhorn Creek photos

Photo 1. Boulder jam and falls blocking anadromous passage on Trib H.

Photo 2. Channel condition and dimensions for Trib H.

Photo 3. Bedrock falls at end of mainstem Elkhorn Creek.

Photo 4. Channel morphology above Anchor Site #2.

Photo 5. Beaver complex in Anchor Site #2.

Photo 6. Channel condition between Trib H and Trib I.

Photo 7. Channel condition between Trib H and Trib I.

Photo 8. Confluence of Trib H.

Photo 9. Debris torrent jam at current end of Coho distribution.

Photo 10. Channel and riparian condition Anchor Site #1.

Photo 11. Livestock impacts near confluence with mainstem Beaver Creek.

Photo 12. Morphology in Reach 1. Note entrenchment.