A WATERSHED ASSESSMENT FOR THE SIUSLAW BASIN

Siuslaw Basin Council

ecotrust

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INTRODUCTION

Welcome reader, to this assessment of the Siuslaw River Basin of the beautiful central Oregon Coast Mountains. Before you page through the rest of this document, we hope you will take a few moments to read this introduction, in order to gain a clearer picture of what we have hoped to accomplish.

Project Goals

A watershed assessment has been compared to a "health screening" for an individual. In a sense, we are taking the watershed's temperature, blood pressure, and so forth to determine its general condition. We also hope to be able to describe why the watershed is in the condition it is, and to put forth a conceptual program for stabilizing and recovering a more robust health over the long term.

Any large scale watershed assessment has inherent limitations, and this one is no exception. Watershed assessment is a very young activity, having only been used in our region for the past ten or so years. Knowledge about the best way to restore watersheds to health is also sketchy. The field of restoration ecology is only about 20 years old, and the application of restoration is usually done at the scale of a few acres, not 500,000. The information available to work with is never complete. Some of the information may be only approximately right, or out of date. And we may not fully understand what the information is telling us in any case. Our work on this assessment certainly has been faced with all of the above issues.

This part of the Upper Siuslaw has fairly mature riparian forest

The Siuslaw basin is a large and complex watershed, with a long history and story. We cannot hope to learn or know everything about it. Even if we did know everything, we would find it impossible to transfer all of this knowledge to the reader in a digestible format. In fact, most of this basin has already been assessed by Forest Service, Bureau of Land Management, and in one case Weyerhaeuser teams. Since 1995, these teams have developed independent assessments for; the Upper Siuslaw, Wolf Creek, Wildcat Creek, Lake Creek, Deadwood and Indian Creeks, the North Fork, and the Lower Siuslaw River. These assessments have a great deal of information on the aquatic ecosystem, as well as uplands.

We encourage the reader of this assessment who is interested in learning more to read these other documents. Several are available via BLM's Eugene district web site. Most are available in hard copy from the Siuslaw Council office in Mapleton, or at local BLM and Forest Service offices. The Weyerhaeuser assessment is available at their corporate office in Springfield.

An independent assessment of the entire Siuslaw basin was recently developed by the Coast Range Association of Corvallis, Oregon. This project did a good job of summarizing stream habitat survey information, and is available on that organization's web site (Willer). The only part of the Siuslaw Basin that has not been assessed to date is the estuary.

There have been significant advances in the study of stream and watershed ecology over the past twenty years. We have attempted to apply these to this assessment wherever we could. Among the key concepts we have employed are:

-Stream Continuum Theory, which posits that in order to understand the condition of a stream, all the processes from ridge tops to the mouth of the river need to be considered. Restoring fish populations means considering the entire chain of habitats, from headwaters to the ocean and back, required for the life histories of the species.

-The condition of streams reflects the condition of the surrounding landscape. Thus they cannot be understood or "fixed" independently. Nor can the focus be only on parts of the landscape, or restricted to public lands. Aquatic habitats are the result of landscape scale processes.

-Ecosystems are dynamic. Thus "restoring" a watershed may have more to do with adjusting land use to conform to dynamics (fires, floods, debris torrents) than with creating a static, idealized landscape picture.

- "Clean streams" are not "normal," at least by historic standards. Large wood plays a key role in many aspects of aquatic habitat, particularly in coastal streams.

-Smaller streams on hill slopes are heavily influenced by upland forest conditions.

Given this background, we set seven main goals to achieve.

1) *Gather information from previous assessments* and organize these into a comprehensive data base that covers the entire basin. Since the previous assessments were done by different teams and different agencies using a variety of approaches, the information was not been compiled in a comprehensive way. In addition, there is more up to date information available from other agencies that can now be better integrated.

2) *Focus on the aquatic ecosystem.* There are many issues in the basin, including old growth forest habitat for spotted owls and marbled murrelets, recreation access, scenic conditions, economic development, and so forth. Our assessment looks at the entire land area and communities of the watershed, but only in so far as these relate to the aquatic ecosystem.

3) *Provide a "big picture" of the basin.* The previous assessments focused on smaller geographic areas (5th field watersheds). This one looks at a larger scale (4th field). Thus in some ways it is less detailed, but provides a better framework for understanding the entire system.

4) *Provide a comparative assessment of 107 "catchments,"* which are 3000 to 6000 acre small watersheds within the basin. By comparing conditions in these smaller areas, we hope to build a strong foundation for prioritizing future protection and restoration projects.

5) *Provide a condition assessment of the estuary.* This includes assembling data from various sources. One key question has been; is the estuary condition inhibiting salmon numbers upstream?

6) *Make the assessment readable and accessible* to Siuslaw residents, landowners, and managers. Thus our intent has been to avoid overly technical language, make liberal use of maps, photos, and other graphics, and to provide information in a variety of formats.

7) *Follow the format suggested in the Oregon Watershed Assessment Manual.* Funding for this project was provided through an Oregon Watershed Enhancement Board grant. OWEB is Oregon's key state agency focused on watershed health. The OWEB manual was designed to be used on watersheds only 1/10th the size of the Siuslaw. Consequently we could not follow all of the procedures recommended, but we did focus on the same issues and format. One key departure from the OWEB approach is our evaluation of the role of "ecological capital".

These goals were agreed to by the Siuslaw Watershed Council, and consulting team.

Assessment Participants

Many individuals and agency representatives contributed to this assessment. The following list may not be all-inclusive, but attempts to provide a sense of who did what.

The Oregon Taxpayer provided funding ($90,000) through the Oregon Watershed Enhancement Board (OWEB) grant program. Tom Shafer served as OWEB's field representative, providing timely advice, wisdom, and support. Ken Bierly provided a thorough review of the draft.

The 75 member Siuslaw Watershed Council provided staff support, organizing, and public outreach. While many members of the Council assisted in various ways, Dave Eisler served as overall project manager and wrote the section on pre-European settlement history. Johnny Sundstrom provided key insights on social issues

in the watershed, and Pete Barrell (Watershed Executive Director) provided important support for meetings and workshops.

The Siuslaw National Forest, Eugene District of the Bureau of Land Management, Oregon Department of Forestry, and Oregon Department of Fish and Wildlife all provided staff support and timely information. These agencies, along with the local *Soil and Water Conservation Districts*, are valuable resources of expertise and information to residents and landowners in the Basin.

The Mapleton Grange provided a wonderful meeting space, and Vernon Van Curler (Rosie) served as host for several meetings.

The Ecotrust Consulting Team had responsibility for preparation of this document, consequently any errors or omissions must rest squarely on our shoulders. The team included:

Ecotrust Staff:
Charley Dewberry, Restoration Ecologist (and North Fork resident) as Aquatic Specialist
Mike Mertens and Dorie Brownell as Geographic Information System (GIS) Analysts
Debra Sohm provided graphic layout design
Rosemary Allen provided project budget accounting
Eileen Brady provided principal support

Sub-consultants:
Dean Apostol, Landscape Architect as Team Leader and main author/editor
Ralph Garono, of Earth Design Inc. as Estuarine Aquatic Ecologist

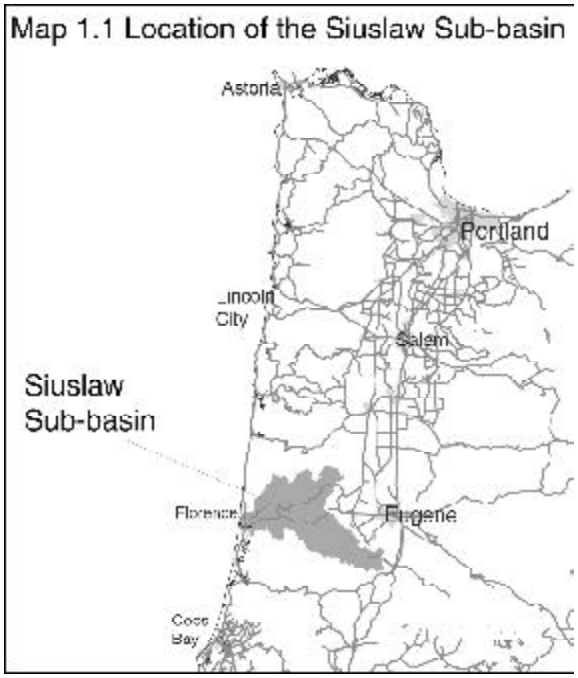
Paul Agrimis, and Adam Zucker of Vigil-Agrimis, as Project Hydrologists

Our team is thankful for the opportunity to have prepared this assessment. We have incorporated comments on the draft into this final report, and hope our work can help guide the Council on its long path to recovering aquatic health throughout the Siuslaw watershed.

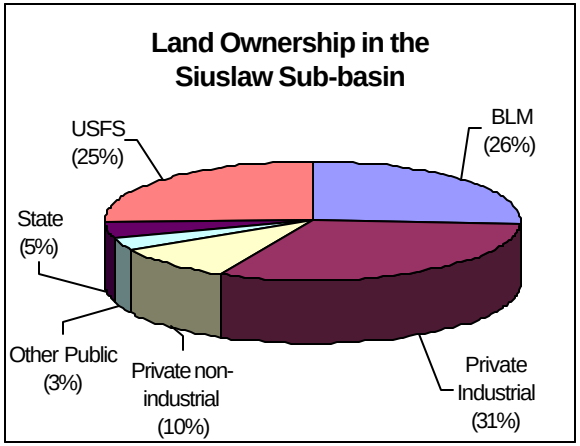
EXECUTIVE SUMMARY

Siuslaw Basin Physical and Cultural Geography

The 504,000 acre (773 square mile) Siuslaw River Basin is located on the Central Oregon Coast (see map 1.1). It stretches from Lorane Valley and Low Pass in the east through the Coast Mountain Range to Florence, the Dunes, and the Pacific Ocean in the west, an "as-the-crow-flies" distance of about 50 miles, but a river distance of nearly 120. Mountain ridges on the north and south separate the Siuslaw from the Alsea and Smith Rivers. Near the coast, low dunal hills separate the Siuslaw from several small, self-contained lake basins. The east edge of the basin is separated from Willamette River tributaries by a north-northwest to southeast trending ridgeline.



There are three distinct geographic parts to the Basin. First, in the east the landforms and settlement patterns are similar to the Southern Willamette Valley. Low, rounded hills frame broad, nearly level valleys that historically had prairie vegetation, still evident when the camas



(historically an Indian staple) is in bloom in early spring. Oak and pine edge the valleys, giving way to Douglas and grand fir on cool, north facing slopes. Riparian woodlands are characterized by Douglas and grand firs, black cottonwood, and Oregon ash trees. Farms are relatively large and diverse, with new wineries overlooking the landscape. Lorane Valley and Upper Lake Creek basin characterize this part of the watershed.

As one travels west, the valleys narrow, the hills become steep mountains, and the ridges are more

A view of the Lorane Valley from the King Estates Winery. This landscape is more characteristic of the Willamette valley than the Coast range.

The checkerboard ownership pattern in the eastern basin

Rolling dunal hills and forest islands south of Florence

knife-edged than rounded. This is the Coast Mountain Range, and it covers the great majority of the total land area of the basin. Farms hug narrow valley floors. Homes are clustered along stream junctions. Roads wind along with the creeks. The forest crowds open areas, but numerous clearcuts are a significant part of the landscape mosaic. Forests are for the most part fairly young, with "old growth" stands only occasionally seen. The pattern of logging in the eastern half of the Basin reflects the "checkerboard" land ownership, a long-lived echo from the Oregon and California Railroad land grant. In the western half, most of the uplands are within the Siuslaw National Forest, with scattered in-holdings of private, industrial forestland. The valley floors are mostly small farms and homesteads.

West of Mapleton, where State Highways 36 and 126 come together, the Siuslaw River becomes very wide, with a broad floodplain, numerous wetlands, and tidal islands. This is the estuary, which leads to the dunes along the coastal plain at Florence. Here the land is characterized by barren sand dunes interspersed with pine woodlands and deflation plain lakes or wetlands. The wind picks up, the air feels different, and most residents make their living off of retirement pensions or tourists rather than from the harvest of trees, crops, or fish.

Landscape Ecology

The ecology of the Siuslaw Basin landscape is complex, and reflects the interaction of climate, geology, landforms, natural vegetation, and land use. Most of the basin lies within the Coast Range Physiographic Province (Franklin and Dyrness). The underlying geology is almost entirely layered marine sandstones, known as the Tyee Formation. This is a soft, erodable rock that, when combined with the high seasonal rainfall and steep slopes is subject to landslides known as "debris flows". The overall shape of

the land, with relatively level but narrow valleys flanked by steep low mountains with knife-edge ridges, is a result of this interaction. The Coast Range is still actively rising, but the main streams have the power to carve out low-gradient paths through the mountains to the sea. The Siuslaw is one of only a few rivers that has managed to cut a path entirely through the coast range.

While the coastal mountains have a clear north-south axis, numerous faults and joints establish more variable patterns of ridges and valleys. The southeastern part of the basin, from Lorane Valley to Whittaker Creek, has a decided east-west orientation. The northeastern quadrant orients northeast to southwest. In the western half of the basin, the valleys and ridges generally run more north-south, but are quite variable. This complex topography facilitates the flow of hot, dry air from the interior well into the Coast, while blocking the cool, moist air from penetrating very far inland (during the dry season).

There are five fairly distinct "geomorphic," or landform zones in the basin. First are the terraces and floodplains along the main streams, most notably; Upper Siuslaw/Lorane Valley, Lake Creek, Lower Siuslaw and the North Fork, and to a lesser extent Indian Creek, Deadwood, Sweet, and Wildcat Creeks. Since the valleys are wide

Triangle Lake is one of only two natural lakes in the Siuslaw Basin

enough in these places to retain alluvial deposits, they have been the most suitable for settlement, farming, and transportation corridors. Second, the gently to moderate sloping hills in the eastern quarter of the basin. These have rounded shapes, low stream density, and fairly deep soils. They feel more like "foothills" than mountains. The hills that frame Lorane Valley are entirely volcanic in origin, and are geologically related more to the Cascades than to the Coast Range.

Third, there are infrequent but important volcanic formations that break through the coastal sandstones. The volcanics are harder, more resistant rocks, thus they form the upper ridges of the highest mountains (i.e. Roman Nose, Prairie Peak, and Walker Point). Fourth, the most dominant in terms of area and processes are the sharp-ridged, steep sloped heart of the Coast Range. This is where the sandstones are at the surface. Erosion rates are high, and debris torrents a major force in shaping the landscape. Fifth and last is the coastal terrace at and around Florence.

There are two interesting anomalies to the basic geomorphology of the Basin. The first of these are Triangle and Esmond Lakes, which formed as a result of large debris flows during ice age times. In a basin with very few lakes, Triangle is quite intriguing, one of the largest in the Coast Range. The second anomaly is Lorane Valley. Ecologically, this area is much more like the Willamette Valley than the Coast Range. In fact, it is believed that the Valley used to drain to the Willamette. A very low divide sends water south and west instead of north.

The hot, dry summers in the east created a fire-prone vegetation community and pattern. Indians frequently burned the prairies and oak woodlands to facilitate hunting and food gathering (Boyd). On occasion, these fires from the east were (and still are) pushed west by strong late summer or early fall winds. The denser forests of the coastal

Industrial forst and BLM landscape mosaic at Upper Siuslaw/Wolf Creek divide

Potential Natural Vegetation
1.2

This photo panaramic shows the rounded landform, young forest matrix, and fragmented ownership pattern of the upper Siuslaw area, near the confluence with Wolf Creek

mountains burn less frequently than the valley woodlands, thus fuels have more time to build up, and when fires arrive they are more intense, replacing stands over wide areas. Sitka spruce forests along the coast burn rarely, with wind disturbance more important as the way in which stands are naturally cleared and regenerated (Agee). Much of the basin burned heavily in the mid-nineteenth century, resulting in large areas of brush-covered hills. The valley bottoms and north facing slopes were generally too wet to burn hot, so forests in these areas were able to develop over a longer period. But the valley forests were subject to frequent flooding, beaver activity, and patch burning of open meadows by Siuslaw Indians. Ridgelines may also have been deliberately burned to facilitate travel and hunting.

Characteristic steep coastal mountain topography and narrow valleys

The western, coastal fog line reaches east up the main stream valleys, allowing sitka spruce to grow inland as far as the north fork of Indian Creek. Western hemlock grows with the spruce, but is joined by Douglas fir at about the place where the spruce stops its penetration. Because of fire and logging history, Douglas fir is by far the dominant tree in most of the basin. The valley floors were a mixture of old growth cedar, maple, and alder groves interspersed with wetlands and swamps before they were cleared and drained by early loggers and farmers. Huge logjams gathered along the lower valleys. Early visitors recorded old growth cedar trees growing on top of logjams at the mouth of the North Fork (McLeod). They also noted many large, downed trees that made travel very difficult. The beach and estuary collected large amounts of driftwood (Maser).

The mountain ridges are low enough that snow pack does not persist beyond a few weeks. Forests drape right over the tops of the hills, and there is no true alpine vegetation. There are a few “grass balds” such as those at Prairie Mountain. Erosion rates are highest in the middle part of the basin, where the mountains are steepest and rainfall highest.

The natural vegetation composition and structure of the basin has been significantly altered by Euro-American settlement. Valley bottom prairies, wetlands, and riparian forests have been converted to pasture, cropland, and homesteads. Much of the upland forest has been clearcut at least once, and in some cases converted to plantations that are now logged and regenerated on a 40-60 year cycle. Introduced species have spread and altered the ecology of the area. These include: pasture grasses, scotch broom, European beach grass, gorse, Himalayan blackberry, and spartina grass (in the estuary).

Upper Lake Creek Valley landscape mosaic

Prior to Euro-American settlement, the forest had significantly more old growth and mature forest than it does now. Old growth for the Coast Range Province is estimated to have ranged between 25-75% over the past 3000 years (Wimberly). Fires in the eastern part of the basin were fairly regular, resulting in areas of open forest, and a "patchy" mosaic of young, middle-aged, and older stands. In the western part, fires were less frequent, but burned much larger areas. Forest age and composition was fairly uniform over wide areas, averaging 10,000 acres in size. Older forests would have had small gaps in the canopy caused by disease pockets and windthrow. The last major fire occurred in the 1840s, and burned a large part of what is now Siuslaw National Forest land. There were also a number of moderate sized fires in the early to mid 20th century. The most recent fire burned several hundred acres of private forestland west of Whitaker Creek a few years ago.

The lack of snowpack, steep terrain, low gradient streams, shallow soils, relative dryness in the east, and absence of a true "headwaters" conspire to create a naturally "flashy" stream system, with unpredictable and highly variable flows.. The first heavy rains of autumn are only partly absorbed into the dry, porous sandstone soils. Streams rise quickly once the rains return, then dry to a trickle by mid summer. The land has limited ability to store water, and what natural ability it does have has been compromised by logging, road construction, valley clearing, wetland draining, removal of logjams and resulting stream downcutting. This has important effects on the aquatic system, as will be discussed later on.

Land-use practices have resulted in a lack of large wood and log jams, keystone elements of healthy aquatic systems in the Siuslaw Sub-basin

Rainfall is much higher in the western part of the basin than in the eastern part. This, combined with the pattern of seasonal rain, also limits the amount of water available to streams in the summer. Relatively very little is generated or stored in the upper watershed (Armantrout 1).

Historically the low gradient stream system contributed to frequent flooding of the valleys. It was likely winter or spring floods, stored in the valley wetlands, were crucial to maintaining base flows in the summer. As streams have cut down and lost contact with adjacent floodplains, and wetlands drained, the aquatic system has in turn declined (Westfall).

Aquatic Conservation Issues

The Siuslaw River Basin has been the subject of many studies and much interest with regards to the aquatic ecosystem over the past few years. The basic story is well known by most of those who have taken an active interest in the watershed.

Historically, the Siuslaw Basin was one of the most abundant anadromous fish producers in the Pacific Northwest. The combination of geology, climate, forest development, and lifeways of the Siuslaw Indians established and maintained a system where salmon and the people who depended on them flourished for many years. Archeological records indicate that salmon "arrived" in the basin in abundance about 3000-4000 years ago. The evidence is in midden sites that show the diet of the Native people shifted to salmon at about that time. This corresponds roughly to a general cooling of the climate, which likely established conditions more favorable to salmon, and allowed them to extend their range south.

Early cannery records indicate that the Siuslaw was second only to the Columbia River in numbers of coho. The average coho numbers from 1889-1896 were 209,000 fish (Booker). This compares to an average of just over 3000 in the years 1990-1995. Why have the numbers declined to such an extent?

There are some factors that have affected salmon in other watersheds that we can rule out. Unlike many other river systems in the Northwest, there were no large dams built in the Siuslaw basin. There are only a few small dams in upper reaches that form mill ponds. The basin has not been heavily urbanized or extensively farmed. There are farms to be sure, but the percentage of land in

agriculture and urban areas is very small compared to most Northwest River systems.

Two significant activities that likely affected the salmon did happen however. The first of these was the simple fact of over-fishing. The Siuslaw Indian population was relatively low. The most reliable early estimate indicates that 900-2100 Indians were present in the Basin at the first recorded contact with Euro-Americans (Booker). These numbers may have been unusually low due to diseases that preceded settlement. Nevertheless, the Siuslawans had an economy and social structure, similar to that of most Pacific tribes, that insured that enough salmon would reach spawning grounds each year to perpetuate an abundant population. In addition, they did not heavily alter the basic ecology of the land. They did not clear logjams, practice agriculture (though camas collection did border on becoming agriculture in some areas,) or engage in large scale logging. They also did not build roads and railroads. They did harvest plants and cut trees, particularly the western red cedar. But their harvest style was to split planks for homes off of live trees. Whole tree harvest, primarily for canoes, was selective and rare. We know that their exploitation of the salmon and other resources proved to be sustainable over hundreds, and perhaps thousands of years.

The North Fork illustrates downcut stream, altered wetlands, and lack of riparian cover

Early Euro-American settlers saw the salmon as more of an economic resource than as a purely subsistence one. In an era of unregulated harvest, the first one that caught the most gained the rewards. In 1875 the few Siuslaw Indians who had managed to survive diseases introduced by initial contact lost their legal battle to retain the entire basin as their reservation. This opened the area to pioneer settlement. The first salmon cannery opened at the site of Florence in 1876. Other canneries followed, and Chinese laborers were imported to provide the labor. From 1887-1892 over 68,000 cases of Siuslaw caught salmon were packed and shipped to markets in Portland or San Francisco (Booker).

While the salmon were now harvested in numbers far beyond what the Indians likely had taken, the valleys were being cleared for settlement. The first farms located in the far east of the basin, near Lorane and in upper Lake Creek. These were extensions of Willamette Valley settlement patterns. Prairies and oak woodlands were transformed into grazing or crop production, depending on how wet or fertile the soil. Land claims also began working their way upstream from the river mouth in the late 1870s. The first of these were near the head of tidewater, near Mapleton. By 1882 all the farmable land up to tidewater was claimed. By 1893 Florence was platted as a town site. And by 1894 land was claimed along all the main tributaries of the Siuslaw (Karnes).

Recent logging in the middle part of the sub-basin

The early pioneers lacked modern power tools, but still cleared the valley forest and logjams as best as they could. A sawmill opened in Florence in 1879. In the absence of roads or rail lines, “splash dams” were used to drive logs to the estuary. These were temporary log crib structures that backed up water and logs for some distance up stream. Some were then dynamited out to release a torrent that carried the logs downstream. Others were released in a more controlled fashion, and used repeatedly. One unintended result was scouring of the creek bottoms to bedrock. Another was the loss of natural logjams. Deep pools were lost, and the streams became increasingly channelized.

As the valley bottoms were logged and drained, and the streams scoured out, the aquatic ecosystem lost much of its ability to store water, sediment, and nutrients. The river network that had been so hospitable to salmon and other aquatic wildlife functioned more like modern urban

land ownership
1.3

Upper North Fork "thinned" Forest

streams, in that they funneled water quickly downstream.

By 1893 these cumulative impacts had driven the numbers of salmon downwards. To compensate, a hatchery was built at Mapleton, but it only operated for five years. Surplus fish from hatcheries outside of the basin continued to be released annually from 1964 to 1988 (Booker).

A jetty was completed at the Siuslaw mouth in 1918. This project helped get larger ships more safely in and out of the harbor. In combination with completion of a railroad connection to the Willamette Valley in 1914, the basin was now available for industrial scale logging. But the technology of the time still limited logging to valley bottoms and lower slopes. It was not until after World War Two that hillside logging really got under way. Extensive road systems were constructed. Many roads were built on steep side slopes, with little regard to stability. One result was an increase in the frequency and size of landslides, particularly debris flows. And where debris flows that carried large trees into streams were important contributors to the aquatic system, those that occurred after logging carried mostly sediment, which likely did more harm than good.

There were few regulations governing the practice of forestry on private lands until the State Forest Practice Act of 1972. Streams became choked with logging debris, leading to efforts on the part of state and federal biologists to "clean" them of slash. In many cases this led to over clearing, where large and small pieces of wood were removed to aid salmon passage, but at the expense of habitat and structural stability of streams.

Efforts to stabilize or improve aquatic habitat in the basin have been under way for many years. Gillnet licenses were required as early as 1899. The Oregon State Fish Commission began restricting river fishing intensity and methods in 1939. Commercial fishing was closed on the river in the 1950s. But the fishing pressure simply moved out into the open ocean. The last cannery in the basin closed in 1956, as numbers of returning salmon continued to decline. Even sport fishing for coho was closed in 1993 (Booker).

By the mid 1970s, private and public forest managers began constructing roads differently. They avoided "sidecast" methods that had proved unstable, and adopted full bench construction. The Northwest Forest Plan for federal lands, adopted in 1993, protected most of the National Forest and BLM lands from clearcut logging. Riparian buffers were greatly enlarged.

Ditching and draining of valley wetlands may resort in lower water quality and reduced summer base flows

Most of those who have followed the issue of salmon in the Siuslaw Basin over the years now agree that the combination of over-fishing, loss of habitat, and poor ocean conditions in the 1980s and 1990s finally brought the entire situation to a head. The listing of coho as a threatened species in 1996 forced policy makers, resource managers, and local communities to try new approaches to aquatic conservation. The question now is not on how many fish we can catch, but whether the aquatic ecosystem can recover to a point where salmon can again be a sustainable resource. The essentials are clear. The basin ecosystem (including changes in the ocean) may have been changed to the point where it likely can no longer can support historic, or even reasonably high numbers of most salmonid species. One exception appears to be the chinook, which has recovered to nearly historic levels. There are two likely explanations for this. First, the chinook may have a greater reliance on the estuary, rather than the river system, as essential rearing habitat. Second, chinook juveniles rely on stream reaches only during late winter and spring seasons, when there

mature forest
1.4

is plenty of cool water. Their life history demands may be met during this period.

A summary of aquatic ecosystem issues is provided below:

-Bedrock and downcut stream beds.
Significant reaches of mainstem and tributary sections appear to have been either "sluiced down to bedrock," or show visible evidence of down cutting. While scouring and downcutting can be a result of natural stream processes, the present extent is believed to be far greater than the historic occurrence. The main causes are believed to be clearing of log jams, logging of riparian areas, conversion of valley bottoms to farms or homesteads, increased frequency of debris flows, and scouring of channels by splash dams. No measurement of downcutting across the basin is available, but the BLM estimates that the Upper Siuslaw and its tributaries are between two to ten feet lower than they were historically (USDI 1996).

-Degraded riparian habitat.
Because the narrow valley bottoms are the only places in much of the watershed suited to agriculture, home building, and transportation corridors, and because these areas were the easiest to log initially, riparian forests and associated wetlands have born the brunt of the last 125 years of development. Only about 36% of the entire riparian zone (measured as 200' on either side of streams) is in mature or very mature forest condition at present. The extent of wetland loss is unknown, but is likely very high, particularly in farmed areas.


The natural resource economy of the basin is in decline: farming, timber, and fishing

-Loss of habitat complexity.
The two factors above have combined to result in a simplification of the aquatic system. As stream channels become cut down into the landscape, they lose contact with floodplains and wetlands. Large wood, a keystone of the ecosystem, is no longer present in sufficient quantities, and the few pieces of wood that make it to the streams are quickly swept to the estuary and out to sea during winter storms. This is reflected in stream surveys conducted over the past 10 years by ODFW and the Forest Service, which identified a lack of large wood and "complex" pools (Willer).

-Loss of food web support.
The loss of complexity has resulted in a leaking of nutrients from the stream system. Salmon eat bugs that eat other bugs that eat vegetation. The vegetation is retained in the system by complex habitat, including floodplains, flats, and wetlands. Fish need foraging habitat to go along with spawning and rearing.

-Loss of estuary habitat.
About 58% of the original wetlands in the estuary below Mapleton have been diked or drained. Dredging of the channel, and the funneling effect of the jetty likely results in a leakage of wood and nutrients to the ocean. This may in turn limit the ability of salmonids to "fatten-up" before heading out to sea, thus reducing ocean survival. Most of the remaining wetlands in the estuary are privately owned and only partly protected from development. There are emerging opportunities to restore former tidal wetlands by removing dikes and tidegates.

-Factors outside of the watershed.
Fluctuating ocean conditions, predation of salmon at sea, and competition from hatchery fish are all factors affecting the year to year abundance of fish in the Siuslaw. Even if the watershed were in pristine condition, there would be good years and bad years. But with the populations reduced to a level far below that experienced at any time in the recorded

past, there is little room for further habitat loss. The system has lost much of its resilience.

There are a number of social and cultural issues that also may be working against recovery of the aquatic ecosystem, as follows:

The settlement pattern and infrastructure is "fixed" in place:
Recovery will have to happen without significant change to existing patterns of ownership and use of land, or to main transportation corridors. The checker-board ownership of forest lands in the eastern half of the watershed presents a particular problem in coordinating protection and restoration efforts. Valley bottom settlement limits the potential for wetland and riparian restoration.

Lack of economic opportunity:
The loss of fishing, and general decline in agriculture has been accompanied by a decline in forest related jobs. The amount of trees that can be cut each year has dropped, particularly on federal lands. Private, industrial forests are being cut on 40-60 year economic rotations that are less than optimal in terms of maintaining high harvest volumes. State forests are still at mostly young ages, and will be harvested at a fairly slow rate. Many local mills have closed. Others operate at lower levels than they had in the past. Wages of forest workers have stagnated or declined. The tourist/retirement economy in Florence is relatively strong,


Whitaker Creek in-stream structure & riparian conversion

as is the diverse economy of the Eugene area. But service jobs typically pay less than ones in natural resources.

Continued logging and valley bottom farming :
These combine to deprive the stream system of a steady supply of large wood


A boulder log stream structure in the upper Siuslaw

that could rebuild complex habitat over time at relatively low cost. The legacy of large wood that formed the backbone of the aquatic habitat has mostly been lost, and there is not enough left in the land-scape to replace it. In addition, continued logging of high risk debris flow areas disrupts the natural cycle of sediment and organic delivery to streams.

Natural resource economic pressures:
The need to return profits on investment capital over relatively short time frames (in the life of a forest) makes long term retention or re-growth of mature forest on private lands problematic. Large indus-trial forest companies are compelled to harvest trees as soon as they become economically useful, in order to maintain adequate returns to investors, or just to keep mills operating to protect worker's jobs. In addition, the market for large logs has significantly diminished over the past few years. Family owned and managed forests often harvest trees less intensively, and practice alternative silviculture (such as uneven-aged for-estry) that has lighter impact to the aquatic ecosystem.

Insufficient funding for watershed "restoration":
The total amount of public funding, at about $1.5 million per year, is small compared to the need, and spread be-tween many agencies. The Siuslaw basin must compete with watersheds through-out the state and region that have equally

recent restoration
1.5

protected areas
1.6

great needs. Political support for maintenance or increase in funding levels is weak, particularly as the economy has slowed.

Staff cutbacks at federal and state agencies:
The Forest Service, Bureau of Land management, National Resource Conservation Service, and Oregon Department of Fish and Wildlife have all experienced continued budget cuts over the past decade, resulting in gradual loss of local aquatic resource expertise. One example is the planned merger of the Siuslaw National Forest into the Willamette, which will result in closure of the Corvallis headquarters.

Restoring the aquatic ecosystem is a complex challenge:
To our knowledge, no one has ever successfully restored a watershed the size of the Siuslaw. Reaching a level of watershed health where salmon will once again be abundant will likely take many years, require unequal sacrifices or efforts on the part of local land owners and taxpayers, and may be resisted by those who feel the burden on them is not fair or affordable.

Recent Protection and Restoration Efforts

Natural resource managers from various agencies have been attempting to address habitat related issues in the Siuslaw Watershed since the late 1960s. The Bureau of Land Management began installing rock gabions in streams at that time, as a way to improve habitat (Armantrout 2). The Oregon Department of Fish and Wildlife began efforts to build a fish ladder at Lake Creek Falls in 1964, but this was not completed until the late 1980s. Streams were cleared of log jams and beaver dams in the mistaken belief that this would aid fish passage. Restoration efforts since the 1980s have focused on installing in-stream structures to help capture gravels, wood, and nutrients. Since the 1970s, midslope roads on federal lands have been built to higher standards, so that they will stay put on the hillsides.

In the 1990s, multiple efforts have grown. ODFW, the Forest Service, and BLM have continued to experiment with various techniques for improving in-stream structure and habitat. Many unneeded roads have been closed or "storm-proofed." Timber companies have worked to stabilize roads and replace problem culverts. Some valley-bottom landowners, particularly in Deadwood Creek, have restored wetlands and replanted or fenced riparian areas. Overall, the Watershed Council has distributed an estimated 25,000 trees to private landowners for riparian planting, resulting in about 20 miles of new streamside trees (Nichols). Parts of the estuary are planned to be restored to tidal wetlands. Florence has upgraded its sewage treatment plant, and is taking progressive steps at recharging its aquifer by directing stormwater into the ground. The Siuslaw Watershed Council is gradually building a "watershed community" that will ultimately improve stewardship from Lorane to Florence.

Most of the Federal land in the basin is now protected from clearcut logging (as a result of the Northwest Forest Plan,) and may eventually recover to mature forest condition. State forest management has been re-oriented to growing more mature forests. Combined federal and state spending on restoration is running at about 1.5 million dollars a year. In kind contributions of labor, machinery, and materials from private landowners may be matching or exceeding this amount (Westfall).

A recent study of Northwest coastal rivers by Ecotrust evaluated three parameters believed to be critical to restoration of aquatic ecosystems: (1) the historic carrying capacity of the system, (2) the potential for restoration based on the degree of human influences, and (3) the current aquatic production. Based on these criteria, the Siuslaw Basin received the highest ranking among all of Oregon's coastal watersheds. This study particularly reflects the high historic numbers of salmon, and that in spite of 130 years of intensive land use, the system remains free of large dams or urban areas, and is still mostly forested.

Some fishery managers believe the efforts of the past decade may have succeeded in "stabilizing the decline" (Armantrout 2, Westfall). Clearly a number of individuals, local communities, and agencies are working very hard to improve aquatic conditions. The Siuslaw Watershed Council has been organized to facilitate recovery efforts throughout the Basin.

Assessment Conclusions

The conclusion of our team is that, while all the present efforts to help the Siuslaw Basin aquatic system recover are well intended and certainly useful, they could be better focused and coordinated. In particular, there needs to be a clearer link established between overall land use and the aquatic system. The streams need to be seen as fundamental aspects of the entire terrestrial environment, rather than as discreet areas that can be "fixed" without changes to upland land management and valley bottom farming. Our recommendations, described in greater detail later in this report, are as follows:

-The first, fundamental step in helping to recover the aquatic ecosystem to health is to identify and secure the habitat that is presently in best condition, and that has the highest potential for aquatic recovery. We have built on earlier work by identifying concentrations of "ecological capital" that appear to support the aquatic ecosystem at the "catchment" scale. Further analysis will be needed before more specific "anchor habitats" can be positively identified and protected.

-Also important is the identification, nurturing, and building of "social capital" throughout the basin. We define social capital as all the individuals, institutions, and collective knowledge that are playing positive roles in protecting or restoring the aquatic system. We have identified some of these in this report, but feel that this is an area best addressed by the Watershed Council over the long term. In the end, the people who live, work, and own land in the basin will be the ones to restore it to health, or restoration simply will not happen.

-Restoration and protection should be matched to the varying geography of the basin. Those streams nearest the coast are closely tied to the estuary and condition of the low lying valleys. Wetland and riparian restoration activities may have very high value here. In the Coast Range mountains, the focus should be more on restoring the natural dynamic of the debris flow process. This means stabilizing or removing mid-slope roads, and finding ways to leave significant amounts of trees in high and moderate risk areas. In the upper watershed, riparian and wetland restoration again rise in importance, along with attention to farm and forest best management practices and reductions in road density where possible. Culvert modifications to improve fish passage may also make the most sense in this area.

-The long run goal should be to retain or restore natural processes that are essential to the aquatic ecosystem. But it may in some cases take 50-100 years to achieve this goal. In the meantime, restoration projects should be planned as "temporary bridges" that will improve local habitats until natural process are once again functional. In-stream habitat improvements at this time appear to be most effective in upper watersheds, in relatively confined streams, where flows are most stable, and at natural "flats," where organic and sediment storage is most crucial.

-Additional actions that hold promise include: land acquisitions or trades, particularly in the "checkerboard" area, or where there are key in-holdings on sensitive lands. Riparian thinning and planting aimed at restoring large conifers (though alder conversions must be done with care to avoid loss of precious shade and nutrient input). Fish passage improvements are beneficial, but it should be noted that many of the upper, steep gradient creeks were always somewhat cut off from the lower ones, and that these may in some cases be important refuges for resident trout.

It is the "suite of environmental forces" across the landscape that maintains the aquatic system over time. Large trees sliding down the steep ravines and into streams, then transported to flat areas where jams form and nutrients are held, floodplains that store water and release it slowly, forests that capture rainfall and fog, riparian woodlands that shade streams as well as providing wood and nutrients, and busy beavers re-building wetlands. We need to find ways to work with these and other elemental forces of the land by forming a stronger partnership with nature. Ultimately, this means

modifying the way we farm, build homes, and manage forests. Getting basic land use more in synch with natural processes may ultimately be more important than investments in restoration projects.

We must acknowledge that we lack any good models for restoring a 500,000 acre river basin to health. For the past 130 years, we, our parents, and grandparents have altered the habitat of the Siuslaw watershed to a point where the aquatic system is clearly in trouble. This was not done deliberately, but rather out of ignorance of how the system works. We are still fairly ignorant. Thus we should view all of our efforts (including this assessment) with humility. A clear need is to more methodically build in experimentation and a willingness to abandon efforts that are not working in favor of those that have a better chance. This is known as “adaptive” management. It requires a commitment to monitoring, learning, and an openness to try new approaches.

The remainder of this document will focus in more detail on aspects of the aquatic ecosystem and issues. The last chapter outlines a proposal for aquatic conservation and recovery.

LANDSCAPE HISTORY

The landscape of the Siuslaw basin that Euro-American traders and settlers first encountered in the early 19th century was one shaped by the interaction of climate, geography, and a long history of occupancy by Native Americans. The extreme eastern parts of the basin were mosaics of wet and dry prairie, oak, pine, and fir "savannas," and fir woodlands. As one traveled west through the Coast Range, the prairies and open woodlands gradually gave way to dense forests. Valley bottoms were mosaics of open wetlands, with patches of alder, and groves of conifers. At the coast, the dunes were largely unvegetated, except for the deflation plains and patches of lodgepole pine.

Large logjams were characteristic of the lower parts of the main streams. Some, along the North Fork, apparently had been stable long enough to have old growth trees growing over the top of them (Schofield). Numerous smaller log jams along tributaries were key elements of streams. The upland forest was a mosaic of burned over and forest patches of varying ages.

How did this landscape pattern come to be? Was it one that had been there for a long time? Recent research by paleo-botanists and fire ecologists has built an interesting picture of how the land changed over time. Much of the Pacific Northwest was repeatedly covered and then uncovered by glaciers for a period that began some two million years prior to today. The last glaciers only left the scene about 14,000 years ago. A few continue to hang on along the slopes of our higher Cascade volcanoes. The Coast Range and interior valleys were not covered by glaciers, but experienced a much cooler climate in comparison to that of today. Pollen records indicate that the Siuslaw Basin was forested throughout the last glacial period. But the forest character was different from the one that was found by trappers and pioneers in the nineteenth century (Hebda).

About 35,000 years ago, western white pine grew along with fir and western hemlock as the dominant trees. The climate was likely much cooler than it is today. By 20,000 years ago, this forest had changed into an open, subalpine-like forest of Englemann spruce, lodgepole pine, and mountain hemlock. It would have resembled forests found at timberline in the high Cascades.

As the last glaciers retreated, the land warmed up, and the forest composition shifted to Douglas fir, red alder, and western hemlock. This would have been similar to the "post-logging" forest we have today, except that there would have been more mature trees. A further warming of the region some 10,000 to 5,000 years ago resulted in the advance of pine into the area (Hebda). The prairie grasslands and oak woodlands of Lorane valley likely became established around this time.

About 4000 to 5000 years ago, the local climate cooled, and the Coast Range forest composition shifted to the one "discovered" by Euro-Americans: Douglas fir, alder, hemlock, and western red cedar. Interestingly, this appears to be around the same time that salmon took up residence in the basin, though they had likely been here on many other past occasions. Cooling of the climate would have allowed conifer forests to overtake the prairies and savannas of the eastern basin, but Indians developed the technique of using fire to maintain open areas (Boyd). They also likely used fire throughout the basin to clear travel corridors, and to establish or retain berry patches, particularly salal.

The fire history of the Siuslaw watershed is not well known for the period prior to the mid 19th century. But recent studies of the coast range as a whole demonstrate that over the past 3000 years, the amount of old growth conifer forest generally ranged from 25-75%, with a mean of 45%. This contrasts to only 5% old growth throughout the coast range at the present time. At smaller scales (5th field watersheds of about 40,000 acres,) the amount of old growth may have ranged from 0-100% (Wimberly).

The earliest writings on the condition of the land in the Siuslaw area come from the journals of David Douglas, who traveled through the Umpqua basin, and from Hudson Bay Company records, particularly journals by Macleod. Douglas noted the widespread nature of Indian burning of interior valley grasslands. In the coast range, he described passing over giant fallen trees, some 240 feet long and 8 feet in diameter. He also described great amounts of wood accumulating in streams as they neared the coast, and passing through open grassy areas on the valley bottoms.

Nathan Scofield also described the area in a journal of the Klamath Exploring Expedition, 1850-1853. Scofield described cedar in the bottomland of the lower Siuslaw as the "finest I

ever saw, extending all along the river." He described the bottomland as only sparsely forested however. Along with patches of timber were brushy areas and some prairie. Surrounding mountains were also brushy, probably as a result of recent large fires.

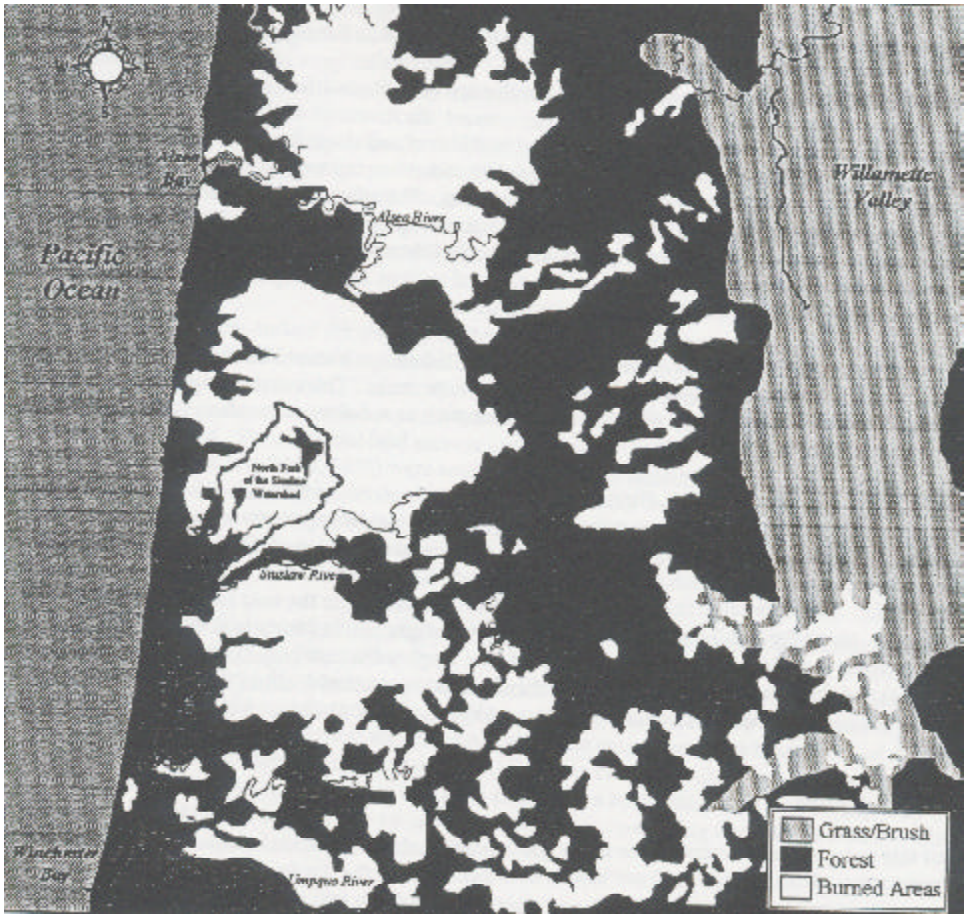
The Hudson Bay Company account from an 1826 expedition described extensive logjams at the confluence of the mainstem Siuslaw and the North Fork. Later accounts, from Government Land Office surveys and pioneer journals, describe the valley of the North Fork as maple, young fir, and extensive brushy areas of salmonberry, crabapple, and vine maple. The lower basin was not opened to settlement by Euro-Americans until 1875, when the Siuslaw reservation was opened to settlers.

The Umpqua fire of 1846, which covered 450,000 acres along the central Coast range, burned large areas of the west half of the Siuslaw Basin. Most of the upland areas were heavily burned, with only patches of remnant old growth trees spared. The main river valley also did not burn. The fire apparently left many standing snags. The forest that the Umpqua fire burned may have originated after a previous fire in the late seventeenth century.

In the central-east part of the basin, the Umpqua fire apparently did not have much effect. Ninety-five percent of the Wildcat Creek watershed, for example, was described as mature conifer forest in the Government Land Office Surveys (GLO) of the late nineteenth century (USDI 1999). Less than four percent was "burned over." Sixty-five percent of the Upper Siuslaw was likewise forested with mature trees, with about thirteen percent burned (USDI 1996).

Fires also burned portions of the basin in the early 20th century. Records from 1929 indicate that six large fires totaled over 60,000 acres burned, though some of this was east of the Siuslaw basin. About half of this area was in mature timber, the other half in former burns or recently logged areas (Johnson).

There are several lessons we can draw from the pre-Euro American landscape of the Siuslaw Basin. First, over the long term of thousands of years, there has been, and probably always will be a shift in vegetation structure and composition as a result of periodic climate change. During warmer periods, the aquatic system may not support high salmonid populations. This should give us some concern as we contemplate the possible effects of global warming.



Map 2.1

Fire history of the general area surrounding the North Fork of the Siuslaw Watershed showing the extent of the Umpqua Fire in 1846. Total acres burned by this fire was estimated at 450,000.

Second, disturbance and change over the shorter term (hundreds of years) established a dynamic mosaic of old growth, younger forest, and open areas. It is likely that at times, parts of the aquatic system were not very hospitable for salmon, but populations shifted along with forest patterns. In others words, Salmon may have found refuge in unburned areas until burned areas recovered.

Third, people have had a hand in shaping the landscape of the Siuslaw for a long time. Fire was the primary historic tool for creating favorable landscapes in the past.

Perhaps these lessons can teach us that humans can learn to co-exist with salmon and the natural system of the Siuslaw Basin. We do not need to have 100% of the landscape in old growth forest to have a healthy aquatic system. But we may need to have a fair amount of older forest, and given natural disturbance cycles, it may not be able to be limited to designated late successional reserve boundaries.

SIUSLAW CULTURAL HISTORY

This introduction to the Siuslaw culture history has been included in order to provide the reader with the long term perspective of human land use. For nine thousand years a Native American population lived within the Siuslaw basin without adversely impacting the productivity of the aquatic ecosystem. As we currently struggle with failing runs of anadromous fish and degraded water, it becomes crucial for us to better understand the relationship between the early population and the environment.

Residents of the Siuslaw basin are now the stewards of the aquatic system. Elements of the philosophy and technology of the previous culture may have been instrumental in successful land stewardship. It may now be an appropriate time to examine how the Siuslaw Native Americans lived on the land.

This chapter provides an approximate timeline for Native American presence in the watershed, but is based on very limited archaeological and ethnographic data. A preliminary map shows the distribution of documented and undocumented sites and locations of use areas recalled by the Siuslaw. An estimate of the populations, a very brief description of Siuslaw culture and a reexamination of the term "village" will allow us to examine the possible distribution of Native people within the watershed. Because the long history of Native occupation demonstrates a successful and relatively stable, sustainable model for land use, prehistoric data through archaeological sites represent a "resource" capital of considerable value to the present community.

Occupation Timeline of Native Populations Within the Watershed

11,000BP (before present) to 2,000 BP (year 0)
There have been no early archeological sites located within the Siuslaw drainage. In 1908 local landowner Glen Dowell located an obsidian clovis point in the sands at the west end of Sutton Lake (1). Clovis points are relatively large, lanceolate, deeply fluted and are associated with the late Pleistocene Big Game Hunting cultures. Clovis points were hafted to spears used in the hunting of mammoth Kill sites are typically dated at 11,000 BP. The Sutton Lake Clovis point was found along with late archaic lithic tools suggesting that it had been found and reused by more recent Siuslaw Natives (2). Although its origin is uncertain it does give an indicator of Big Game Hunting Native American presence in the general area. Two archaeological sites in adjacent watersheds have been dated to 9,000 BP, the Tahkenitch Lake site ten miles south of the Siuslaw and two miles inland from the coast (3), and the Long Tom earth Oven Site (4) in the Willamette Valley ten miles to the east of the Siuslaw headwaters. A 3,000 year old midden site is located on the Lower Umpqua River (5). These sites provide well documented presence of Native Americans in the region and by inference in the Siuslaw Watershed over the last 9,000 years.


A sandstone bear figure from North Fork

Owing to sea level rise following the last glacial melting, there is little likelihood of locating coastal and lower estuary sites dating prior to 3,000 years ago. These early sites are buried beneath estuary silts or offshore coastal sands and sediments. While we can assume that the Siuslaw or their predecessors were present in the basin 9,000 years ago, we cannot say what areas of the basin were used by these early populations.

2,000 BP to 1800AD
The Coastal and Estuary Area
A very limited number of documented and undocumented sites provide a sketchy picture of more recent Native use of the watershed, as well as Siuslaw territory to the north and south along the coast. Undocumented coastal shell middens occur at many of the eroding headlands. A shell midden at Neptune, several miles south of Yachats is dated to 320 BP (6). The Dune Site (500-1000BP) near Florence is the best-documented site in the watershed. Excavations yielded tool making debris, fire cracked rock, burned shell and bone with midden remains of shellfish (mussel and crab), barnacle, herring (the most frequent) tomcod (summer fishery), sculpin, flatfish and surf perches (estuary species). There

were few bird and mammal remains with the exception of bones from infant seals suggesting summer hunting near a seal calving area. The nature of this site is still uncertain. It may represent a village midden, or a summer encampment hearth where tools were produced (7). Robin Smith from Western Oregon University is currently doing analysis from an adjacent area excavated last year.
A prehistoric burial area in the town of Florence (8), a site in a wetland at the east end of Florence, eight fish weirs in the estuary dated to between 1100 and 600 years ago (9), and a small midden near the South Slough (10) are the only other recorded sites within the lower part of the basin.

Middle Siuslaw Tributaries
Projectile points and woven fiber were found by a current landowner less than a mile from the confluence of Indian Creek with Siuslaw River (11). Approximately 7 miles up North Fork two exquisitely carved sandstone bears (see photo) were located by a landowner plowing his fields and, at Brickerville, 4 miles upriver from Mapleton, another landowner located a bird carved from basalt as well as sandstone and basalt pestles and grinding stones (see photo).

Upper Siuslaw Area
Two recorded sites in the Upper Siuslaw are located in the Lorane area, one at Siuslaw Falls (12) and the other at the confluence of North and South Forks (13). Large numbers of mortars and pestles have been located by landowners in this latter area which is believed to be at the crossroads of major east-west and north-south Native trails (14).


Basalt carving

A plank tree (a live cedar from which Natives split planks for their houses) has been documented in the lower Wildcat sub-basin (15). This may have been used during the period after Euro-Americans arrived in the area. Projectile points were located by a landowner in plowed fields 3 miles up Chickahominy Creek (16). A site with mortar and pestle grinding tools is located near Triangle Lake (17). Projectile points located on a ridge above Triangle Lake and south of Prairie Mountain suggest ridgeline travel and hunting trails (18).

At this point, we do not have enough information to know whether these sites in the upper basin were used by coastal Siuslaw, or by the interior Kalapuya Indians. There may have been overlapping use of the areas by both groups. Although the lithic (stone) materials at the Siuslaw Falls site are similar to those associated with Willamette Valley culture, we do not know enough about the tool tradition of the Siuslaw to draw a comparison.

These few sites in the upper Siuslaw River, Lake Creek and Wildcat Creek indicate native presence in this area in late prehistoric times. Generally, the late prehistoric period is considered a time when trade and exchange increased between previously more isolated communities and language groups. Some researchers believe that these upper basin sites, if they are Siuslaw, may be early historic settlements (19).

Population estimates of precontact to 1850s
No reliable estimates are available for the Siuslaw prior to 1850's. Writers have used the figure of 2,000- 3,000 for the aboriginal population. According to Zenk (20) the earliest population estimates come from Natives at the mouth of the Columbia who in 1806 gave an estimate to early travelers of 900 Siuslaw. Chinook tribes from the north canoed as far as the Siuslaw to raid for slaves. Their population estimates probably did not take into account Siuslaw living in the interior of the basin.

Certainly, as Mcnaughton (21) writes, the population suffered a relatively precipitous decline. The first small pox epidemic was probably introduced by the Spanish along the Oregon Coast in 1775 with a subsequent outbreak in 1801. This was followed by measles, whooping cough, influenza, syphilis and dysentery brought by the later Russian, British and American traders. In 1830 an epidemic of what is believed to have been malaria killed thousands of Western Oregon natives. In 1836 another small pox epidemic further reduced the remaining population.

In 1852 land surveyor Nathan Scholfield estimated that there were about 100 (possibly referring to the Florence area) Siuslaw (22). In 1854 Joel Palmer, the Indian agent for the BIA wrote "The Si-u-slau band reside on and about 2-

4 miles above the mouth of the river of that name… and they number 26 men, 36,women 26 children" (23). Zenk (24) suggests that in 1867 the number was about 133.

An estimate of 2,000 to 3,000 Siuslaw prior to the impact of European disease (1750) does not seem unreasonable. Over A 100 year period, the population dropped dramatically to between only 100 to 200. These low population numbers during the period of initial recorded observations complicate answers to important questions regarding the distribution of people to natural resources.

Early Historic Period Land Use: Early observations

The scattering of observations by early European travelers/observers, government agents, ethnographic and linguistic researchers and from interviews with Native informants offer another layer to the land use of the Siuslaw. In 1826 Alexander McLeod traveled from the mouth of the Siuslaw and up the North Fork collecting beaver furs for the Hudson's Bay Company. In 1854 Nathan Scholfield traveled up the Siuslaw to tidewater looking for a route to the interior Willamette Valley.

Field notes from both of these travelers offer brief first glimpses of the Siuslaw. In 1879 Albert Gatchet published, in German, a linguistic study of the Siuslaw based on vocabulary collected by Dr. John Milhau, an army surgeon posted at Fort Umpqua in 1856. In 1884 Reverend Owen Dorsey worked with Siuslaw Native Louisa Smith on the Siletz Reservation. Dorsey's recording of important linguistic and ethnographic information was sponsored by the Bureau of American Ethnology of the Smithsonian Institute.


Margie Young Knowles, 1965

"Our Siuslaw Natives"

In 1909 Leo Frachtenberg, a student from Columbia University, began his ethnographic work with the Siuslaw. His primary informant was Jim Buchanan, a Coos who lived on the river near Florence. In 1931, in deposition before a Federal Court for the Confederated Tribes suit against the United States, Andrew Charles, a Coos Native who had grown up in the Florence area, recounted some of the customs and land uses within the Siuslaw basin that he had witnessed and that had been told to him by the elders.

In 1932 Melville Jacobs, an anthropologist from University of Washington, worked with Frank Drew and Jim Buchanan in the Florence area. In the summer of 1934, Homer Barnett worked with, among others, Spencer Scott, the son of Louisa Smith. Barnett collected information to fill out cultural traits lists for the Cultural Elements Distribution Study at the University of California, Berkeley.

In 1942 John Harrington of the Smithsonian worked with Frank Drew and Drew's daughter and son-in-law, Marge and Carl Severy, as well as Spencer Scott, Clay Barrett, and other members of the Barrett family who were of Siuslaw descent. Harrington's notes were not published but are available on microfilm.

In 1953 Morris Swadish, working with Clayton and Howard Barrett, and May Barrett Elliott, collected linguistic information from some of the last speakers of Siuslaw. In 1954 linguists Dell Hymes and his wife Virginia worked in Florence with the Barrett brothers and Billy Dick (25). Utilizing very limited early observations by some of these sources, Scott Byram and Bob Kenta have assembled an Oregon Coast Indian Database, with a section devoted to the Siuslaw area (26). The following draws largely from their work.

Coastal headlands, Coastal Lakes, Mouth of Siuslaw

Ten mile creek was considered the boundary between the Siuslaw and the Alsea. It was an important source of clay and was referred to as Tsi'imal or "clay land" Both the Alsea and the Siuslaw did ocean fishing, collected butter clams,

rock oysters and mussels in this area. Devil's Churn was another important area for collecting blue paint (Harrington interviews with Frank Drew).

A village, Pinnik, was situated 1 to 1.5 miles south of sea lion caves. There was an Indian camp at Big Creek ("near where Joe's crab stand was"). Clover Ridge (behind Munsell lake) was a major hunting camp. There was elk hunting north of Florence in the "open country" (an area quite possibly deliberately burned). A hunting area northeast of Mercer Lake was referred to as tsahautiita.

An historic homestead of Siuslaw Native Frank Drew is noted by Harrington at the mouth of Sutton Creek ¾ mile from the ocean a half mile up from an old shell midden. The old Sutton Creek village was called Tl'iiyax .This was a place where informants say they used gaffs to capture salmon as they swam upstream. Andrew Charles and Frank Drew mention a big village on the edge of Munsell Creek, and Spencer mentions that there was mussel drying and smoking west of Munsell Creek. Clay mentions a big prairie near Munsell where there was a big "shinny" ground (competitive game played between groups). Drew also mentions that several houses at Florence were built close together on the north side of the river. Marge Drew Severy recalls Jim Buchanan calling them as Quat-Quat "Many Large Crabs" and Quat Quat Clee or "Many Small Crabs".

Frank Drew refers to a village in the estuary (Glenada?) and Scholfeld mentions a Native coming from his residence on the south slough. George Kammon lived 3 miles above Cushman on the South Bank of the river at Duncan Slough or Cox Island and Margie Knowles mentions in a 1952 Siuslaw Pioneer article a remnant elk pit near Cushman (27).

Tidal North Fork and tidal main stem to Swisshome

Scholfield in 1854 mentions "the principal Indian ranch" five miles from the mouth of the Siuslaw on the North Fork. He also mentions a whale hunt (apparently the occasional stray whale entered the estuary) in which six canoes unsuccessfully tried to spear and shoot the whale. McLeod in 1828 ascended the North Fork and noted two Indian dwellings referring to them as the "first Chief Village". Frank Drew mentions that chief John had a fall home for fishing at qa!a-itc, 3-4 miles up the North Fork where there is "400 acres of marshland, now McCormick's place".

"Hauyat" (mentioned in Dorsey's list of Siuslaw villages) was the eel camping place of Siuslaw Dick (and many others) on North side of the river. Frank Drew talked of Indians building a box of twigs above Mapleton and "spring salmon jumped into that box".

Lake Creek

North bank 3mi upriver from Mapleton just above the mouth of Lake Creek is where John Mishel and his wives and daughters went for eels using willow eel traps. The Johnsons went 30-40 miles above tidewater into the coast range to catch eels.

Indian Creek and Deadwood Creek

There was a gathering place "picnic ground" at the Indian Creek falls ("riffle" may be a more appropriate interpretation according to Patty Whereat, Cultural Coordinator for the Confederated Tribes). Pioneer settler, Margie Knowles, wrote about Indian sweat-houses at the confluence of Deadwood Creek and the Siuslaw River (28).

Wildcat Creek

At Chickahominy Hill there were pit falls for elk (elk herds were driven towards deep holes covered with brush) . Martha Johnson (informant of linguist Morris Swadish) spoke of collecting eels on Wildcat Creek as a child.

Triangle Lake

Andrew Charles recalled elk pits and old fire pits and bones at Cummins camp near Triangle Lake. He also recalled a "shinny" ground in the area, and talked about it being a place for trading with Willamette Valley Indian groups.

Upper Siuslaw (Lorane Valley)

Mrs. William Smith, living on the Siletz reservation in 1884 gave 34 village names to Owen Dorsey; including "a village south of the site of Eugene City, below a large mountain." And "far up the river, near the site of Eugene City, Oregon" (possibly Lorane Valley or Triangle Lake).

This information may have led Beckham and Toepel to write "… it is likely that villages of Siuslaw-speakers or summer camp sites were not many miles away from the Willamette Valley, a short distance beyond the crest of the coast range of mountains." (29)

Siuslaw Culture

It is beyond the scope of this chapter to provide an exhaustive description of the language and culture of the Siuslaw. Based on relatively limited ethnographic data there have been a number of overview descriptions of Siuslaw culture. These include Zenk (30), Beckham (31), Beckham and Toepel (32), Mcaughton (33). Some of these cultural overviews draw from ethnographic data on the Coos and, particularly, the Lower Umpqua, who are considered to have strong cultural similarities to the Siuslaw.

The Siuslaw are near the southern tip of the Pacific Northwest Coast culture area .The southernmost grouping includes; the Chinook, Tillamook, Alsea, Siuslaw, Lower Umpqua, and Coos tribes (34). Their language belongs to the regional Penutian family, with the Siuslaw and Lower Umpqua speaking two dialects of "Siuslaw". Typical of coastal cultures, their surrounding geography is the river valley with highly confined, steep Coast Mountain Range slopes. This served to limit interactions with neighboring tribes to the north and south except along the coastal corridor. While Siuslaw interactions included intermarriage with the Lower Umpqua to the south, travel and social interactions were less frequent with the Alsea to the north. East-west river travel corridors may have favored trade and exchange with the Willamette Valley Kalapuya, at least in the late prehistoric and early historic periods.

Social/Political/Religious Systems

The Siuslaw had no central leader. "Chiefs" were men of relative wealth and influence. Highly valued prestige items such as woodpecker head feathers, dentalium, olivella, and abalone shell, and clamshell discs symbolized wealth and status. The society had three social rankings, high class, low class (people who held few wealth items), and slaves who were captured in raids or who had become indebted through gambling.

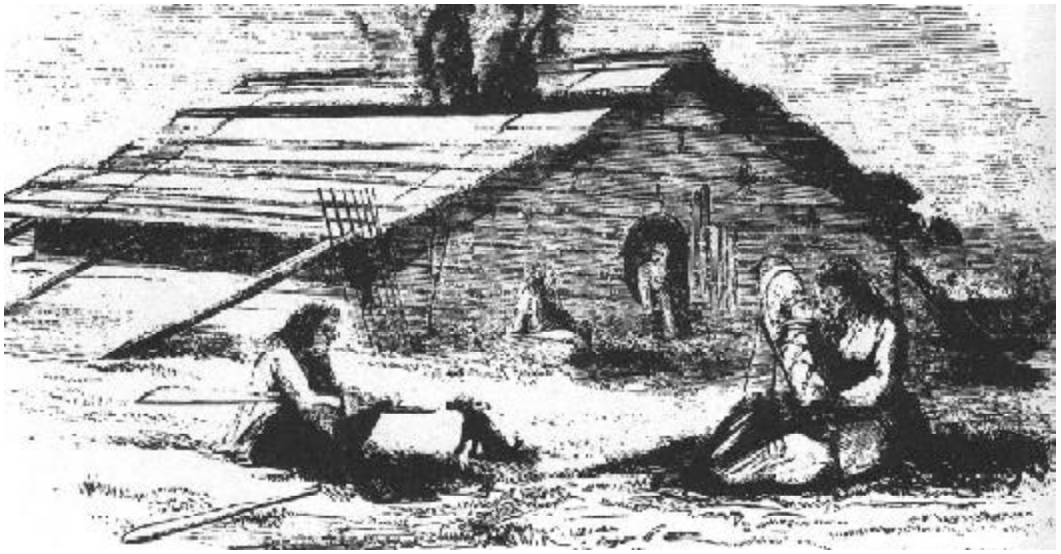
Status for a bride (and her family) was established by a presentation of large amounts of wealth items to the husband's family. Wealth was also important in the settlement of disputes between families. However, unlike tribes to the north, competition between families for status and prestige was not a driving force in the Siuslaw culture. Residential units were exogamous patrilineages (extended families who recognized descent through the father's line) which had access and responsibility for resource areas (possibly subbasin drainages).

Settlements had large cedar plank houses, or smaller woven mat or grass bundle covered houses. They were located along the rivers, usually on flat terraces near stream confluences, or near open prairies. Cedar plank houses were roughly 20 feet by 10 feet, but when several houses were joined they could be 50 feet or more long. Exterior walls were horizontal planks. The roof was a two-pitched gable roof held up by a single ridgepole. The inside was excavated 3-6 feet deep and lined and partitioned with woven mats. Raised sleeping platforms were covered with hides. Overhead racks were used for drying foods above the fire and for storing goods. A ladder led from the sunken living space to the door. Smaller plank-walled residences were covered by grass bundles or woven mats instead of a planked roof. Other structures included pit sweathouses and drying sheds for smoking fish, meat, and mussels.

The world of the Siuslaw was animated with spiritual forces which commanded respect, caution, or fear. Shamans functioned as the main intermediary between the general population and the spiritual world. Important ceremonies included cleansing rituals for menstruation, childbirth, death or a murder, the yearly first salmon ceremony, the first elk or deer ceremony for young men, and rites of passage for both young men and women. Large-scale inter-community ceremonies included feasts, dancing, games and gambling. Frequent references are made to the "shinny" grounds which were open fields were competing groups played a hockey-like game.

> The Siuslaw men wore a simple skin breechclout in summer; on some occasions naked. The rest of the year the men and boys wore buckskin breechclouts, fiber fringed skirts, fiber capes, otter fur or deerskin capes, rabbit fur robes, knee leggings, and, occasionally, one piece moccasins. Special clothing or decorative materials for their heads included fur headbands, fur caps, bird-skin headgear (probably with the feathers yet attached), and ornaments in their ears and nose

(Barnett 1937; 172-73; Harrington 1942).



Spencer Scott reported that the Siuslaw women wore a one-piece fiber apron, fiber capes, moccasins (in winter), leggings, and caps made of raccoon skin. They often tied their hair into two side clubs and wrapped it with mink strips or otter skin. Face paint was common among the Siuslaw. Frank Drew and Jim Buchanan reported that the Indians of the estuary obtained red ochre at a site near Cook's Chasm at Cape Perpetua (Harrington 1942; Barnett, 1937: 173).

Subsistence and the distribution of people to resources

It appears that the Siuslaw seasonal resource cycles may not have been as systematic as those described for the northern Northwest Coast cultures. There the social/political and religious nexus was the well documented winter village. For the Siuslaw there may have been no obvious seasonal movements of populations from the winter village to the summer, fall and spring residences.

Anadromous fish runs from the coast to the interior occurred over more than half of the year, beginning with fall Chinook and followed by Coho, Steelhead, cutthroat trout, finally ending with the lamprey runs in May. Spring Chinook runs may have extended this season even further. Fish were apparently taken by a wide range of techniques, from the river mouth to the upper drainage falls and riffles (spearing from boats, platforms, weirs, basket traps, nets, and clubs). Deer and elk hunting and berry picking took place in the late summer and fall in coastal headlands and interior forests.

An extremely wide range of plant materials, used for all facets of life were scattered throughout the drainage. Villages in the Triangle Lake and the Lorane Valley (possibly Siuslaw or Kalapuya) had access acorns, large amounts of camas and tar weed seed. Subsistence resources from the marine and estuary environment were available over the entire year. These included clam, mussel, oyster and barnacle collecting, as well as hunting of sea mammals. Sea weeds and estuary grasses could also be collected year round and are mentioned as winter foods.

Migratory birds were available in the estuary during both spring and fall migrations. This broad pattern of resource availability would have allowed for a more widely dispersed population over a basin 60 lineal miles and possibly 100 or more river miles from river mouth to the Upper Siuslaw headwaters. Informants mention the trade of collected resources not only between the Valley Indians and those who "had land" up Lake Creek but between the Lake Creek families and the families in Florence. Individual and group trade and exchange served to move both prestige and subsistence resources between geographic regions.

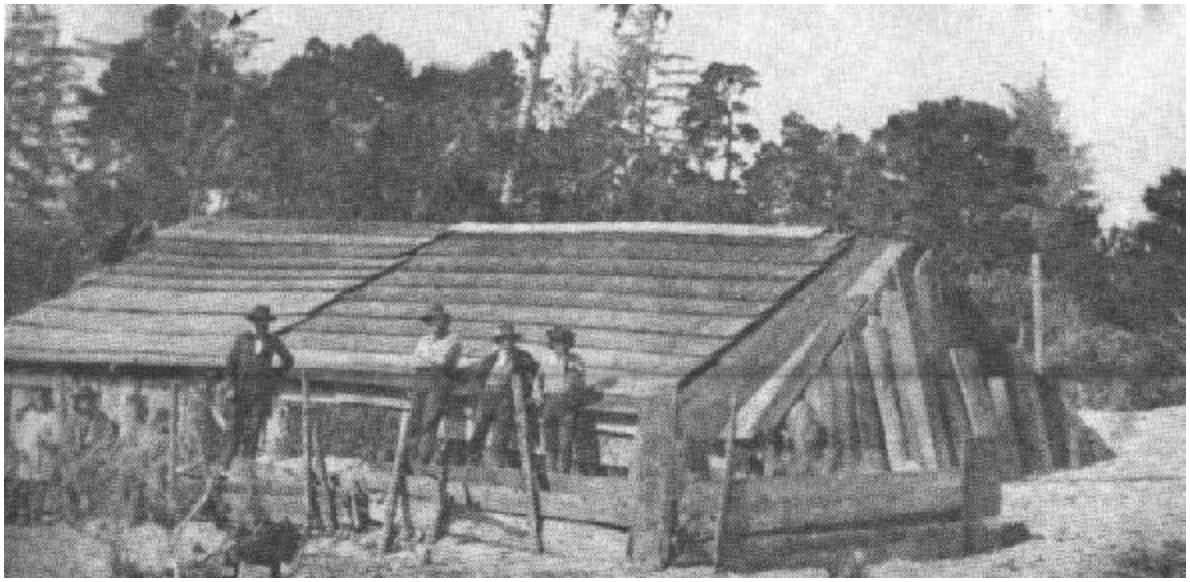
Distribution of people throughout the landscape

How was the prehistoric population distributed throughout the watershed? It is possible that the commonly used term "village" elicits visions of the large winter village of the northern coastal tribes. The English word "village" implies a habitation of somewhat "permanent" residence. It has been associated with the presence of numerous plank houses and secondary structures such as sheds and sweathouses.

Early observers, white interviewers, Native informants and writers, seem comfortable with the word "village". Mrs. Smith mentions 34 Siuslaw villages to Dorsey, Charles refers to the five or six Indian villages. Frank Drew talks about a big village at the edge of Munsell Creek. McLeod calls the two Indian houses he camped at "first Chief Village". There is a reference to a "principal Indian ranch", but also to camping places, hunting camps, and fishing grounds. Whether Native Siuslaw speakers used "village" to include a range of situations, is uncertain. Patty Whereat says that reference to a habitation or specific use site, and to places in the landscape in general, are referred to with a descriptive name which identifies an event or important resources.

Siuslaw territory extended more than 60 miles east of the river mouth, and people clearly moved in varying numbers from different residences over the course of the year. Jacobs, referring to the Coos, indicated that some people preferred residences further up the rivers and used these as permanent homes. "So these villages were by no means deserted, they were partially occupied all the time". It seems possible then that Siuslaw extended families had access to dispersed residences along certain tributaries from one end of the watershed to the other, with varying amounts of migration of individuals and groups over the seasons from the east extremes (oak, camas, tar weed valleys, salmon/eel river camps, upper elevation elk/deer/berry sites) to the west extreme (fish/invertebrate/sea mammal).

There are no historic observations of a Siuslaw village comprised of more than two houses. This, of course, is within the context of a population reduced to perhaps one tenth of its aboriginal peak with the possibility that the communities reorganized and consolidated toward the coast. The Siuslaw "village" may have included one or more plank houses, one or more reed bundle or grass mat covered houses and these "residences" may have been anywhere in the territory where important resources were located and they may have been used at various seasons by large or small numbers of people.



Impact of Siuslaw subsistence on the landscape

Despite over nine thousand years of known occupation within the watershed, the Siuslaw left behind few visible alterations to the landscape. Fire as a vegetation management tool, estuary weirs, residence middens, and selective plant management did alter the landscape to some degree. Fire management was used by Native Americans for at least the last thousand years (and possibly going back 20,000 years in North America). The use of fire as a vegetation management occurred in the Siuslaw drainage in both the forested hill slopes (for the maintenance of berry patches) and in the open valleys to the east for maintenance of the oak savanna and camas meadows. Fire was also necessary for harvesting tar weed seeds, which was a highly valued food for the coast communities. The region in general experienced periodic large, stand replacing forest fires, some of which may have been inadvertently caused by Indian burning. Far to the north Lewis and Clark reported one vast burned area which had disastrous effect upon the subsistence base for the natives in the region. A large-scale fire of the 1830's has been noted for the Central Coast Range.

Scott Byram, who has documented and extensively researched fishing weirs in

the Coquille and the Siuslaw, suggests that the placement of weirs may have resulted in trapping of sediments in the estuary channels, and the subsequent build up of the estuary plain. This in turn could have resulted in lower gradient flows, thus increasing channel sinuosity and favorable fishing conditions.

Structures were built on "natural flats," either flood plain terraces or landslide terraces. Shell, bone, fire-cracked rock and other refuse created middens which added to terrace dimensions.

Cultural and religious restrictions probably acted to limit over harvesting of resources. The first salmon ceremony, which was performed as the first run of salmon entered the rivers, was done to help insure that a sufficient population was able to pass upriver. This opportunity for survival may have affected the genetic preference for earlier runs over time.

Selection, protection and maintenance of important plant communities undoubtedly influenced the botanical composition of the landscape. The Siuslaw utilized an extremely wide range of plant materials for food, clothing, medicine, building materials, rituals, containers, cordage, canoes, and tools. Margie Knowles, writing about Siuslaw weaving, said:

> *Cedar, willow or yew wood were used in making large baskets. Iris, squaw grass, nettles, dogbane and many other tough grasses were pounded into a soft mass and the fiber employed in making strong threads for use in weaving cloth, hats, pouches, cooking baskets or stout string. When woven into ropes these were strong enough to hold elk though the rope was not larger than the little finger* (Knowles 1952:13).

See also Patty Whereat's extensive list of native plants, names and uses.

Early contact history, land loss and current Tribal status

It is likely that the during the 1700s the Siuslaw had brief contacts with Chinese fishing vessels- (based on the presence of early Chinese coins). They also likely met with the Spanish explorers traveling along the coast.

By the early 1800s the fur trade was at its most intense, with British and American traders establishing regular contacts with virtually all of the coastal tribes. In the mid 1850s government agents were assigned to the Siuslaw, Lower Umpqua and the Coos. Gold miners and homesteaders in the south were engaged in a war of annihilation with the Rogue River Indians and hysteria spread through the European settlements. In 1855, Superintendent of Indian Affairs, Joel Palmer, gathered the leaders of the Siuslaw, Lower Umpqua and Coos and offered them a reservation and $90,000 in amenities if they would agree to give up much of their territory.

Congress never ratified this treaty but the Siletz reservation was established by President Pierce for the relocation of many central, southern and coastal tribes. Between 1856 and 1859 the Coos and Lower Umpqua were relocated to the reservation. Most of the Siuslaw remained in the vicinity of their old homes. Over time many of the surviving Coos and Lower Umpqua drifted off the reservation to settle on the Siuslaw with friends and relatives. Many of the Siuslaw applied for land allotments, but the Forest Service opposed many of these on the grounds that they were not suitable for agriculture. Others applied for Indian Homesteads. Seven Indian allotments are recorded for the Siuslaw in 1913. Some of these allotments were sold and others converted to fee title.

In 1893 the issue of the non-ratification of the 1855 treaty was referred by the U. S. Senate to the Secretary of The Interior. Commissioner Morgan of the Bureau of Indian Affairs responded:

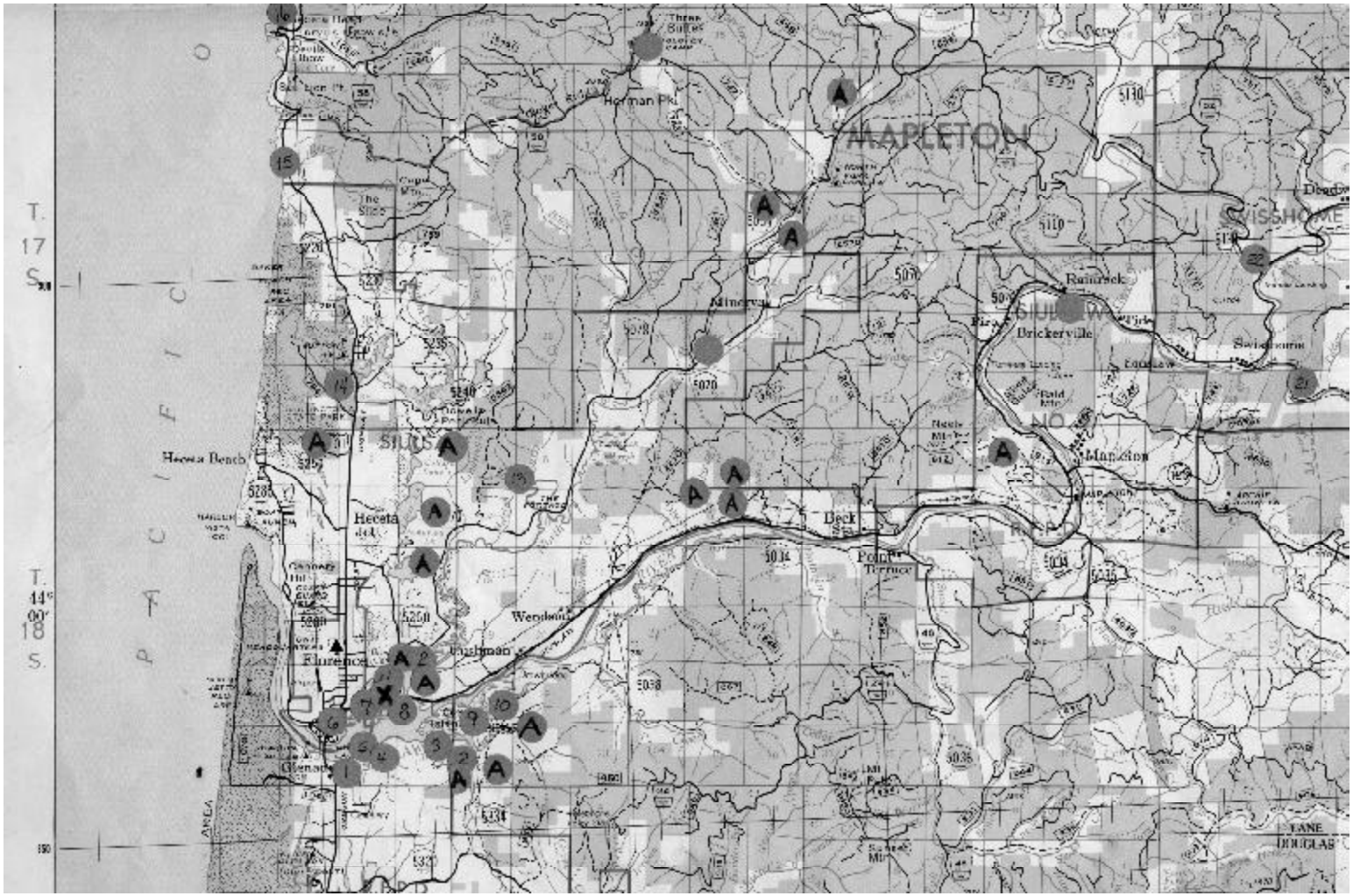
> "from these reports and records I think it is fair to presume that the government has never paid the Indians the amounts stipulated for in the treaty of 1855, which failed to be ratified by the Senate, but the provision of which appear to have been faithfully adhered to by the Indians themselves…"

Legal attempts to receive compensation for the lost lands over the following decades were unsuccessful. In 1956 the Federal government terminated tribal status of the Confederated Tribes of the Coos Lower Umpqua and Siuslaw. With much effort, tribal status was restored in 1984 (35). Today the Confederated tribes have, within the Siuslaw watershed, one 99 acre parcel and a .03 parcel in Florence. The tribe is currently attempting to regain a small part of its former land from the government, on what is now the Siuslaw National Forest.

Archeological Research and Prehistory Data as Resource Capital

The pre European occupants of the Siuslaw watershed were able to utilize a very wide range of resources and employed technologies to successfully survive over nine thousand years without adverse impacts to the productivity of the environment. It is important for us to understand this relationship between human residents and the environment. Some of that information lies beneath the surface in the habitation sites of the early occupants. Currently there is a very meager prehistoric record available for a reconstruction of Siuslaw prehistory. Even though one informant mentions 24 "village" names and early observers give us some indication of the location of habitations in the 1800s there are no Siuslaw villages located to date.

Ideal habitation sites are on wide, flat alluvial terraces, most frequently at the confluences of major streams and tributaries on valley bottom land. Most of these locations have been homesteaded and farmed since the turn of the century and many of the surface features of Native Siuslaw sites are no longer obvious. Many early residents recall projectile points, materials from hearths and middens such as fire cracked rock, charcoal, bone fragments, or mortars and pestles being plowed up. Other indicators of sites may have been seen in eroding stream banks.



Map 3.1 General locations of historical significance

In order to recover this important information, landowners within the watershed should come to understand the incredible value these potential archaeological sites have, not merely to the scientific community but to all of us living within the watershed community. While the history of occupation by the ancestors of the Siuslaw Tribe is a tribal history and a history of the previous stewards of the land, it is also a human history for all Siuslaw residents.

As we struggle with failing runs of anadromous fish and degraded water quality, an understanding of the aboriginal system of stewardship becomes critically important to all of us. State of the art, scientific excavation and analysis of habitation sites within the watershed has the potential to more accurately and completely reconstruct the history of native land use. This information may provide us insights into a stable and sustainable relationship between a culture and an environment.

Footnotes

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2. Minor, Rick, pgs 33-40, 1985.
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4. Oniell, B., Connolly, T. and Freidel, D., 1999.
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11. Personal communication June, 2001, with Patty Whereat, Confederated Tribes.
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14. Thomas, R.G., 1991. Note; the author interviews local landowners who have located large numbers of projectile points and mortars and pestles within a three mile radius of the town of Lorane.
15. SHPO site number 35-LA-1038, BLM Coast Range Cultural Resource Site Record OR-09-188
16. Private collection of Carroll E. Kirk, personal communication
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19. Beckham, S., Minor, R., Toepel, K., 1981
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25. Toepel, K pages 97-100, 1981
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27. Knowles, M., page 9, 1952
28. Knowles, M., page 14
    Steinhauer, page 1 “At the mouth of Deadwood Creek, a shallow hole, about six to eight feet wide and fifteen feet long, marked the site of a sweat house, which the Indians used as late as 1878. Also near the mouth of Deadwood, early residents found hundreds of arrowheads.” From interviews with George Birkshire and Marie Johnson, 1971.
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SOCIOECONOMIC HISTORY OF THE SIUSLAW WATERSHED, 1850 - 1950[1]

This chapter provides a 100-year history of the settlement and development in the Upper Siuslaw (Lorane), Lake Creek, Wolf Creek, Wildcat Creek, Indian and Deadwood Creeks, Lower Siuslaw River and Florence areas. It is a history of the struggles and challenges of individuals and families but it is also a history of the process of change occurring throughout the watershed. The history illustrates the relatively rapid social, economic and infrastructure expansion into the watershed from several directions until the entire region became linked together and linked as well to the larger external community. This process resulted in major changes to the watershed landscape and ultimately had impacts upon the productivity of several species of salmon, which, to some, symbolize the wild and abundant resources of the Pacific Northwest.

Early Euro-American exploration and settlement

Explorers employed with the Hudson's Bay Company were some of the first Euro-Americans in the Siuslaw Watershed. In 1826, Alexander McLeod traveled up the Siuslaw and the North

The Siuslaw Pioneer Museum

Arnold, Bella and Wilhelm Karnowsky in front of their homestead.

Fork trapping beaver for the Hudson's Bay Company. Other travelers in the area during that time, including David Douglas, noted evidence of widespread fires in the basin as well as giant trees. Nathan Scholfield of the Klamath Exploring Expedition, 1850-1853, noted that the bottomlands in the watershed were excellent, as he and his party searched for gold and for an interior route to the Willamette Valley.

Originally, all of the coastal lands between the south end of Tillamook Bay and the mouth of the Umpqua River were off limits to Euro-American settlement. Pressure to open tribal lands for Euro-American settlement were intense and in 1865 a wide swath was cut through the center of the Siletz Reservation in order to permit the construction of a railroad between the Willamette Valley and Newport on Yaquina Bay. In 1875 the Alsea subagency was closed by the Oregon legislature and the entire southern portion of the reservation, including lands that were previously the territory of the Siuslaw, was thrown open for settlement.

With the opening of the Siuslaw lands, settlers could take advantage of the Donation Land Act of 1850, which allowed free land for settlers. In addition, the 1862 Homestead Act allowed homesteaders to purchase 160 acres for $1.25 per acre or 80 acres for $2.50 per acre. By meeting residency and improvement requirements, homesteaders could purchase the land for a small filing fee. Settlers moved into the Siuslaw watershed and set up subsistence farming homesteads as well as timber production.

Settlement and Farming

The first Euro-American settlers were attracted to the Siuslaw basin because of abundant salmon, lush forests and the temperate climate. The Illustrated History of Lane County, Oregon, described the Siuslaw region in 1884,

> Immediately along the watercourse and its tributaries, there are numerous small level valleys or bottoms of the most fertile soil, suitable for the production of vegetables and cereals. The hills are all of sufficient fertility to subserve grazing purposes while there are many good locations for dairies to be found. The forests of timber, valuable for lumbering purposes are very extensive, and the tributaries of the Siuslaw River, spreading, as they do, over a large area of

> country, afford better means for floating logs to market, than is to be found at any other harbor along the coast. The lumbering interest here, alone, are of ample importance to warrant the opening of the country, and as an example we may look at the lumber trade and ship building carried on at Coos Bay.[2]

As settlers moved into the region, they did so with an eye on converting the vast natural resources into a livelihood. Many of the early newspaper articles failed to mention the challenges of the heavy rainfalls or the fast rate of vegetation growth that settlers combated on a regular basis. As one historical accounting of the settlement of the Siuslaw Valley stated in 1884, "These pioneers at once commenced transforming the wild unclaimed lands into what it appears today—a valley of pleasant homes and pastoral prosperity."[3] Instead, the early reports concentrated on the vast natural resource base, which sustained the population from1850 to 1950 and beyond. Indeed, many romanticized, "Great Oregon, the land for opportunity for farms."[4] One Siuslaw pioneer who traveled from Pennsylvania to live in Oregon, George Beers, had dreamed as a boy, "of the great Oregon Territory and at the possibilities of a new life of adventure and the money to be made there."[5] For many, living along the Siuslaw and its tributaries was too strenuous, and they departed after a short stay. Many others embraced the pioneering spirit and their descents live in the watershed today.

Many settlers came from foreign countries or from eastern and Midwestern states. They found fertile land on which to farm and raise their

Siuslaw Pioneer Museum

The Karnowsky family homesteaded 6 miles upriver from Florence in 1885.

families. But most Euro-American settlers in the region survived by subsistence farming as larger commercial crops were difficult to maintain, with the exception of the Lorane region. Later settlers in the lower sections of the Siuslaw were able to augment their incomes by working in canneries in the late 1800s and early 1900s. Almost all settlers cleared portions of their land for timber, and many worked as loggers or in any number of the hundreds of mills that dotted the watershed between the 1870s and the 1950s.

One early homesteader on upper Sweet Creek claimed, "This was wild country, but the people were hearty." [6] Homesteaders in the late 1800s and early 1900s had to be hearty to survive in the isolated Siuslaw watershed. One of the first homesteaders, William Martin, built a log cabin in the Upper Siuslaw Valley in the neighborhood of present-day Lorane in 1850. Martin stayed in the watershed for a few years, however he was quickly replaced by the influx of pioneers traveling to Oregon in the hopes of acquiring good land to farm in the famed temperate Oregon climate. By 1854, claims had been staked throughout the Lorane valley, claiming the best land. Transportation to Cottage Grove was relatively good for residents in Lorane, who could get any surplus goods to Willamette Valley markets, at least during the dry summer months.

Euro-American settlement in the western Siuslaw watershed lagged some 40 to 50 years behind settlement in the Willamette Valley. There were several reasons for this difference in settlement dates. The majority of the Siuslaw watershed was Indian Reservation lands and not available for settlement until 1875. Also, the problems associated with carving out a homestead were rigorous under the best of conditions; in the Coast Range these problems were particularly daunting. Perhaps the most important were differences in physiographic character and vegetation between the Coast Range and the Willamette Valley. While the Willamette Valley and the Lorane Valley contained broad tracts of gently rolling terrain covered with prairie grass or oak savannah, which were amenable to agricultural pursuits, the heavily forested and steep, dissected terrain of the Coast Range did not lend itself to agricultural endeavors. Even the small tracts of level land along the stream valleys required much arduous labor to clear the timber before crops could be planted. Roads, where they existed, were little more than ribbons of mud much of the year, making it difficult to bring supplies and equipment into the homesteads and to haul surplus crops to market.

Lack of transportation and ready access to a market for agricultural products also hampered

settlement in the Coast Range. The first settlers had to rely on pack trails to move goods in and out of their domain and, although these trails were quickly upgraded to wagon roads, they were nevertheless impassable quagmires for six to eight months of the year. As a consequence, most Coast Range homesteaders practiced a subsistence lifestyle that relied on the produce of a large garden and wild game and fish.

By the late 1870s, settlers were working up the Siuslaw River from the port town of Florence and all farmable land up to the tidewater was claimed by 1882. These farmers logged valley bottoms and drained them for subsistence farming, which often meant channelizing streams along the edges of valleys and filling wetlands. Just a few of the crops and livestock raised at different times throughout the watershed included sheep, dairy, cows, goats, turkeys, chicken, hogs, rabbits, hay, wheat, oats, apples, pears, prunes, corn, filberts, and hops.

Before the 1920s, most farming was done by teams of oxen, horses, or by hand. Tractors became common by the 1940s, as mechanized farming replaced manual methods. Barns were necessary to store hay out of the wet winter rains.

Ione Reed settled with her husband on her father-in-laws farm in 1927 along Knowles Creek 10 miles from Mapleton. She commented on the simple life her family lived,

> In these days of expensive necessities for a comfortable life it's difficult to imagine the ease with which Ike and I lived on almost no money during our early years on the ranch. We had no rent or taxes to pay and Bert (Ione's father-in-law) took care of the food, which was fair enough since Ike received no wages. We had our own beef and veal, port, hams, sausage and lard, not to mention bear grease, deer meat and fish. The old orchard gave us apples and pears, and we made cider with a press that Bert had brought along. Visiting relatives or friends often brought such luxuries as peaches or grapes. From the garden came potatoes and squash and all kinds of vegetables to be eaten fresh or canned.[7]

The Cartwright house in Lorane was used as a post office and telegraph office during the civil war until 1875.(Photographed in 1945)

Life could often be hard for pioneers during the years between 1850 and 1950. The isolation, rough roads, the need to educate their children, and difficult economic conditions discouraged many settlers and sent them packing back to cities or to relatives with established farms in other parts of the country. But they were always replaced with more settlers. Homesteading continued in the Siuslaw throughout the 1920s and1930s. A flurry of Homestead Entries was filed during the Great Depression and entries continued to be patented, albeit at a much reduced rate, as late as 1940.

Young men were lured to serve in the army or work in factories and mills during World War I. Although some returned to the farm after the war, many others remained in the towns and cities where the burgeoning post-war economy created well paying jobs. However, during the Great Depression people returned to their family farms. The later economic recovery stimulated by the onset of World War II was the beginning of the end for most of the small farmsteads in the watershed. As the economy improved during and after World War II, jobs in factories and mills or on logging crews offered opportunities to earn wages that far exceeded the income possible from a small back-country farmstead. As families began to leave the watershed, large timber companies began to buy up the abandoned homesteads.

Timber Harvesting in the Watershed

One of the first activities that settlers undertook once arriving in the Siuslaw watershed was to clear a portion of the land for a homestead, gardens and pasture. The logs felled were used for houses, barns, fences and a variety of other structures. Personal use of lumber was quickly replaced by commercial timber harvesting. Hundreds of mills, large and small, sprouted up throughout the watershed soon after settlers

arrived. Some of these mills operated for just a few weeks, others for many years.

Timber harvesting technology dictated where, when, and how trees were cut. Valley bottoms were the first areas to be logged, primarily to make way for homes and pastures. Log transportation in the late 1800s up until the late 1930s was dependent on streams feeding into the Siuslaw River. Until the coming of the railroad from Florence to Eugene in 1914 and major road improvements and the invention of log trucks in the mid 1930s, water was the only way to transport logs downstream to mills along the banks of the Siuslaw and then shipped out of Florence. Streambed clearance of debris was widespread throughout the watershed to allow logs to freely move downstream. Lower slopes along creeks were generally the next area to be logged. The upper slopes had to wait until the 1940s for better road building techniques and log trucks before the trees high on the hills could be harvested and transported to far away mills.

Small mills were scattered throughout the watershed and many operated for specific building projects or were moved once the logs in the vicinity were logged out. In 1913 Assistant Forest Ranger Simmons described North Fork logging. "The method of logging now in use . . . is to follow up some drivable stream and log only the readily accessible timber that can be reached by extending yarding lines out from a donkey engine placed along stream."[8] There the logs would wait for high water during winter storms to transport them down to the Siuslaw River and the mills along its banks.

Bill Cunningham's mule team hauls water in the Wildcat area.

While donkeys continued to drag and cold-deck logs in the canyons, crawler tractors became the common method of transporting logs from the cold-decks to the river between 1930 and 1950. Tractors operated both on the stream banks and directly in the streams degrading riparian and stream habitat.

Most of the logging between 1850 and 1925 in the watershed occurred primarily on private lands. Logging of national forest lands began in the early 1900s, though no records were kept until 1922. The Siuslaw National Forest was created on March 2, 1907, when President Theodore Roosevelt signed an Executive Order adding 16 million acres to the forest reserves, just days before Congress took those powers away from the President. In 1916, lands on the eastern portion of the watershed came under federal management through the Chamberlain-Ferris Act (which revested about 2 million acres to the federal government). Those lands came under management of the Bureau of Land Management in 1946. Small sales were negotiated with land and mill owners and all harvests were concentrated near the valley bottoms and lower slopes.

The Mapleton Ranger District records show that only 38,000 board feet was harvested from National Forest lands during this period. This number drastically decreased in the 1940s; only 115 acres of timber were harvested from National Forest lands.

Life was challenging and often hazardous for the men cutting timber. Accidents were common and sometimes fatal. Pay for workers plummeted during the Great Depression. Kermit Sams, a worker in the Chambers Mill in the Lorane Valley, recalled pay for the typical mill hand, "The average pay for mill workers in the early 1900s was $3 to $4 a day working in the mills and up to $6 a day for working in the woods. But once the depression hit, wages plummeted. Workers were lucky to make "two bits" (25 cents) per hour . . ."[9]

Wood products from the Siuslaw area found their way throughout the United States and even around the world. Poles processed at the Bill Moore Lumber Company in Lorane were used as light poles and shipped all over the United States by railroad during the 1940s. Wood from the area was also shipped as far as Hawaii.

The first salmon cannery was established in Florence in 1877.

Fish Harvesting in the Watershed

While the Siuslaw Indians had used the resources of the river basin for food and shelter on a subsistence scale for millennia, the new occupants began converting resources to commercial products within a few years of settlement. Salmon runs in the early 20th Century are thought to be one of the largest in the Northwest. Three salmon canneries were established in Florence along the Siuslaw River and operated from the 1880s until the early 1900s. By today's standards, the catch numbers were enormous. It is estimated that the annual catch during the lifetime of the canneries was approximately 4,500 Chinook salmon and 60,000 Coho salmon per year. From 1887- 1892 over 68,000 cases of Siuslaw salmon were packed and shipped to markets in Portland or San Francisco.

George Duncan built one of the first sawmills and canneries on the lower Siuslaw in 1876. The cannery broke down shortly after it was opened due to shifting sands, but was up and running again by 1879. It is likely that Chinese laborers worked in this cannery and the others in the vicinity. The canneries also employed locals.

Early cannery records document the relationship between fish abundance and habitat conditions. It was estimated that between 1889 and 1896, approximately 11,000 Chinook salmon and 87,500 Coho salmon were harvested per year from the Siuslaw River. With a catch efficiency assumed to be about 40 percent at that time, runs of Chinook and Coho salmon in the Siuslaw River in the 1890s would have been about 27,500 and 218,750 respectively.

Gill netting resulted in large salmon harvests from the main Siuslaw River. It became clear early on that the numbers of returning salmon were declining. Although regulations were placed on the fishery to help conserve salmon runs, there was little enforcement and the regulations were largely ignored. The first hatcheries were built on Sweet Creek and Knowles Creek before the 1900s in an effort to increase the number of harvestable fish. These efforts had little effect. Gillnet licenses were required as early as 1899.

By 1914, the number of fish being caught for the canneries had plummeted and eventually dwindled to levels too low for commercial cannery operation. In an effort to eradicate predators and increase fish numbers, fishermen attempted to destroy the seal population that lived at the mouth of the Siuslaw by using dynamite. Over 100 seals were killed during one episode.

Commercial salmon fishing continued on the Siuslaw River at a much smaller scale than in the early 1900's and provided fish for non-cannery markets. The Oregon State Fish Commission began restricting river fishing intensity and methods in 1939. Commercial fishing was closed on the river in the 1950s. But the fishing pressure simply moved out into the open ocean. The last cannery in the Basin closed in 1956, as numbers of returning salmon continued to decline. In mid-1990, all commercial fishing of Coho salmon was stopped. Today's runs of Coho salmon are no more than five percent of turn of the century runs.

Transportation and Road Construction

Traveling the first Siuslaw watershed roads was often a harrowing experience. Winter travel was muddy and not advisable. The worst roads were made passable by putting down puncheon. Puncheon roads were made of hand split logs laid crosswise in the road for the wagons to roll over. An article dated May 1904 states, "Wagons passed through Nelson bottom sometimes, but it is said that in parts of the road the drivers hair stands up straight enough to raise up his hat as he climbs over logs or goes down into mud holes."[10] Early roads were often built on sides of foothills for drainage. Roads along valley bottoms were often impassable six to eight months out of the year because of heavy rains and mud.

In 1878, the settlers of Lower Siuslaw presented a petition to the Lane County Commissioner's Court requesting a wagon road to the Willamette Valley. In 1879, a route was surveyed that would travel southwest from Elk Prairie (present day Hale Valley), a few miles west of Noti, over Cougar Pass to Wildcat Creek, then follows Wildcat Creek to the Siuslaw River (along present-day State Route 126), and follows the Siuslaw River to the confluence with Lake Creek, at present-day Swisshome. Construction of the route took longer than expected due to difficult traverses below rocky outcrops and the lengthy stretch following the winding path of the Siuslaw River. Even with a well-mapped route, travel was treacherous.

In 1896, a stagecoach route was established between Seaton (now Mapleton) and Junction City, and by 1914 a railroad was completed between Florence and Eugene, providing for more convenient transport of goods in and out of the area.

The state Department of Transportation had been slowly improving the road from Florence to the Willamette Valley, beginning in 1929 with the stretch from Cushman to Rainrock and completing a second improvement in 1936 from Florence to Mapleton. The major route to the Valley continued to be along Lake Creek (present-day State Route 36) to Blachly for many years. It was not until 1955 that a road was tunneled through the hills east of Mapleton to provide a direct route to Noti. This new road (State Route 126) surmounted one of the last barriers for easy access and transport of logs to mills in the Willamette Valley.

The development of a transportation infrastructure eventually linked the individual watershed subbasins. These highways and railways quickly accelerated the population growth and economic development of numerous communities. Improving infrastructure transformed clusters of small homestead farms into towns with schools, post offices and businesses of every kind.

The following sections briefly describe the unique histories of homesteading, logging, fishing and transportation in each of the Siuslaw subbasins.

Florence

Fishing, timber and catering to Siuslaw watershed settlers dominated activities in the city of Florence between 1875 and 1950. Florence became a critical transportation hub as shipping large quantities of supplies in and out of the watershed by boat was the only option until the railroad was extended to Florence from Eugene in 1914 and the roads were improved in the 1930s. A post office was established in the settlement of Florence in 1879, and the town was platted in 1893. By 1928, Florence had a population of 300 people and 100 homes. Farther up river, Cushman had a population of 200 people.

Early settlers depended on stores in Florence for supplies that they could not make themselves. In addition, coming to town provided a social outlet and an opportunity to go to saloons, dances, plays, and to festivals. Florence was a portal for goods, as well as people, who arrived and departed to and from ports in San Francisco or Portland.

During the 1880s and 1890s fishing developed into a major industry along the Siuslaw River. Financier George Duncan, for whom Duncan Slough and Duncan Island are named, started the first cannery in 1876.

Oscar Hurd opened one of the first canneries in Acme in 1882. He also had a cannery at Rose Hill, on the south shore opposite the North Fork of the Siuslaw River. Fires plagued many of the canneries that his company, the Hurd Lumber and Navigation Company, owned. One cannery that

was burned in 1908 was rebuilt as a co-op with local fishermen buying stock in the cannery. Approximately 25 to 30 fishermen joined the co-op. In 1912, discontent within the co-op led to two boards of directors to be elected, one headed by Oscar Hurd and the other headed by F. W. Carey. When Carey leased the cannery to investors in Astoria, Hurd refused to give up possession until warrants were issued against the watchmen that Hurd had hired. Additional disputes disrupted canning, including worker strikes. Workers went on strike for approximately one month in 1895. The strike ended peaceably.

William Kyle started a cannery in 1894. He brought Chinese laborers from Astoria each canning season. They stayed for approximately three months. They would often come before the cannery season began to make fishing nets. They also made the salmon cans by hand. Fire destroyed many canneries and mills throughout the late 1800s and early 1900s; Kyle's cannery burned in 1901 and was rebuilt soon after the fire.

The need to improve the safety and expand the capacity of shipping in the Siuslaw led to the construction of a jetty at the mouth of the Siuslaw River. Jetty construction began in 1892 with "the installation of a receiving wharf, a tramway and locomotive, a fifteen ton hoisting derrick, a pile driver scow, all at the river mouth, and the development of a quarry up the river at Point Terrace as a source of rock for the jetty, and the construction of scows for transporting the stone to the jetty."[11] The jetty was finished in 1918.

Extraction of natural resources was dependent on Florence as a processing and commercial center.

1927 Florence House

The Siuslaw Oar in 1938 commented on the perceived strength of the timber industry in the Siuslaw watershed after a fire destroyed the Hurd mill, "Florence was once destined to be a city of thousands. Its timber resources are incalculable to the ordinary mind. The mill was here and investments were made readily. There was no better mill at that time along this part of the coast and commerce on the river was really good."[12]

Lower Siuslaw River

The relative ease of navigability of the Siuslaw River, compared with the overland route from Eugene, made large tracts of bottomlands attractive for settlement. By 1882, most land along the tidewaters of the Siuslaw was homesteaded. A map by Joseph Koch in 1894 shows most land was claimed along the Siuslaw River bottoms as well as four miles up Sweet Creek, all the way up Knowles Creek, five miles up Hadsall Creek, and three miles up Bernhardt Creek. The initial development activity in these areas was the clearing of woodlands for pasture and crops.

The first saw mill was established near Florence in 1879; logging was conducted by teams of horses and oxen. Steam powered logging was introduced in the 1880s. Between 1880 and 1910 splash dams were used on Knowles Creek, "run-of-the-river" drives on the Siuslaw River, lower Sweet Creek, and lower portion of the creek flowing into South Inlet. By 1897 there were four mills on the river and lumber was being shipped by schooner to San Francisco. A boom was linked across the river seven miles below the head of tide to catch logs as they were floated down the Siuslaw. By 1900 four mills on the lower Siuslaw had a combined capacity of 200,000 board feet per day. Over 125 log brands were registered to drive logs on the Siuslaw River and its tributaries.

Mills at Cushman at the turn of the 20th century included the Siuslaw River Lumber Co. and the Saubert mills, in Glenada, David & Son's sawmill, and in Florence the Spruce Point Mill. Additional mills along the lower Siuslaw included the Yellow Fir Lumber Company outside of Florence, The Huntington Shingle Company Fir Mill in Mapleton, the Swenson Mill and the Siuslaw Valley Veneer in Swisshome, and the Erskine Lumber Mill in Tide.[13] Schooners would often bring in freight for farmers, fishermen and timber harvesting, and leave loaded with fresh cut lumber bound for San Francisco, Portland, and points beyond.

In 1892 Tom Saubert's mill began operations. By 1902 the mill was closed for lack of logs. Mayer and Kyle built a larger mill in Florence that produced over seven million board feet of lumber. By 1911 there were two mills at Acme.

By the 1930s there were hints that larger lumber companies were interested in moving into the watershed and buying up huge tracts of land. The local newspaper reported, "Rumor is current that the various owners of large timber tracts on the Siuslaw are endeavoring to get the timber under the control of one head. It is presumed, if this is accomplished, that it would warrant the establishment of a big mill somewhere on the Siuslaw." [14] In 1937, Arthur Sherman Davidson came to the Siuslaw River area. For almost half a century, Davidson Industries employed many residents along the Siuslaw River and its tributaries. Along with Davidson Industries, LaDuke Lumber Company was a major employer in Cushman in the 1940s. They made many improvements and upgrades to the mill that occupied the old site of the Saubert mill years before.

By the 1940s, Florence had at least 17 mills. Siuslaw lumber was shipped all over the world. Local mill owners eagerly awaited the opening of the Panama Canal in the hopes of shipping lumber to the eastern seaboard. Lumber was also shipped to England.[15]

Indian Creek and Deadwood Creek

Prior to 1881, there were no reports of settlers above the mouth of Lake Creek. The earliest settlers to the lower Lake Creek area came from towns like Gardiner on the coast south of the Siuslaw River, since the area was relatively inaccessible from the Willamette Valley for anything but packhorses. One of the lower Siuslaw River settlers was impressed by the bottomlands found along Lake Creek and its tributaries. In June 1881, Rev. Cary A. Wooly wrote:

> The narrow bottoms of rich lands extending up and down the Siuslaw, the Lake Creek and their tributaries, will furnish houses for four to six hundred families... the timber resources of the Siuslaw and Lake are almost inexhaustible, while their waters abound in delicious fish.[16]

With such favorable reports, some of the local settlers requested surveys of lands beyond the mouth of Lake Creek. The earliest settlers to the area claimed the choicest, most convenient lands along Lake Creek between the mouths of Deadwood and Nelson Creeks (just east of the Indian/Deadwood watershed). As lands along the Siuslaw River and Lake Creek became occupied, later settlers began exploring the bottomlands along tributaries.

The first settlers to the Indian/Deadwood area found suitable land near the mouth of Deadwood Creek. John Whisman was the first to make improvements on a claim in September 1881 and established a residence in November 1882. Only one early settler was reported coming into Deadwood from the north, via Five Rivers. Ben Kilgore developed a homestead in 1887 about 11 miles up Deadwood Creek without realizing other settlers had developed homesteads about six miles downstream from him.

The completion of a road from Florence to the Willamette Valley (present-day State Route 126) in 1884 produced a steady stream of Valley residents who began making the difficult trip to the lower Lake Creek area.

Wagon routes to the lower Lake Creek area improved slowly between 1884 and the early 1900s. By late 1884, the Nelson Mountain Road was declared a "public highway," providing an alternate route to Lake Creek from Elk Prairie, ending at the mouth of Nelson Creek. In 1887, bridges were built to cross Nelson Creek, Deadwood Creek, Indian Creek, and the mouth of Lake Creek at the Siuslaw River. These made access and travel along Lake Creek and to the Willamette Valley much easier and extended the travel season into the winter months. By 1889, roads opened up Deadwood Creek and Lake Creek east to Blachly.

By 1890, all the best bottomland along the first five miles of Deadwood Creek was settled, and by the early 1900s about 100 families lived up Indian Creek. The early settlers used the land's resources to provide housing and food. They had small gardens to meet household needs and hay was grown to feed stock animals. A few raised fruit, potatoes or other crops for sale, but only in small amounts. As ground was cleared of forest vegetation, cattle were brought in for milk, cream, and meat.

Most of the settlers sought employment to supplement their meager farm incomes. Some worked at the fish canneries on the Siuslaw River, some worked at the small lumber mills, others worked at farms in the Willamette Valley. Illnesses and difficult living conditions affected most of the early settlers and few remained for longer than about 5-10 years in the area.

The first logging in Indian/Deadwood was associated with early settlers opening up fields and cutting timber to construct buildings on their homesteads. Most of this occurred along the mainstem valleys of Indian and Deadwood Creeks and at the mouths of these creeks where they flow into Lake Creek and where Lake Creek joins the Siuslaw River.

Commercial logging operations began about the same time as commercial fishing. Within 18 years after the Indian reservation was opened up to settlement, five large sawmills were in operation in the Cushman-Florence area. Much of the timber was east of Indian/Deadwood, but the only way to market it was by ship from the mouth of the Siuslaw River. At the turn of the century, both Indian Creek and Deadwood Creek were beginning to be logged and logs were floated down the creeks to the Siuslaw River. Small intermittent operations and full-scale logging camps for year-long operations were established. The logs were yarded down canyons and valley bottoms to the streams by steam and later diesel-driven donkeys. They were stored in the streams until high fall and winter precipitation, when they would be floated downstream to the river.

About 1910, splash dams were used in the watershed to aid movement of logs from higher and drier locations — one splash dam was located on Indian Creek; five dams were located on upper Deadwood Creek. Dynamite was sometimes used to remove obstructions in the creek and free frequent logjams. With no shortage of anadromous fish in the Siuslaw River, the effect of these logging activities on a few streams was not a serious consideration at the time.

In addition to the mills in Cushman-Florence, several small and large sawmills were built within the Indian/Deadwood watershed. These were often located along the side of a tributary, which would be dammed to provide a floating-pond for logs destined for the mill. The earthen dams would be 50 to 80 feet in height. In a few locations along Deadwood Creek, the mill operators dammed the mainstem to create a holding pond for logs. The mills in Deadwood watershed typically operated for 10 to 15 years, while those in Indian drainage operated for only 1-2 years. When the mills closed down, the dams were blown up and debris in the pond was washed downstream.

About seven such mills operated in the Deadwood watershed during the 1930s and 1940s. Most of the mills were located along the mainstem, but a few were located along Panther Creek (the largest in the watershed), Misery Creek and Failor Creek. After 1950, these mills dwindled to two near the lower end of Deadwood Creek that operated during the 1960s and one located along Misery Creek that operated sporadically during the 1970s and 1980s.

Numerous small “tie” mills also operated throughout the Deadwood watershed during the World War II to feed the large demand for railroad ties. These mills were set up and torn down quickly, often operating for only a couple months, before being moved to other sites to harvest available timber. Although operations were short-lived, the waste from these mills was large. Unused sidecuts from the milling were discarded over a slope, some ending up in stream channels.

The Indian Creek watershed supported about four such mills during the 1930s and eight during the 1940s. Most of the mills were located either along Indian Creek, with about six in the upper portion of the stream, or along a tributary of the North Fork Indian Creek at the northern end of the watershed. No mills or splash dams had been built on Rogers or Maria Creeks (in present day Key Watershed). Two of the oldest mills in the Indian/Deadwood watersheds were located in the Indian Creek drainage, both built about 1889, initially to mill lumber for two of the early homesteads in the upper portion of Indian Creek.

Until the late 1920s, all logging occurred from the valleys, with logs being dragged or floated downhill to the river. About 30 miles of road existed in the watershed, generally built along valley bottoms. During the 1940s, 11 miles of road were added to access upper reaches of Indian Creek and the ridge between Rogers and Maria Creeks, though relatively few acres were harvested compared to the late 1900s.

Wildcat Creek

Settlement along Wildcat Creek was influenced more by the promise of harvesting lumber than by the possibilities of subsistence farming. Settlement did not begin in the Wildcat Creek Watershed until sometime around 1880. Surveys conducted in 1880 and 1881 identified no homesteaders, which may be because there was no location desirable enough to lure an individual to illegally squat land. The earliest patented homesteads occur along Wildcat Creek in the vicinity of the present community of Walton and on the

lower reaches of Pataha Creek. (It is probable that valid land sales along the lower reaches of Chickahominy Creek by the Southern Pacific RR, successor to the bankrupt Oregon and California Railroad occurred at about the same time as the early homestead entries.)

Homestead patents continued to be granted in fair numbers in the watershed through the first decade of the 20th century and included land at least marginally suitable for small-scale agriculture or grazing. However, some appear to have been made by "entrymen" acting on the behalf of large timber companies who in turn were trying to secure a base of forested lands. One suspects that cash entries filed on heavily forested tracts of steep and dissected terrain were not acquired with an eye toward agricultural development.

Commercial logging in the Wildcat area probably began shortly after the first settlers took up claims there. As land along Wildcat Creek and Chickahominy Creek was cleared for agricultural purposes the logs could have been floated to mills near Florence that were constructed in the late 1870s and early 1880s. Similarly, some strictly commercial logging began in the watershed prior to the beginning of the 20th century. There are records in the files of the Division of State Lands that indicate logs were "splashed" on Wildcat Creek from a point above Walton between 1899 and 1911.

The construction of the Coos Bay branch line railroad, completed in 1916, was of great benefit to the logging and lumbering industry at all points along the route of the railroad. Prior to the construction of the railroad the only way to move

In the 1960s tunnel and highway construction linked Eugene to Florence through Mapleton.

logs to a mill was by water, and this might take most of a year to float logs from Wildcat Creek to mills at Florence or Cushman. After the railroad was built both logs and finished lumber could be transported to the coast, to the Willamette Valley, or to points in between. At least some of this land was railroad logged. Several miles of logging railroad were constructed in the Bulmer Creek watershed connecting with the Coos Bay branch line.

Wolf Creek

The first claim along Wolf Creek was filed by Joseph W. Arbuckle and patented in 1866. His homestead must have been lonely, as settlement in the area was slow until roughly 1890. The isolation of Wolf Creek made it less attractive to homesteaders than other areas in the basin. A surge of settlement followed the revestiture of the O & C Railroad lands in 1916. Lands classified for agriculture were offered for homestead entry in 1920.

Euro-American settlement in the Wolf Creek watershed introduced three factors that changed conditions within the watershed. Each settler cleared land on the flats along the stream for crops or pasture. The amount varied from a large garden plot of an acre or so prepared by families eking out a subsistence living during the economic depression of the 1930s to genuine farmsteads with between 40 and 80 acres of cleared land, sizeable orchards, a house, barn, and smaller outbuildings. Farming on more than a subsistence scale required a means of transporting agricultural products to market. In the Wolf Creek watershed this need was answered, albeit imperfectly, by the construction of a wagon road along the stream to connect with the Territorial Road in the Valley of Coyote Creek via a low pass on the divide between the Siuslaw and Willamette basins. Sometime before 1914 a wagon road was completed following the present route of the Wolf Creek Road (Lane County Road No. 4078) and connecting with the Territorial Road just south of Crow.

No significant logging occurred in the Wolf Creek area until the 1930s or 1940s. Early logging practices (1930s-1950s) included ground yarding and extremely high road and skid trail densities. In the late 1940s and early 1950s much of the area east of the Wolf Creek–Panther Creek junction was logged. Landings, skid trails, and roads were placed directly in Wolf Creek and many tributaries. Vast amounts of logging slash were left in the streams. Examination of 1953 photos shows what appear to be large amounts of sediment in Wolf Creek down to the mouth. The sediment formed point bars and islands. Although much damage was done to stream channels on

site, the logging debris added structure to the streams. Upper Wolf Creek and Salmon Creek had landings in the creek; however, neither has had much downcutting, and streambeds may be at the same or higher levels than pre-logging. Beaver in Wolf Creek may be another explanation for the condition of the channels. There is no record of splash damming having occurred in the Wolf Creek watershed. As late as 1953 the Wolf Creek Road only extended to Oat Creek.

Many young men were drawn away from the area during World War II and many families throughout Wolf Creek sold their property. By 1952 the only occupied homestead on Wolf Creek west of the mouth of Swamp Creek was located at the mouth of Wolf Creek.

Lake Creek

Until 1875 most of the lands in the Lake Creek watershed were off-limits to homesteading because they were within the boundary of the Siletz Reservation. When the Alsea sub-agency was closed in 1875 the Siuslaw drainage was opened to settlement.

The earliest settlers in the Lake Creek Watershed settled on the valley bottoms along Lake Creek beginning in the late 1860s or early 1870s and the earliest patents were granted to lands in that area in 1877 and 1878. Between 1880 and 1899 title was granted to an additional eighteen parcels within the watershed. Many of these parcels were located in the Triangle Lake Basin and along the narrow valley of Lake Creek between Triangle Lake and the mouth of Deadwood Creek.

During the first decade of the Twentieth Century, Cash entry's and Homestead filings reached their peak in the Lake Creek Watershed and title was granted on a large number of tracts. Many of the tracts filed upon during this and the succeeding decade were heavily timbered and the claimants probably sought the land more for the value of the timber on it than for use as agricultural lands. Homesteading in the Lake Creek Watershed continued at a much reduced pace during the third and fourth decades of the century with the last transfer of title from the public domain to private ownership occurred in 1940.

Before 1900 there was little work in the valley except farming, hunting, trapping and peeling chittum bark. Vegetation type maps for the periods around 1910 and the mid-1930s show only small parcels of cutoff land. Nevertheless, some logging and lumbering was taking place in the watershed during the 1900s and 1910s. The first types of logging operations in the area were hand-logging operations, which were carried on along Lower Lake Creek, Nelson Creek and the Upper Siuslaw. Most hand logging consisted of felling the trees along the banks of streams and the Siuslaw River and rolling them into the water. Horse or bull team logging was carried on extensively in the Long Tom and upper Lake Creek areas where the ground was suitable. The first power driven sawmill in the area was built in Nelson Creek approximately in 1895. This sawmill was water powered.

In 1901, the first steam donkey was used to log in the Triangle Lake area. In 1902 the W. & E. Wolfe Company of Blachly recorded production of 800,000 board feet. In 1904, the Horton Brothers moved their sawmill operation on the Upper Lake Creek. It was a good-sized operation, which operated with a full crew and was the first mill in the area to operate with a full-scale steam donkey logging layout. The Hortons yarded their logs directly into the millpond. There were other sawmills in the valley, Slayter & Johnson, Druggs & Blachly (later bought out by the Rusts) to name a few. In 1905 and 1906 Johnson and Slayter of Blachly recorded production of 210,000 and 200,000 board feet, respectively. In 1912 the Horton Bros. Lumber Co. of Blachly recorded production of 1,000,000 board feet while the M. Johnson Company produced 200,000 board feet during the same year.

During 1913 and 1914 the M. Johnson Company recorded production of 200,000 and 150,000 board feet, respectively. No production figures are given for the Druggs and Blachly Company operating at Blachly but in 1910 the company is credited with operating two miles of logging railroad. Lumber production in the Lake Creek Watershed had to be shipped to the Willamette Valley in order to reach any but the most local of markets. A 1927 news article cites lumber being shipped from Horton to Swisshome by truck. It is possible that some logs cut in the Lake Creek Watershed in the early decades of the present century were destined for the tidewater mills located at Point Terrace, Acme and Florence. There is evidence that splash dams were operated on Lake Creek and Deadwood Creek until 1910. Whether it was possible to splash logs past Lake Creek Falls just downstream from Triangle Lake is unknown.

The first roads into the Lake Creek Watershed were actually trails, which were later widened to accommodate wagons. During winter these roads turned into mud, making travel mostly impossible. In June the roads were sometimes not passable. An article dated June 10, 1899 states: "Mr. Tripp came into Junction City from Blachly with his first load of shingles. He couldn't find the words to express the horrible condition of the roads...his wagons mired to the hubs coming down the hill and he had to unload to carry most of the load himself. He will not venture out again until the sun comes out and dries things up."[17] In June of 1892 Ida Banning was the first white woman to come over the new High Pass Road and later confided that she never expected to reach her destination as she clung tightly to her three-month old baby girl and her two-year old boy with one arm and the handle on the old hack seat with the other. With braced feet they bounced over logs and uproots, around rocks, mud holes, limbs, small tress or anything that got in their way. In 1915 Lower Lake Creek residents often went to Swisshome to catch the train to reach the Willamette Valley.

In 1925 Highway 36 was constructed, which improved access into the watershed, and visitors took advantage of this access. An article dated July 26, 1925 said, "Now that the roads have improved, there are many surf boards and speed boats on the lake."[18]

Upper Siuslaw River (Lorane)

The Lorane area was among the first settled in the Siuslaw Watershed. Unlike tracts farther west, travel to and from the Willamette Valley was accomplished with relative ease.

During the second, third, and part of the fourth decades of the twentieth century orchards played a large role in the local economy of the Lorane area. Eastern speculators purchased 1,800 acres of land immediately north of Lorane along the west side of Territorial Highway in the 1910s. The acreage was planted in apple and pear trees and offered to buyers in 40-acre "shares." The organization operated under a number of different names but was commonly known as the Lorane Valley Orchard. By 1919 the orchards were producing and much of the fruit was hauled to Cottage Grove and processed in the Cottage Grove Cannery. Local men from the Lorane area managed the orchards. Many locals, including women and children, found seasonal jobs picking the fruit and working in the packing shed.

Timber patents also played a significant role in shaping the economy of the Lorane Valley as they enabled local mills to tap the supply of federally owned timber. Beginning in 1920, timber patents were granted by agents of the Government Land Office to timber companies, allowing a company to harvest timber from a specific tract of Federal land for a set rate. It is likely that a large number of patents granted in 1925 for extensive acreage in the Kelley Creek and Tucker Creek drainages were probably granted to the Lorane Lumber Company owned by Jay H. Chambers of Cottage Grove. This company had a mill along the Gowdyville Road and shipped lumber by rail from that mill to Cottage Grove. It was not determined if this company also employed the railroad in their logging although this is possible as the rail line ran through three of the major tracts on which timber patents were granted in 1925.

The Addison Lumber Company operated extensively in the Sandy Creek area during the 1920s and 1930s and was probably the recipient of timber patents granted in the Sandy Creek drainage.

The Powell Lumber Company was probably the recipient of a series of timber patents. This company operated a small mill and owned a logging camp located north of the Lorane-Cottage Grove Highway. The company operated between the 1920s and the mid-1940s.

Summary

Over the period of 100 years - 1850s to 1950s - farming, logging, fishing, road and railroad construction progressively changed the landscape from the forested ridge tops to the valley bottoms within all of the Siuslaw subbasins.

New technologies were applied to utilize the abundant resources; wetlands were drained and diked, streams were used as sluceways for log transport, gill nets were used to catch salmon, private logging roads, railroads and public roads were constructed across the landscape. Estuaries and streams were cut off from their floodplains, fish passage was blocked by culverts, streams were choked with logging debris, spawning beds were covered by sediments, gravel beds and large woody debris were lost, water temperatures increased as riparian forests were cut and, in

general, riparian habitat became degraded in many areas. This was an inadvertent legacy. The people who were maintaining their livelihoods and supporting their families could not have foreseen the impacts and the outcomes. Time has given us the opportunity to examine the historic process. The last 50 years introduces far greater complexities into the Siuslaw watershed's socioeconomic history. That effort should be undertaken but it is beyond the scope of this initial watershed analysis.

Footnotes

1 Large portions of this chapter have been taken directly from the Siuslaw National Forest's Indian/Deadwood Watershed Analysis and Lower Siuslaw Watershed Analysis, and the Bureau of Land Management's Wildcat Creek Watershed Analysis and Siuslaw Watershed Analysis.

2 Illustrated History of Lane County, OR Portland: A.G. Walling, Publisher, 1884. p. 449.

3 Illustrated History of Lane County, p. 450.

4 Siuslaw Pioneer Association, The Siuslaw Pioneer 1978, "The Story of Indian Creek." p. 26.

5 Siuslaw Pioneer Association, The Siuslaw Pioneer 1978, "The Story of Indian Creek." p. 26

6 Siuslaw Pioneer Association, The Siuslaw Pioneer 1977. "The Story of Sweet Creek" p. 57.

7 Reed, Ione. Pioneering in Oregon's Coast Range. Brownsville: Calapooia Publications, 1982. p. 84.

8 Lower Siuslaw Report, p?

9 Patricia Ann Edwards, et al, Sawdust and Cider: A History of Lorane, OR and the Siuslaw Valley, self published, 1987. p. 107.

10 (Siuslaw Watershed Assessment, I've got to get you this source)

11 Siuslaw Oar 7/25/47.

12 Siuslaw Oar, "Taps" 1/28/38.

13 The Siuslaw News, When tugboats led the cash crops downriver, by Alicia DeNicola. 1993.

14 Siuslaw Oar, (can't read headline) . . . Selling off fixtures" 9/9/32

15 Siuslaw Pioneer Museum, Tidewater Mill, Florence, notes from files.

16 USDA 1996, *Indian/Deadwood Watershed Analysis*, U.S. Forest Service, Siuslaw National Forest, Mapleton Ranger District. p. 43.

17 USDI 1996, *Lake Creek Watershed Analysis*. Eugene, OR. Bureau of Land Management, Eugene District, Coast Range Resource Area. Available on the BLM Eugene District web site.

18 Ibid.

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USDI 1999, *Wildcat Creek Watershed Analysis*. Bureau of Land Management, Eugene Disstrict Coast Range Resource Area.

USDI 1995, *Watershed Analysis for the Wolf Creek Watershed*, Bureau of Land Management, Eugene District. Available on the BLM Eugene District web site.

USDA 1996, *Indian/Deadwood Watershed*

Analysis, U.S. Forest Service, Siuslaw National Forest, Mapleton Ranger District.

USDA 1998, *Lower Siuslaw Watershed Analysis*, U.S. Forest Service, Siuslaw National Forest, Mapleton Ranger District.

HYDROLOGY

As mentioned in the introduction, the hydrology of the Siuslaw Basin is the expression of number of intersecting landscape attributes. The Siuslaw basin has generally high precipitation, but atypically for Coast Range streams, it is much drier where it starts than where it ends. Precipitation rates in the east part of the basin are similar to those in the Willamette Valley (approximately 55 inches annually). Precipitation is nearly triple that in the higher elevations of the Coast Range (about 150 inches), about the midpoint of the basin. And along the coast precipitation rates are double (80-100 inches) those in the east. Water yield from the upper Siuslaw was estimated by the BLM to contribute only 15% of the flow, even though it comprises 31% of the total basin area (USDI 1996). Since the Siuslaw basin has very few areas high enough to retain snow in the winter, it is a rainfall driven system. While the sandstone-derived soils are fairly porous, their shallow nature, combined with the steep terrain causes water to quickly run off to streams. Areas that lack forest cover (recent clearcuts and open land) also shed water more quickly than forested areas (Beschta). Wider valleys with relatively intact wetlands tend to retain water longer into the dry season (Mitsch).

Debris flow tract that delivered to Siusaw River

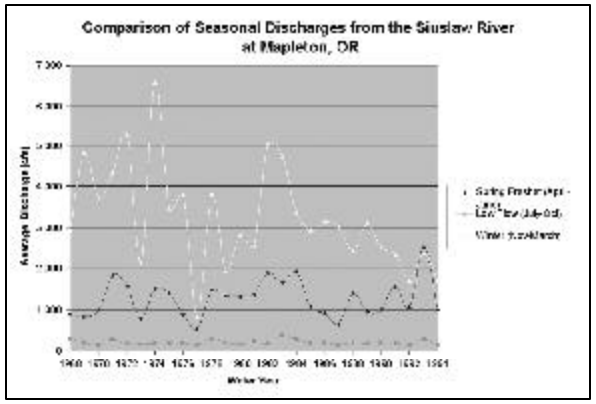


Figure X

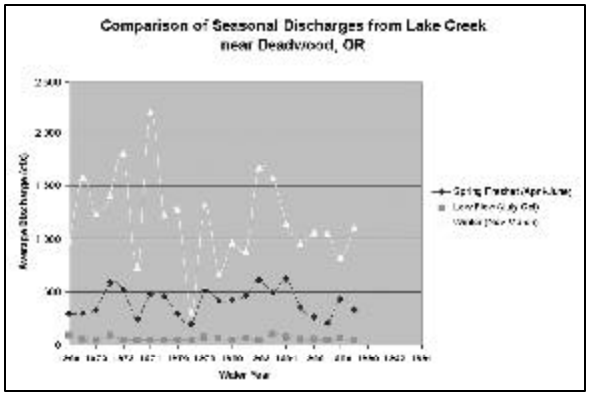


Figure Y

The typically narrow valleys of the watershed do not provide many opportunities for wetlands to form, but Lorane Valley, Upper Lake Creek/ Triangle Lake, and the estuary are clear exceptions. The steeply sloped Tyee sandstones that underlay most of the basin apparently do not have high water storage capacity, (particularly in comparison to the basalt geology of the Cascades, which has soils with higher clay content.) All of this adds up to a hydrology that is naturally "flashy." Streams rise and fall fairly quickly with the rain in the winter, and base flows are characteristically low in summer.

The Siuslaw is the longest of all the mid-coast Oregon rivers. Its mainstem is 109 miles, and the total mileage of streams in the basin is about 4500. The mean annual discharge of the Siuslaw (based on the Mapleton stream gage) averages about 1.5 million acre-feet. December is normally the highest flow month, often generating one-fifth of the total annual flow. August normally produces the lowest flows. The ratio of highest to lowest flow is 35 to 1. This makes the Siuslaw "flashier" than most coastal rivers, but less so than some Willamette Valley streams (Bastach).

Review of USGS Gaging Data

Our analyses of streamflow examined the basin for average daily flow, and for records from the 1972 peak storm event over the entire watershed. This approach helped us understand how the Siuslaw flows seasonally, and to a lesser degree (since data are limited) how it responds during storm events. We chose the 1972 event because it was the highest flow recorded that had multiple gauging stations in operation. The 1964 and 1996 flood events were slightly smaller and slightly larger, respectively than the one in 1972, but for

Hydrology
5.1

Meandering North Flork with riparian trees removed by land developement

various reasons were not well recorded. The USGS estimated that the 1996 flood was a 55-year storm, based on a 29' high water mark left at the Mapleton gage house (Hagervorst). The 1972 event appears to have been only slightly lower, at 28.5'. The 64 flood measured 28' in the same area.

Seasonal Variation

We looked at average daily flow data, available from the three U.S. Geological Survey stations that operated from 1967-1994. The gages at Lake Creek and North Fork were removed after 1994, leaving only the Mapleton Gage still in operation. However, this gage did not operate during the 1996 flood.

We looked at flows in three seasons; spring freshet (April-June,) low flow (July-October,) and winter (November-March). Figure X shows this seasonal data at the Mapleton gage, and Figure Y shows data for the Lake Creek (near Deadwood) gage. The strong similarities in these figures show that yearly variation in discharge is very closely associated with precipitation.

Two trends were observed during the period of record and represented in Figures X and Y. It appears that average winter flows began to decrease beginning in the middle 1980s. It also appears that average low flows increased very slightly over the same period.

Data from a single gauging station makes it difficult to interpret how flows may be affected by land use. Consequently, we do recommend that the Watershed Council consider working with the USGS and other partners to establish a stream gage-monitoring plan that is more representative of the entire watershed. At a minimum, the gaging network should focus on the three major sub-basins:

- Upper Siuslaw
- Lake Creek
- North Fork

Mapleton gauging station

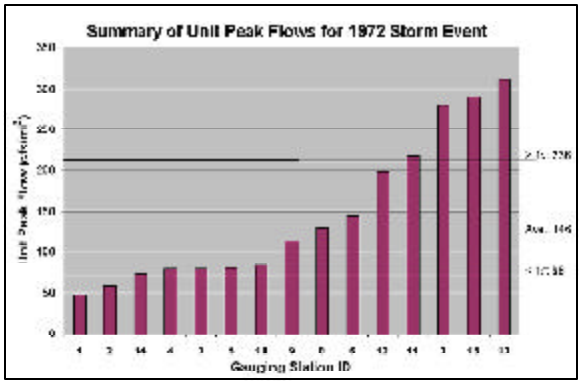


Figure Z

If full recording gages cannot be funded, crest stage gages (that measure the crest of peak events) would be helpful in picking up geographic/landscape variation.

1972 Storm Event Analysis

A large storm event in 1972, when 15 gauging stations were operating, allowed us to develop numerical comparisons across the basin.

Table A shows the recorded peaks by USGS gauging station number, and Figure Z is a summary of unit peak flows (flow/area). Substantial differences were observed between basins ranging from 48 cubic feet per second per square mile (cfs/mi^2) to 310 cfs/mi^2).

Five gaging stations had unit peak flows that were far enough above or below the mean (146 cfs/mi sq) to generate interest. We investigated these to learn what may have led to higher or lower flows in these basins. The three stations

Example of basin with potential wetlands that could be enhanced to decrease peak flows and to improve water quaility

with the highest unit peak flows were:

- Esmond Creek (280 cfs/mi sq) near Austa
- Sam Creek (289 cfs/mi sq) near Minerva
- Condon Creek (310 cfs/mi sq) near Condon

The two stations with the lowest unit peak flows were:

- Siuslaw (48 cfs/mi sq) near Lorane
- Siuslaw (58 cfs/mi sq) near Alma

We used a Geographic Information System analysis (GIS) to examine differences in peak flows through a Downstream Analysis, and through an Isolated Basin analysis.

The former compared hydrologic and GIS data at successive downstream gaging stations, starting with the Upper Siuslaw near Lorane, then at Alma, and finally at Mapleton, as shown in Table B (Downstream Analysis Siuslaw River Reach). We did the same for the Lake Creek watershed, starting near Triangle, then at Deadwood, and again near Mapleton, as shown in Table C (Downstream Analysis Lake Creek Reach).

We looked at several landscape attributes: mean stream gradient, potential valley wetlands, percent forest land use, and road density. There appears to be a strong relationship between the unit peak runoff (flow/area) and the stream gradient, wetland potential, and percent of the land in forest land use. The steeper the stream gradient, the greater the peak runoff. The more potential wetlands, the lower the peak runoff. And the more total forest land use, the higher the peak runoff. We did not find a correlation between road density and runoff rates. A key limitation in this analysis is that we did not compare actual forest cover during this period. In other words, we do not know how the age classes or condition of the forest may have varied or changed.

In the Isolated Basin Analysis, we compared three pairs of sub-basins according to drainage basin area and peak flow for the 1972 event. These were: (1) Lake Creek near Triangle and Deadwood Creek near Deadwood, (2) Wolf Creek and Esmond Creek both near Austa, and (3) Knowles Creek near Mapleton and Sweet Creek near Beck. This information is shown in Table D (Isolated Basin Analysis).

Debris flow riffle

Lake Creek and Deadwood Creek have approximately the same area, but the unit peak flow in Deadwood Creek was over 160% that in lake Creek. Greater stream gradient (167%,) less potential wetlands (24%,) and slightly more industrial forest use (108%) may be the factors contributing to the greater unit peak flow in Deadwood Creek. Wolf and Esmond Creeks had approximately the same peak flows, yet the Esmond watershed is only one-fourth the size of Wolf Creek. Greater stream gradient and fewer potential wetlands may be responsible for the higher peak flow at Esmond. Lastly, Knowles Creek has approximately the same basin size, and about the same peak flow as does Sweet Creek.

One key finding is the apparent importance of potential wetlands in detaining peak flows where stream gradient and industrial forestland appear to increase peak flows. Potential wetlands were used due to limited data on existing wetlands. Areas with Hydrologic Soil Groups C and D soils (poorly drained according to Soil Inventory data)

on slopes less than eight percent were designated as potential wetlands.

Where forests have been recently clearcut harvested, studies show that both peak and base flows will tend to be higher. The change in peak flows is not expected to be apparent for storm events larger than a five year return interval (Beshta). This means that the quality or age of upland forest appears to only affect peak flows that are smaller than five-year magnitude storms. However, some studies at the HJ Andrews Forest near Blue River suggest that, in combination with roads, clearcuts do increase larger peak flows. Other studies suggest that there may be a reduction in base flows (below that of the pre-harvest forest) during the "recovery" stage of a clearcut, that is beginning 10-15 years after harvest (Jones).

Another possible explanation for high variability in flows between watersheds may be the natural local variability in storm intensity. For example, during the 1996 event, the Mackenzie River peak was estimated to be only a two to five year event, yet one if its tributaries, the Mohawk, reached a level estimated at a fifty year event (Armstrong). There are a number of anecdotal observations that suggest that the same sort of variability may be common in the Siuslaw basin.

Conclusion

The apparent positive role of wetlands in flood storage offers promise for assisting efforts for restoring ecosystem health. The results of this preliminary investigation need to be tested further because the analysis used 1972 storm data and compared results according to the available 1999 basin geographic data. We acknowledge the potential for misinterpretation of results based on a number of factors reflected in 30 years of change across the landscape, but our findings are consistent with general hydrology principles. Assuming comparison of geographic data from the early 1970s yields similar results, wetland restoration opportunities focusing on water storage could be identified in further studies.

An important question we are unable to answer is the role of upland forests of the Siuslaw in regulating stream flow. How much have both peak and base flows been altered as a consequence of the shift towards younger aged forests? Studies of hydrologic response to clear-cutting and road building have nearly always been focused on very small watersheds. Thus cumulative impacts at large scales are not well understood. Older forests may collect significant amounts of summer precipitation in the form of "fog drip," particularly near the coast. But it is unclear whether much if any of this additional precipitation actually makes it to local streams. It may simply be used up by the forest vegetation (Beschta).

Further research that compares forest cover age classes with flow rates at various times might shed more light on these issues.

RIPARIAN VEGETATION AND WETLANDS

The quantity and quality of riparian vegetation and wetlands have a significant effect on the condition of the aquatic ecosystem. In the Siuslaw basin, this is undoubtedly the case. High functioning wetlands and riparian areas store winter and spring rains, later releasing water to streams as summer base flows. In an aquatic system that has low natural storage, this is a particularly important service. Wetlands and riparian areas also are vital parts of the aquatic food chain. They contribute organic material that feeds bugs that in turn feed fish. When properly functioning, they also can filter pollutants that otherwise would end up directly in the streams. They also both work to cool water in the summer, another vital contribution to the aquatic ecosystem. Lastly, riparian areas that have mature forests contribute large and small wood to streams. As noted earlier, large wood is a keystone of the stream ecosystem. It shapes habitat, stores organic material and gravel, and moderates or buffers storm flows (IMST).

Wetlands

There is limited information presently available to assess the condition of wetlands in the Siuslaw Basin. Only the estuary wetlands have been digitally mapped under the National Wetlands Inventory system. The remainder of the basin has

Cox Island is a remnant tidal marsh near the mouth of the North Fork. 60% of tidal marshland has been lost to diking and draining

been mapped, but has not been digitized as of yet. As noted in the Estuary chapter, nearly 60% of the original tidal wetlands in this area have been lost to dike construction, filling, and dredging. (More detail on estuarine wetlands can be found in our estuary chapter.) Valley bottom wetlands are believed to play a crucial role in storing winter and spring rains for later release to streams, and as part of the aquatic food chain. We know from early accounts that the valleys of the Siuslaw were complex mosaics of old growth (cedar) forest, hardwoods, open wetlands, and brushy areas. This system has been greatly altered as a consequence of 19th century settlement patterns and modern land use. There are few (if any) local "reference sites" available where one could get a good visual image of what the Siuslaw valleys looked like prior to being settled and developed. But they likely were similar in character to the Hoh Rainforest valley, located on the west side of Olympic National Park. This area has abundant old growth cedar and maple, significant amounts of large wood in the streams, complex, braided channels, and numerous wetlands.

In the upper Siuslaw, particularly Lorane Valley and upper Lake Creek, the riparian areas were likely dominated by hardwoods and prairie vegetation rather than conifers. Intense beaver activity may have resulted in fairly substantial canopy openings along streams (Weyerhaeuser).

We have no information on the original extent of valley wetlands, nor do we know how many of them have been drained or filled. A study of the Willamette Basin determined that 87% of the original wetlands and riparian plant communities have been converted to other land uses or cover types (Daggett). We could expect that the settled valleys of the Siuslaw would show a similar degree of change. Visual observation, particularly from our aerial field trip, indicates that many original wetlands have been altered, but substantial amounts of wetland remain in Lorane and upper Lake Creek Valleys. Wetland traces are quite apparent in the North Fork, Indian Creek, and other valleys of the lower Siuslaw.

We built a map of "potential wetlands" based on location of hydric and poorly drained soils on areas of low slope with concave surface profiles (map 6.1). This could serve as a guide to where wetlands are most likely located, until the National Wetlands Inventory data is available.

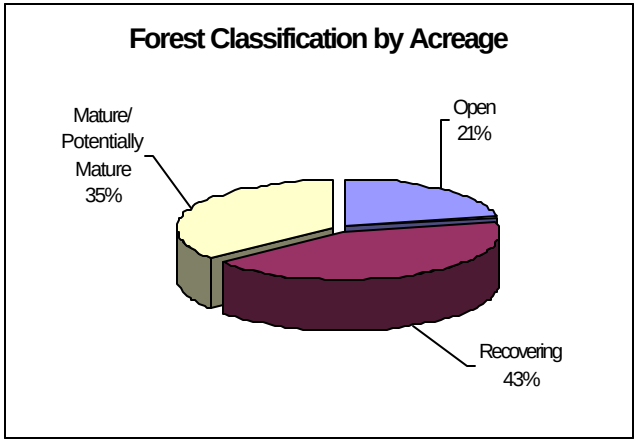
Potential Wetlands
6.1

Riparian Vegetation

The condition of riparian vegetation is a key factor in the health of aquatic ecosystems. Shade, filtering of pollutants, contributions to the food web, storage of water, and large wood are all important functions of riparian vegetation. Loss of original riparian forests has occurred throughout the basin. Lower valleys have received the most impact, since these have borne the brunt of development pressure over the years. These of course are ideal areas for logging, farming, transportation corridors, and homesteads.

There appear to have been at least two, and quite possibly three consequences to loss of riparian cover. The first is elevated stream temperatures, which appear to be a widespread problem (Weyerhaeuser). A second is lack of large wood in streams (Willer). The third may be reduced base flows, though there is little evidence to base this on.

We used CLAMS data, and observations from our aerial field trip, to analyze riparian condition. It should be noted that this data does not show what the riparian vegetation is like at the ground level. For example, we don't know how many canopy layers there are, or what the ground cover condition is. We also do not know the specific composition of riparian plant communities. These are important factors in how well a riparian area functions, particularly in filtering pollutants. From CLAMS, we do get a good sense of whether riparian areas have forest, whether this is deciduous, conifer, or mixed, and approximate sizes of trees. In addition, CLAMS data is based on the dominant canopy vegetation within 30-



meter squares. A single square could thus be 51% forested, and 49% unforested, but would be counted as all forested. Lastly, CLAMS data has not been updated since 1996, so there may have been changes in some areas. CLAMS data is a good tool for getting a general picture of the riparian condition, but should not be used for site specific planning.

What width should be used in measuring riparian cover? The Oregon State Forest Practices Act requires a 20-50' no cut buffer along some streams. In addition, it requires landowners or managers to leave varying amounts of conifer trees within a greater distance, based on stream classification. Farms and homesteads are not presently required to have any buffer at all. However, Senate Bill 1010 has initiated rule-making procedures under the Department of Agriculture. The Siuslaw Soil and Water Conservation District is in the process of developing a management plan and water quality rules for agriculture. These may result indirectly in increased riparian protection for Siuslaw area farms. County land use standards also have some protection of riparian areas from development activity by requiring setbacks and retention of vegetation.

The Forest Service and BLM use "potential tree height" to determine riparian reserve widths. Potential tree height ranges from 210' in the Upper Siuslaw to 250' in the western part of the watershed. On fish bearing streams, riparian protection is twice this distance. The Forest Ecosystem Management Assessment Team (FEMAT) developed an analysis that measures the effectiveness of riparian forest width relative to a number of functions, including; litter fall, root strength, shade and coarse wood debris input. It was this analysis that led to establishment of the federal land buffers based on tree height. A study by the National Council of the Paper Industry for Air and Stream Improvement (NCASI) challenged the FEMAT findings, and suggests that "most of the potential contribution of vegetation to riparian functions is in the first 5-25 meters" (15-75 feet). In other words, over 50% of the benefits associated with riparian vegetation can be gained within fairly narrower buffers (Ice).

The Independent Scientific Multidisciplinary Team (IMST) states that precise riparian boundaries are not the best way to protect aquatic habitat. "Managing riparian areas as a strategy for protecting fish habitat is scientifically valid only if it is done with the goal of maintaining the dynamics of structure and function across the landscape" (IMST). Specifically, the IMST recommends that upslope processes may be equally important to riparian areas, particularly where landslides are likely. They view sharp

Riparian Veg
6.2

demarcations between protected riparian zones and adjacent land uses as unnatural and inconsistent with historic patterns.

The riparian zone should be thought of as the key connection between upper slopes and stream channels. For example, large trees at tributary junctions may be very important in moderating the impact of debris flows by breaking their force (Dewberry 6). The condition of riparian zones may be a key element in helping to reconnect downcut streams with adjacent floodplains and streamside flats.

There may be no "ideal" riparian width. In the Siuslaw, entire valley bottoms influence the streams, and are considered riparian by some (Bennett). Studies by the BLM indicate that the 100' distance is critical for contribution of large wood. Shade requires only a narrow band of tall trees, or even fairly short trees where streams are narrow. Dense meadow grass may filter pollutants as well as forest does.

We chose to focus on a 200-foot riparian width for this analysis. Our rationale is that this is the narrowest width that can be accurately mapped using the CLAMS data. We did analyze vegetation patterns for specific functions such as streamside shading and contribution of large wood to the aquatic system (see appendix B procedures for evaluating ecological capital) but for understanding riparian condition our goal was to get a general picture of forest size and type alongside basin streams that are second order or larger. We lumped the CLAMS data into three categories, corresponding to: areas with large conifers (highest riparian values,) areas forested with smaller trees and/or pure hardwoods (some riparian value, or recovering) and unforested or recently logged areas (generally low value, or degraded). Table 6.1 shows riparian condition for each major owner type. Map 6.2 shows distribution of riparian condition throughout the basin. Note that 36% of the total riparian area is classified as "high value." These are the areas that likely have trees big enough to contribute large wood, and to shade the larger streams.

About 26 % of the total riparian is either open or with very small trees. This includes farms, homesteads, and main transportation corridors, as well as recent clearcuts. These are areas that do not produce much shade, food, or other aquatic benefits. They appear to be concentrated in lower valley segments. In its analysis of the Upper Siuslaw, Weyerhaeuser concluded that agricultural riparian areas had the lowest stream shade levels. Beaver dams also appear to be resulting in loss of shade in local areas. In the Lorane area, beaver activity has created open riparian mosaics over approximately 10% of the total stream mileage (Weyerhaeuser). On the other hand, recent research by the Forest Service indicates that juvenile coho are highly dependent on slough and beaver pond habitats (Wilson). Thus any loss of shade may be compensated for by improved habitat complexity.

Nearly 38% of the total Siuslaw basin riparian area is in some form of fairly young forest or pure hardwoods. The majority of this is broadleaved, probably dominated by alder. These are areas that may offer at least partial shade to streams (depending on tree height, stream width, and topography.) They also contribute to the aquatic food chain, particularly alder stands. But they do not contribute large wood. Some studies suggest that alder may act to reduce summer base flows (Belt). Others point out the important role of riparian alder stands in contributing nutrients, particularly nitrogen to streams (Volk).

Of the total riparian area (using the 200'' measurement,) 12% is in small private ownership, 30% in timber industry ownership, 58% in public ownership. This information is important in that it provides a sense of where the potential problems and opportunities lie. Areas of private land ownership with existing large trees should be prime candidates for protection, perhaps through negotiation of conservation easements. Areas lacking trees may be the focus for restoration efforts, particularly where there are high stream temperatures.

CHANNEL HABITAT TYPES

Background

Channel habitat types (CHTs) are stream segments with similar characteristics, including: gradient, size, confinement and location. Understanding the nature of channel habitat types provides insights into how land use activities might alter channel form, and how certain channels might respond to restoration activity (Watershed Professionals Network). Furthermore, specific channel types are normally associated with different life stages of salmonid species. Understanding of the location and distribution of channel types can also help prioritize aquatic restoration efforts.

The Oregon Watershed Enhancement Board Watershed Assessment Manual provides an outline for evaluating channel habitat types, including:

- Stream channels form specific patterns in response to the surrounding geologic material, topography, and climate. These patterns can be used to identify channel habitat types.

- Channel habitat types are expected to have consistent responses to changes in inputs of sediment, water, and wood across the basin.

- The natural distribution of CHT's throughout the watershed and their condition work together to influence aquatic habitat quality.

There are some limitations to identifying CHTs in the Siuslaw basin. The OWEB manual offers procedures for classifying CHTs at the 5th field watershed level (50,000 acres). These procedures would be quite time consuming at the scale of the 4th field Siuslaw (500,000 acres). The existing watershed assessments for the Siuslaw did map stream gradients, but did not develop detailed CHTs.

Stream habitat surveys within the basin identified channel form, but again, did not fully classify channel types. Since the OWEB manual places great emphasis on understanding and classifying channel types, we developed a process that allowed us to map CHTs using GIS modeling. In effect, this model "predicts" channel types across the basin. We were able to compare results of the model against existing habitat information for known locations, and adjusted parameters until results were satisfactory. We have confidence that the results of this analysis are fairly accurate, and can be used to help inform the larger watershed analysis. But they are not accurate enough to support site specific project planning or prioritization.

Methods

Channel habitat types are typically classified based on gradient, confinement, stream size and location in a watershed. In some cases, surface morphology and geology are also considered. Information for each characteristic is available through previously mapped efforts or can be derived through modeling techniques.

The Forest Service (in cooperation with the BLM) has compiled a stream layer with gradient classes associated to reaches for the entire basin. Furthermore, confinement patterns have been mapped for approximately 2/3 of the basin. We were able to use this information to classify CHTs for much of the basin. In the 1/3 of the area that lacks confinement pattern mapping, we modeled it. A total distance of 1,780 miles was modeled.

Stream size was determined using surface modeling techniques by comparing locations of known average annual stream flow with total upstream area. We then did a linear regression to determine correlation between stream flow and accumulation. Oregon Department of Forestry stream class parameters were used to define the streams as small, medium, or large.

Once confinement and stream size had been approximated for all stream reaches, criteria were established for predicting channel habitat types based on gradient, confinement and stream size (Table 7.1). Results were verified using existing habitat surveys, shaded relief, aerial photography and USGS topographic maps.

Results

The OWEB Manual classifies channel habitat types into 14 standard descriptions (Table 7.1). All of these types are found within the Siuslaw

Table 7.1: Channel Habitat Type Criteria

Code	CHT Name	Gradient	Channel Confinement	Size
ES	Small Estuary	1%	Unconfined to moderately confined	Small to medium
EI	Large Estuary	1%	Unconfined to moderately confined	Large
FP1	Low Gradient Large Floodplain	1%	Unconfined	Large
FP2	Low Gradient Medium Floodplain	2%	Unconfined	Medium to large
FP3	Low Gradient Small Floodplain	2%	Unconfined	Small to medium
AF	Alluvial Fan	1-5%	Variable	Small to medium
LM	Low Gradient Moderately Confined	2%	Moderately confined	Variable
LC	Low Gradient Confined	2%	Confined	Variable
MM	Moderate Gradient Moderately Confined	2-4%	Moderately confined	Variable
MC	Moderate Gradient Confined	2-4%	Confined	Variable
MH	Moderate Gradient Headwater	1-6%	Confined	Small
MV	Moderately Steep Narrow Valley	3-10%	Confined	Small to medium
BC	Bedrock Canyon	120%	Confined	Variable
SV	Steep Narrow Valley	8-16%	Confined	Small
VH	Very Steep Headwater	16%	Confined	Small

Note: Stream size refers to the ODF designations based on average annual stream flow. Small streams possess flows less than or equal to 2 cubic feet per second (cfs). Medium streams possess flows greater than 2 but less than 10 cfs. Large streams possess flows of 10 cfs or greater.

basin. Of the nearly 5,300 estimated miles of streams in the basin, nearly 60% (3,100 miles) are steep / very steep headwaters or steep narrow valley / bedrock canyon streams. Many of these are most likely intermittent. These channel types are very important for their role in transporting nutrients and large wood to lower gradient streams. The OWEB manual describes them as having "low sensitivity" to land use. This means their physical characteristics resist change. They stay put where they are. However, many of these channels are subject to periodic debris flows. Approximately 15% (800 miles) of the total stream channel types are moderate and low gradient confined streams and headwaters. These are believed to have moderate sensitivity to surrounding land use and restoration activities. Approximately 23% of the streams are low gradient unconfined or moderately confined streams (1,200 miles). These are felt to be highly sensitive to land use and responsive to restoration.

Channel habitat types (but for those related to the estuary) are relatively evenly distributed throughout the basin, though there is variability among catchments. Map 7.2 shows distribution of channel habitat types across the Siuslaw Basin. In general, most catchments within the Lower Siuslaw, Deadwood Creek and Indian Creek watersheds show similarities. A large portion of stream miles are dominated by steep and very steep headwater and bedrock canyons (70-75% of the total stream miles / watershed). Lake creek, Wildcat creek, Wolf creek and the Upper Siuslaw watersheds have less total steep and very steep confined reaches (50-60% of the total stream miles,) and more moderate gradient confined and moderately confined reaches (15-25% of the total stream miles). Low gradient, unconfined streams are relatively evenly distributed throughout the basin (16 to 23% of stream miles within each watershed). Exceptions include Wolf creek and the Upper Siuslaw (28% and 30% of total watershed stream miles respectively). In other words, these two have a greater proportion of low gradient, unconfined stream miles than others within the basin.

Ownership patterns

Channel habitat types are closely tied to ownership and land use. Nearly 95% of the steep / very steep headwaters or steep narrow valley / bedrock canyon streams are found on private industrial lands, state forest lands, USFS lands or BLM lands. Conversely, a disproportionate amount of the low gradient, less confined response reaches are found on small private non-industrial lands. Our calculation is that over 70% of these total stream miles occur on the smaller private land ownerships. This is not surprising, in that these

Table 7.3: Miles of Channel Habitat Types by Ownership

Ownership	Low gradient un-confined and moderately confined flood plains and streams	Moderate and low gradient confined streams and headwaters	Steep / very steep headwaters or steep narrow valley / bedrock canyon streams
BLM	246.77	218.23	745.35
Private Industrial	409.21	280.05	871.33
Private, non-industrial	274.94	81.98	145.81
Public	14.01	9.42	30.93
Right of ways	40.40	13.55	13.68
State lands	25.52	33.09	134.36
USFS	196.41	172.23	1,248.93
Total	1,207.26	808.55	3,190.39

are the wider valleys, more suited to agriculture and homestead development. It does have important implications for restoration however. Table 7.3 shows the distribution of channel habitat types by ownership type.

Discussion

What does the distribution of channel habitat types tell us about the Siuslaw Watershed? If we compare CHTs with the best information available on coho distribution, we find that the best existing coho areas appear to be in or near the low and moderate gradient, confined streams. This contradicts the theory that unconfined streams are superior habitat, and should be the focus of restoration efforts. We believe there are two reasons for this.

First, the low gradient, unconfined streams in the Siuslaw, particularly near river mouths, may have never been good coho habitat due to high summer temperatures. As was described in the water quality chapter, the Siuslaw basin lies far enough south, that it experiences fairly high summer temperatures. The flat gradient river mouths are wide, experience frequent severe flooding, and were historically great habitat for beavers. This may add up to inherently high summer water temperature.

Second, these low gradient, unconfined reaches received the full brunt of land use impacts resulting from Euro-American settlement. They were cleared, drained, and sluiced out early on. Thus whatever localized value they did have was further compromised. (Chinook and steelhead can make better use of these reaches, due to the season of use of the Chinook, and tolerance of higher water temperatures by the steelhead).

While the OWEB manual suggests that the low gradient, unconfined channels are generally the most responsive to restoration activities, we do not believe this is the case in the Siuslaw basin. We base this on recent research (and direct experience in the Siuslaw,), which demonstrate the difficulty in improving these channels. The frequent high flows tend to blow out engineered habitat structures. And the surrounding private land use pattern makes restoration problematic. While many landowners are willing to fence livestock away from streams, and may allow replanting of at least a narrow riparian strip, they are less willing to give up enough land to facilitate a return to braided conditions. Flat land is at a premium in this area.

It may be a wiser strategy to focus protection and restoration attention on the low and moderate gradient, confined streams, and the upper ends of the unconfined streams. These are likely the areas with highest habitat potential. But to secure this habitat, equal attention must be paid to the steep headwater channel types that have the potential to deliver sediment and organic material downstream. These are a key link in the chain of aquatic habitat in much of the Siuslaw basin.

Results of a debris flow runout analysis performed for this assessment show that steep and

very steep headwater streams and bedrock canyons are likely corridors through which debris flows will travel to mainstem reaches.

Additionally, alluvial fans most regularly occur at the mouth of the small, steep, confined streams where they meet the larger, somewhat less confined streams. This suggests that these channel types periodically deliver essential LWD and other structural components (boulders and gravel) to floodplain habitat. This material transfer has several important roles in the functioning of forest-stream ecosystems. It is an important mechanism for nutrient redistribution and nutrient export from ecosystems. Erosion and deposition create landforms that offer contrasting habitat opportunities for terrestrial and aquatic organisms on a variety of temporal and spatial scales (Swanson).

As was mentioned earlier in this report, the right kinds of debris flows provide several long-term benefits in terms of aquatic habitat quality. The inputs of large wood, gravel, boulders, and flood plain sediment from debris flows over broad time scales are a key important ingredient in maintaining productive aquatic habitat conditions (Bisson).

Conclusion and Summary

The distribution and concentration of channel habitat types within the Siuslaw basin presents an important piece of the watershed analysis puzzle. Below are some findings and suggestions:

-The basin has a vast network of low and moderate gradient streams. This network is the backbone for a very productive aquatic ecosystem.

-60% of total stream miles are steep headwaters and associated channel types. While these are for the most part not important habitat (except for resident cutthroat in some cases,) they are key parts of the aquatic system, and must be part of any protection or restoration strategy.

-The low gradient, unconfined reaches are not likely the best places to recover coho habitat. These are important areas for chinook, steelhead, and other aquatic wildlife. But they will be difficult areas to restore due to natural river hydraulics and land ownership patterns.

-The low to moderate gradient, relatively confined channels and nearby unconfined ones make up the majority of present coho refugia, and are likely the best areas to recover habitat in the future.

SEDIMENT

Sediment, the rock and soil that enters and is then moved by streams, is a key issue in the Siuslaw basin. Sediment, carried in suspension or as bed load, is essential to maintaining a high functioning aquatic ecosystem by providing building blocks for spawning, rearing, and refuge habitats. Sediment and large woody debris provide habitat structure in varied combinations in different landscape settings. Over the millennia the Siuslaw system has responded to the naturally occurring pulses of sediment and large woody debris by forming jams, pools, flats, and other habitat structures that fish and other aquatic species use. The nature of these structures is a function of the available materials, and the frequency and magnitude of delivery.

There are two main potential sources of sediment in the basin: debris flows and stream bank and bed erosion. A third source, sheet erosion, is not likely a large problem, but may be a localized issue in the Lorane Valley where some till agriculture is practiced (Weyerhaeuser). In this assessment, we focused on reviewing and summarizing findings from the previous watershed analyses done by the Forest Service, Bureau of Land Management, and Weyerhaeuser. We have supplemented this work with field observations. The limited sediment data available for the basin did not lend itself to numerical analysis.

Debris Flows

Debris flows are mixtures of soil, water, rocks, and vegetation that originate in steep ravines (inner gorges) and then cascade down slope. They gather force as they travel rapidly down ravines, picking up more material and often scouring the channel to bedrock. They keep moving until they reach a flatter part of the landscape, which in most cases is a larger stream channel and associated valley. At this point, a debris flow usually "fans out," or spreads. Part of it may be transported downstream until it hits a large enough obstacle. Historically, these obstacles were present in the form of frequent logjams. In the absence of jams, debris flows tend to keep moving down the stream, often scouring the sides or bottom of the channel. Comparison with historical conditions suggests that stream areas that had once held the material from debris flows can no longer do so. The result is that flows tend to continue farther downstream with two important impacts: further erosion, and loss of aquatic habitat.

Debris flows are not always negative. There are long term positive effects associated with debris flows. Those originating in forested ravines can bring large trees and spawning gravels down into lower gradient stream sections, and thus "recharge" the aquatic ecosystem with nutrients, cover, and associated structure. This can be pictured as an aquatic "digestive" process (Dewberry 6). The system stores nutrients that originate in debris flows, and then gradually uses these up until the next flow. But debris flows originating in deforested ravines bring only soil and gravel. The soil can fill pools and smother spawning beds. The gravel can be beneficial if it is actually deposited in tributaries rather than simply carried down through to the main stem or the estuary.

The heart of the Siuslaw basin is well known as an area prone to frequent debris flows that can periodically deliver massive amounts of sediment to streams. The silty-sand soils that overlay the Tyee Sandstone have low natural cohesion, meaning they do not bind together very well. Given the steep terrain of this area, these soils are susceptible to failures. It is the inherent soil friction and cohesion combined with the root strength of the trees and brush that knits soils together to hold them on hillsides. The areas most prone to landslides are where water collects during heavy rains, leading to loss of friction and cohesion, and triggering failure. Studies within the Coast Range on the Mapleton Ranger District demonstrate that "headwalls," first order channels, and over-steepened side slopes of the channels account for over 80% of the total debris flows (Plumley).

Debris flows historically occur in the same channels only over long periods of time, on the order of hundreds, or possibly thousands of years. Each ravine, or "hollow" fills gradually with sediment and woody debris. When the hollow is full, or nearly so, it is ready to release a torrent in the next large storm. In Knowles Creek, previous investigations estimated that each hollow releases some or all of its sediment about every 6000 years (Dewberry 6). Logging and road building in the uplands appear to have accelerated the debris flow process, though the exact extent is difficult to determine.

Map 8.1: Shallow Landslide Hazards

A study of debris flows by the Forest Service following the 1996 flood found that the frequency and magnitude of debris flows was greater where roads and clearcuts were located. Road related slides appear to have greater frequency and larger negative effects than clearcut related slides (Hagervorst). Road associated slides in some cases were 40 times more frequent than "in-forest" rates. The same study also concluded that changes initiated over the past 20 years to stabilize roads, along with a reduction in national forest harvest rates over the past 7 years, have combined to reduce slide frequency and severity. An Oregon Department of Forestry study examining the same 1996 event, but over a smaller geographic area concluded that there was no significant difference in frequency in comparing clearcuts with forested areas. But this study did not consider slide magnitude, or the extent to which flows delivered sediment to streams (Plumley).

A shallow landslide model (Montgomery and Dietrich 1994) was used to identify areas in the basin that are of greatest risk for landslides. We then compared the results against areas with limited or no vegetative cover. In looking at the map (8.1,) one can see that the high slide potential areas are concentrated in the south-central part of the basin. In terms of total acreage, the amount of area most subject to debris flows is not that great, but the influence of these uplands on the aquatic ecosystem is substantial. We should also note that areas shown as having only "moderate" potential to generate debris flows do indeed experience them, but probably on a less frequent basis. The post-1996 flood study by the Forest Service shows that 71% of 200 mapped debris flows originated in "high risk" terrain, and 25% on "moderate" risk.

Acres of High Hazard Land Slide Potential

Owner type	*Acres*
Private Industrial	13,750
USFS	12,078
BLM	11,904
State	2,738
Private non-industrial	2,055
Public	896

-High hazard land slide potential based slopes that may fail after on 100 mm of rainfall or less

-Derived from SHALSTAB (shallow landslide predictive model)

phi – 33
bulk density = 1.6
cohesion = 2

Table 8.1

Even parts of the Siuslaw basin that appear to have relatively low risk for debris flows do experience them. A Weyerhaeuser analysis of the Upper Siuslaw estimated that 79% of the "background," or natural sediment comes from landslides originating in steep ravines.

Figure 8.1 shows the total amount of "high risk" area, along with ownership and land cover.

As mentioned, roads can be important factors in accelerating or intensifying debris flows. In particular, roads that were built prior to 1975 along steep slopes typically used "sidecast" construction techniques that proved vulnerable to failures. Sidecast construction is a method traditionally used for forest roads where the excess soil cut from the upper area is dumped over the side of the road to form its outer edge. Typically, these materials were not compacted, leading to high failure rates. Since that time, Forest Service and BLM roads have used construction methods that result in much more stable roads. Both agencies have also taken steps to stabilize the older roads. In recent years they have been removing more roads than they have been building. The State Forest Practices Act also now requires private forest landowners to use methods that insure greater stability. However, visual surveys at ground level and from our aerial survey showed recently built roads that appear to have used sidecast methods in risky terrain. In addition, there is no provision in present state regulations requiring landowners to stabilize or remove older sidecast roads, thus some risk remains from past practices (IMST). Some private landowners have initiated efforts to identify high risk road sections, and have proposed a variety of steps to mitigate potential problems (Weyerhaeuser).

Bank Erosion

Sediment can also be delivered to streams by the action of stream banks being cut by the force of flowing water. This is a natural occurrence, but can be increased in areas where riparian cover is reduced or absent. Visual observations and previous analyses all suggest that bank erosion is occurring at levels that should raise concern, but

further study is needed to understand the extent of this phenomenon better. While bank erosion often results from land use activities, it can also be a natural aspect of stream geomorphology. Even sections of stream with well-forested riparian vegetation can have exposed banks. The Weyerhaeuser analysis concluded that 11% of the natural sediment delivery to streams in the Upper Siuslaw originated from stream bank erosion.

The same analysis observed accelerated streambank erosion in parts of the Lorane Valley. The suspected causes include; channelization, livestock grazing, and removal of in-channel wood (Weyerhaeuser).

Our team observed significant bank erosion that appears to be related to agricultural practices along the North Fork.

Bed Erosion

Sediment can also be generated when streams incise, or "downcut" their channels. Visual observation and previous analyses indicate that there are many miles of downcut streams in the Siuslaw basin, but particularly in lower mainstems and the larger tributaries (i.e. the North Fork). Stream downcutting was likely initiated by historic clearing of logjams and riparian forests, often followed by wetland drainage and land conversion from forest to farms. Other causes of downcutting may include: increased peak flows (due to upland clearcutting and road development,) bank armoring to protect land and homes, and bridge or culvert crossings that constrict flows and concentrate the erosive energy of streams. Once streams cut down, the

Stream bank erosion

channel slope becomes greater, resulting in further cutting upstream until either the slope adjusts, or until bedrock is reached.

Sheet Erosion

Sheet erosion is a mass wasting process where soil is swept by sheet runoff across the landscape in a more or less uniform fashion. It is a process primarily associated with areas where the soil is laid bare, particularly tilled cropland. Sheet erosion can occur on steep slopes that are exposed by clear-cuts. However, it is not clear how much sediment originating from sheet erosion actually makes it to streams. Most of the Sisulaw basin has highly porous soils, which tend to resist sheet erosion. The main concern is interception of fine sediment in roadside ditches that connect directly to streams (Hagervorst). Visual observation by the BLM indicates that sheet erosion is not evident in areas they manage.

The issue of sediment in the Siuslaw basin is clearly more complicated than keeping soil out of streams. The natural, historic dynamic of periodic pulses of sediment and vegetation moving from steep ravines into streams is essential in maintaining the aquatic ecosystem health. Loss of logjams, downcutting of streams, road building and logging of uplands, have all contributed to move the natural dynamic out of its historic balance. A key challenge in restoring the aquatic ecosystem health is to find a way to get the process of sediment and organic material delivery back into historic proportions.

WATER QUALITY

Assessing water quality in the Siuslaw Basin is difficult due to lack of consistent data needed to see trends or make comparisons. Data collection on water quality was performed by USGS from the late 1970s to the early 1990s, but was limited geographically and in terms of frequency. For example, Wolf Creek, Knowles Creek, and Cedar Creek were checked for temperature and dissolved oxygen in October of 1977, but there were no follow-up visits to these sites to collect data for comparison of changes over time. Other data exist in the STORET database, but these data are also limited geographically and in terms of frequency.

The most comprehensive water quality data was collected by USGS at Mapleton from 1978-1992, but the samples were only collected approximately quarterly and do not provide enough data for a robust analysis (Graph XX). However, based on this data, summer water temperatures show slight increases over the monitoring period. A corresponding decrease in dissolved oxygen is also exhibited. No apparent trends are seen in sediment or nutrients.

The entire Siuslaw River has been listed by the Department of Environmental Quality as exceeding water quality standards for temperatures during summer. A number of Siuslaw Basin streams have shown high temperatures, including; West Fork Indian, Lower Indian, Deadwood, Hoffman, Lower Knowles, Middle Knowles, Chickahomony, Lake Creek, Walker (Lower Siuslaw,) Walker (Wildcat,) and a number of others. The temperature at Mapleton has been known to spike to 87°F.

There are likely three main causes of elevated stream temperatures in the Siuslaw basin. The first cause may simply be natural geography. The basin lies at the south boundary of the central and southern coast regions. Summer mean maximum temperatures increase from north to south, with the south coast averaging 81.5Degrees F (27.5C) and the north coast averaging only 69.9 degrees F (21C). The east half of the Siuslaw basin, away from the cooler coastal fog belt, is expected to have a mean maximum August air temperature of between 75.6 and 81.5 degrees F (Weyerhaeuser). Thus to some extent, Siuslaw streams can be expected to have naturally higher summer temperatures than those to the north.

A second cause appears to be lack of riparian cover. In Lake Creek for example, one-third of the total riparian area (measured as 100' on either side of all 3rd order and higher streams) is either recently clearcut, or has no woody cover at all (most likely due to farming practices). Shade analyses by the Forest Service, BLM, and Weyerhaeuser all show that it is primarily the wider valleys, where agricultural land use dominates, that lack riparian woodland cover. In Indian and Deadwood Creeks, only 20% of the lower valley floor riparian areas have enough trees to shade streams. Significant stream reaches in the Lorane Valley have less than 40% shade cover. Yet early land surveys indicate that dense riparian trees were extensive in these areas.

A third cause of high stream temperatures appears to be the amount of exposed bedrock adjacent to stream channels, and in channels themselves. Bedrock, especially when dark, readily absorbs sunlight and has greater thermal mass, thus allowing it to heat up much more than gravel or sand. This heat is then transferred to adjacent water bodies by long wave radiation. This phenomenon is clearly related to lack of riparian cover in many areas.

The combination of increased temperature and decreased dissolved oxygen is stressful to aquatic organisms, and salmonids especially. However, it is difficult to draw any general conclusions on the extent and severity of the situation due to the overall lack of data for reaches where many fish and other organisms would typically reside in the summer.

Chemical Water Quality Issues

Dissolved lead exceeds chronic toxicity levels for most of the recorded measurements at the Mapleton gage. Three of the measurements showed levels above the acute toxicity level. The dominant bedrock in the watershed, Tyee Sandstone, is not a likely source of lead. Lead weights lost by recreational fishers have been identified as the more likely source. However, the data is not sufficient to determine the source of the lead, nor the severity of the extent of lead problems in the Siuslaw watershed.

The soft water chemistry of the Siuslaw makes dissolved heavy metals, (including chromium, copper, lead, nickel, silver and zinc) more toxic

303d streams
9.1

to organisms. We have not investigated other streams along the Coast Range to assess how unique this water quality aspect is for the Siuslaw, but it is very different from the Columbia and the Willamette rivers.

In summary, the data that indicates increasing temperature at the Mapleton gage, and numerous spot readings in other parts of the watershed that show elevated stream temperatures should give cause for concern. Limited data and analysis indicate that lead levels appear to exceed acute toxicity levels at times, and chronic toxicity levels on a regular basis. This problem may be limited to the lower mainstem. Additional data collection and analysis is necessary for improving the understanding of this water quality parameter in the Siuslaw.

AQUATIC RESOURCES IN THE SIUSLAW RIVER

The Oregon Watershed Assessment Manual recommends evaluating aquatic resources by using available information on fish populations, in-stream habitat, and migratory barriers in a four-step process. There are challenges to using this process in the Siuslaw basin. First, the process is aimed at a watershed of about 50-60,000 acres. The Siuslaw covers over 500,000 acres. This difference in scale affects the analysis. For example, cataloging channel habitat types is a central component of the OWEB analysis approach. Large, low-gradient reaches are believed to be those of highest value for spawning, rearing, and migration for salmonids. In the Siuslaw basin the large, low-gradient mainstem streams are not the most important spawning or rearing reaches, nor is there reason to believe that they were historically. Lower Lake Creek and the lower Siuslaw above tidewater have probably always been too warm to rear salmonids during the summer, except in deep, stratified pools near tributary mouths. They are however, important migratory routes at all seasons except the summer.

There are extensive in-stream habitat inventories for much of the basin that have been done over the years by state and federal agencies. The Forest Service is in the process of compiling and standardizing all the available inventories. But

Siuslaw National Forest Stream Habitat Data
216 Total Stream Surveys (1991 1998)

Habitat Element	Not Properly Functioning	At Risk	Properly Functioning	Percent Properly Functioning
Stream Wood Conditions				
Key Large Wood	150	53	13	6%
Stream Pool Conditions				
Pool Area	85	53	78	36%
Pool Frequency	25	72	119	55%
Pool Quality	148	16	52	24%
Other Stream Habitat Conditions				
Side Channel (Habitat)	212	2	2	<1%
Width to Depth Ratio	104	33	79	37%
Percent Gravel	44	78	92	43%

Habitat surveys from 1991 to 1998.
Not all columns add up to 216 because some surveys did not measure all elements.

Table 10.1 Siuslaw Stream Habitat Conditions

Siuslaw Stream Habitat
ODFW Data
102 Total Stream Surveys (1991-1998)

Habitat Element	Undesirable	At Risk	Desirable	Percent Desirable
Stream Wood Conditions				
Complex Pools	46	6	5	9%
Large Wood	18	26	42	49%
Wood Volume	31	15	40	46%
Key Large Wood	64	15	7	8%
Stream Pool Conditions				
Percent Pools	22	23	57	56%
Pool Depth	4	81	4	5%
Pool Ratio	19	26	17	27%
Other Stream Habitat Conditions				
Stream Bottom (silt, sand, etc.)	30	35	33	34%
Width to Depth Ratio	19	33	48	48%
Percent Gravel	11	27	64	63%
Shade	0	0	102	100%

Habitat surveys from 1991 to 1998.
Not all columns add up to 102 because some surveys did not measure all elements.

Table 10.2 Siuslaw Stream Habitat Conditions

this work is not yet complete, thus we were unable to use it in this analysis. However, the Coast Range Association summarized the habitat condition for the Siuslaw basin from these same inventories, and concluded that the general condition of the in-stream habitat was poor (Tables 10.1 and 10.2). In particular, the lack of large wood in channels was listed as a major problem (Willer).

Barriers to fish movement have received considerable attention in the Siuslaw. Over the last few years a thorough inventory of passage problems was completed and the sites prioritized. During the last 2-3 years approximately 31 problem culverts have been replaced or modified in the basin (Map 11.1). A number of "high priority" culverts continue to block fish access for part or all of the year, and remain to be dealt with.

In order to accomplish the goals of the aquatic section specified by the OWEB manual (and meet the needs of the Watershed Council,) we modified our method of analysis. We first examined historical changes in the number and distribution of salmonids in the basin. Second, we identified the factors that have caused these changes.

Change in the population of salmonids from the late 19th century to the end of the 20th century.

The first estimates of the number of coho, and chinook salmon can be made from the early cannery records. The first cannery was established in the late 1870's. For a period of time before 1910, there were up to three canneries operating in Florence. The estimates of these populations have been made a number of different ways. For the period 1893-1903, an average of 1,534 cases of Chinook salmon and 8,596 cases of coho salmon were canned (Cobb 1930). The canneries estimated that it took 65 pounds of Chinook salmon and 70 pounds of coho to fill a case (Crawford 1895). If we assume that Chinook salmon averaged about 22 pounds, and coho salmon averaged 10 pounds, this translates into an annual catch of 4,532 chinook and 60,172 coho. If we further assume that they caught about 40% of the run, then the estimate for the annual Chinook run was over 11,300 fish and the annual run of coho salmon was over 150,430. Other estimates have put the coho salmon runs between 220,000 fish (Sedell and Luchessa 1982) and over 450,000 fish (Lichatowich and Nicholas 1993).

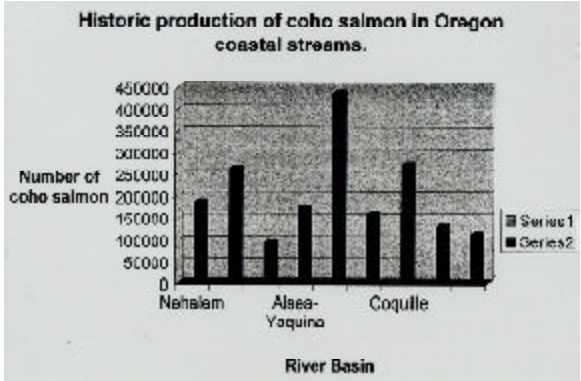


Chart 10.1

Graph 10.1 illustrates the relative production of coho comparing the Siuslaw to the other coastal basins in Oregon. The Oregon coast, and the mid-coast in particular were highly productive areas for coho salmon. If we use the historic production of coho salmon from Lichatowich and Nicholas and compare the Yaquina, Alsea, and Siuslaw rivers on a per unit basis, there were 204 coho/mi^2, 261 coho/ mi^2, and 562 coho/mi^2, respectively. Thus the production of coho per unit area of the Siuslaw basin was twice that of the adjacent watersheds. Early in the 20th century the Siuslaw basin was one of the most productive coho salmon streams in the Pacific Northwest, and the Oregon Coast as a whole was a major production area for coho salmon (Dewberry, Booker).

At the end of the 20th century we have better estimates of salmonid populations. The most important long-term estimates for coho and chinook salmon come from ODFW adult salmon counts. In each year the number of fish in selected sections of streams are counted. These counts are used to generate the population estimates for entire basin. For coho salmon, there are 7 standard sites with a combined length of 7.2 miles, and about 45 sites that are chosen randomly each year with a combined length of about 40 miles. For chinook salmon during the 1990's there are 16 fish spawning reaches that are used to estimate the population number. In addition, statistics are gathered at several moorages to track trends in catch records from year to year (ODFW 1997).

During the 1990's coho salmon runs were estimated to average under 4,000 fish, which is less than 5% of their historical numbers. In the lowest year, less than 700 coho were estimated to have spawned in the entire Siuslaw basin (Table

2). However, the Chinook runs are at present one of the healthiest runs on the coast. About 4,000 fish have been caught per year in the river during the 1990's (ODFW 1997). This is about 89% of the cannery catch of about 4,500 fish at the beginning of the century.

The runs of chum salmon were highly variable around 1900. The estimates were from 0- 65,000 fish. Chum runs are currently sporadic, but large runs do not approach those reported from the late 19th and early 20th centuries.

We have little information about rainbow and cutthroat trout numbers at the beginning of the 20th century. The majority of the rainbow trout (steelhead) in the basin have a life-history which includes migration to the ocean. The cutthroat trout has a number of life-histories in the basin. Most are resident in small streams, some move to larger streams and rivers, others go to the ocean for a period of time. Those that go to the ocean are called sea-run cutthroat trout. We do know from early settler records that trout were abundant in much of the Siuslaw basin.

The earliest records for steelhead in the Siuslaw were from a gill-net fishery in the 1920's, when about 2,900 fish were caught annually. No estimate of the effort or catch rate is available for this fishery. More recent steelhead catch data is available since the 1950's. During the 1950's approximately 2,000 fish were caught per year. Steelhead numbers peaked during the 1960's at about 4,500 fish, and have declined to less that 3,000 during the 1990's.

Sea-run Cutthroat Trout

Thus steelhead are near the same level they were at in the 1920's, but it is not known if the numbers were already depressed by that time. Approximately 60-75% of present steelhead are of hatchery origin.

We know from early settlers diaries and journals that cutthroat trout were abundant, but we do not have population estimates. There are also no current population estimates available for resident cutthroat trout in the basin. Resident cutthroat are presently widely distributed and they are believed to be abundant. There are a number of isolated unique resident populations of resident cutthroat in the Siuslaw basin. One of the best known is the population that rear in Triangle Lake and spawn in tributary streams (ODFW 1997).

Cutthroat probably inhabit over 1,250 miles of streams within the basin. The Siuslaw sea-run cutthroat fishery was internationally renowned by the 1920's. The railroad used to bring anglers in to fish for sea-run cutthroat (L. Hood, personal communication,) and as late as the 1970's the Siuslaw was considered the finest in the Pacific Northwest (DSL 1973). The Oregon Department of Fisheries and Wildlife also considered the Siuslaw to be the finest sea-run cutthroat fishery in Oregon (ODFW.1997).

In the 1960's, Giger (1972) estimated that the sea-run cutthroat population in the Siuslaw basin averaged about 27,000 fish in the late 1960's. The recent catch of sea-run cutthroat trout has been dismal. The population after 1993 has been under 1,000, or only about 8% of what it was in the 1960's. It is not known if the fishery was depressed during the 1960's in comparison with historic numbers.

As mentioned, chum salmon production has been highly variable from year-to-year. Prior to 1900 population estimates were as high as 65,000 fish. After 1900 the populations have been significantly less. Chum salmon numbers are not well enough known to be commented on further in this analysis.

In summary, all salmonid populations in the basin are considered depressed with the exception of fall Chinook and resident cutthroat. The level of depression is most severe for coho. This situation is common in Oregon coastal streams. The issue of what caused the depressed populations is addressed later in this chapter.

The general distribution of salmonids in the Siuslaw basin

One of the most important pieces of information about aquatic species is their distribution within

the basin. Distributional changes are one of the first clues that environmental conditions have altered. Change in location sometimes lead to change in population number as a bi-product. For instance, consider a stream that is 15 miles long. A given species inhabits 1 mile of stream (mile 6 from the mouth). Let's say that conditions change and the species is still occupying 1 mile of stream but has moved to10 miles from the mouth. These fish are now occupying considerably less total habitat (the effective available stream is smaller), and it is likely that the new reach is not as productive as the former reach was. Thus there may be less potential for total production. In addition, changes in distribution often serve as critical clues to help us understand what may have caused the change. Lastly, without information on fish distribution we have no way to prioritize what areas are in most need of restoration. We may realize that some efforts are necessary, but we have no way to understand where to start first.

Example summary of fish life history patterns.

Species	A-Anadromous R-Resident	Location	Spawning	Outmigration
Chinook	A – fall	Mainstem, lower reaches of large tributaries	Oct. to Jan., peak in Nov.	June/July to estuary Summer/fall to ocean as under-yearling smolts
Coho	A – fall	Low-gradient tributaries	Nov. to Feb.	2nd spring after hatching, peak in May; limited estuary time
Steelhead	A – winter	Low-/moderate-gradient tributaries	Oct. to March, peak Dec. and Jan.	2 to 3 years in freshwater, outmigrate in March to June*
Cutthroat	A – summer/fall R Fluvial	1st and 2nd order tributaries	Dec., peaks in Feb.*	Age 1+ and 2+ fish outmigrate April or May to estuary/tidewater Age 3 fish go to ocean in May Adults overwinter in estuaries of origin*

* Based on information from Alsea Watershed; local data not available.

Table 10.3

The River Continuum Concept is a useful context to aid our understanding about the abundance and distribution of aquatic organisms. This concept developed from the idea that streams and rivers make predictable changes in a number of elements from their headwaters to their mouths. Stream discharge, stream size, amount and size of sediment available for transport, kinds and sources of organic matter (food), and stream temperature regimes are among the elements that change along a streams length.

An associated concept is the dynamic of sediment and organic matter from the ridge top to the headwater streams to the mouth of the river. This important watershed process is key to understanding the biology of a stream system (Naiman 1992, Dewberry 1996). The movement of sediment and organic matter creates the physical habitat as well as providing food for organisms. In the Siuslaw basin, this key process is controlled to a large degree by large trees and large woody debris. An important implication of both these concepts is that conditions at a site are a reflection of all that occurs in upstream reaches and on the hill slopes above the stream channels.

Each organism has their own set of requirements and preferences. They also vary considerably in their range of acceptable conditions (tolerance). Some organisms are very tolerant while others have a very narrow range of acceptable conditions. Sometimes an organism is tolerant to a wide range of environmental factors but is intolerant to one or two factors.

Organisms with narrow tolerances are the most useful indicators of changing conditions in a watershed. In general, salmonids are quite intolerant of several factors, including; changes in water temperature, oxygen concentration, and fine sediment. Each organism locates itself along the river continuum based on the available habitat and food resources and its preferences. Only a few aquatic organisms are known well enough to understand their distribution.

Salmonids are among the best understood aquatic organisms in the world. The list of the salmonid species that occur in the Siuslaw and their generalized life cycle is given in Table 10.3. The idealized distribution of salmonids spawning and rearing is illustrated in Fig 10.1A. However, in each individual river basin the actual distribution will reflect the unique climate, geology, and influence of natural and human events. In the Siuslaw basin the hypothesized distribution of salmonids in the late 19th century is illustrated in figure 10.1B. The only major differences between these two distributions are that chum salmon may not have been most abundant in the lower mainstems of Lake Creek and the lower Siuslaw River. The extent of stable, clean gravel beds in the lower mainstems is not known.

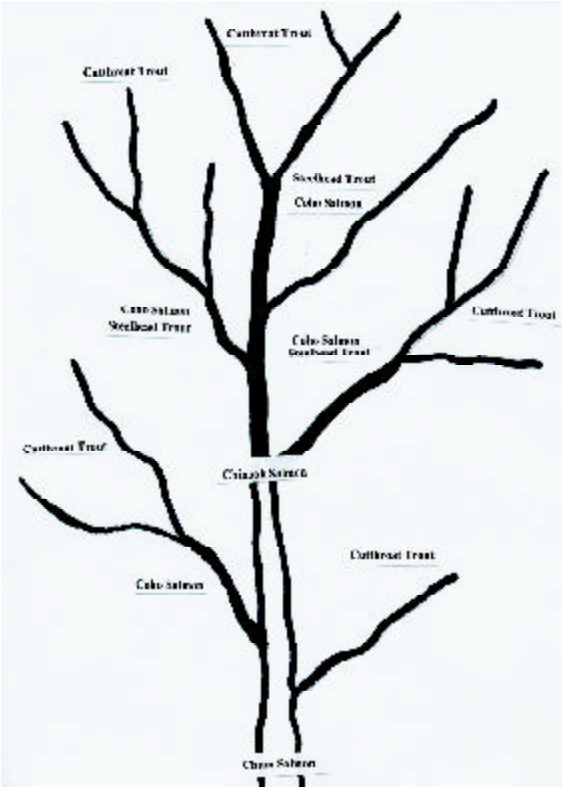


Figure 10.1A

Chum may have been most common in tidal tributaries streams such as Sweet Creek, and possibly as far up river as lower Indian and Deadwood Creeks. Another difference is that the cutthroat trout has a number of life-history variations. Some of these variations include rearing in mainstem and large tributary reaches. But this is largely excluded during warm summer months in the Siuslaw. Anadromous fish lacked adequate access to Triangle Lake and its tributaries prior to the completion of the fish ladder at the mouth of the lake. Except for Triangle Lake, the Siuslaw basin has few natural barriers. The gradient of the mainstem reaches and major tributaries is generally low, which allows widespread habitat availability.

Current distribution of fish in the Siuslaw basin

The idealized and historical distribution of salmonids in the Siuslaw basin agrees quite well with the current distribution information, with the following highlights (Figure 10.1C). Due to the completion of the fish ladder at Triangle Lake, anadromous fish now have access to the lake and tributaries above it. Chum salmon now rarely use the mainstem of Lake Creek or the Siuslaw for spawning (if they ever used it extensively). Most of the known spawning is now in the tidal tributaries, especially Sweet Creek. We have no clear records that indicate major changes in spawning or rearing distribution for the other salmonids.

Several non-salmonid species also have been surveyed enough to make general statements concerning their distribution. Anadromous Pacific Lamprey move upstream into tributaries to spawn in the spring. They spawn throughout the basin (ODFW 1997, BLM data). Brook Lamprey are also found throughout the basin. Sticklebacks have a distribution closest to chum salmon. They are most common in the large streams and tributaries near tidewater. Suckers, Squawfish, and pike minnows are common in larger mainstem reaches. Further upstream and in the lower portions of large tributaries are red-side shiners and dace species. The dace venture further upstream than the shiners, well into the summer coho salmon rearing zone. A number of sculpin species are common from the headwaters to the mouth. (Sculpins, along with cutthroat trout are often the main species found in headwater streams). In the estuary, both green and white sturgeon occur. Their origin is unknown. In the early 1990's up to 100 might be caught in a season (ODFW 1997). A species list for the fishes of the Siuslaw basin has been complied from agency watershed assessments (Appendix A).

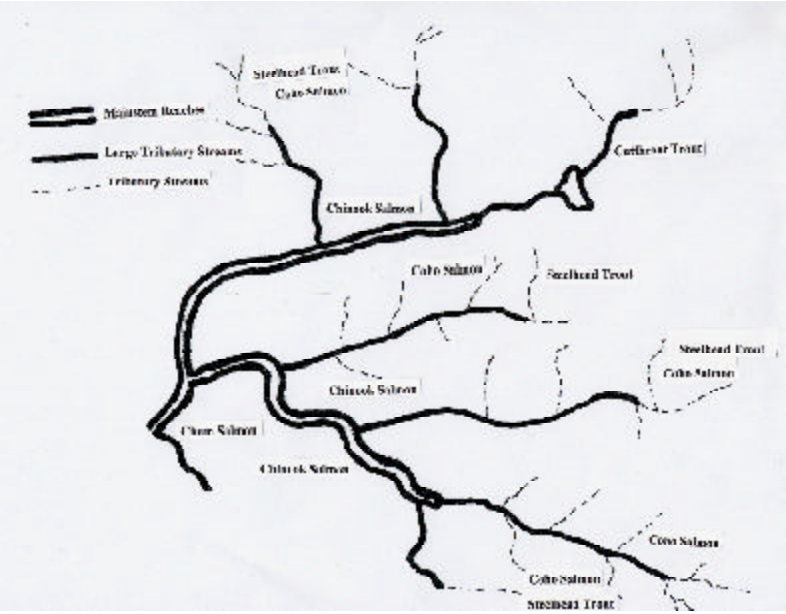


Figure 10.1B

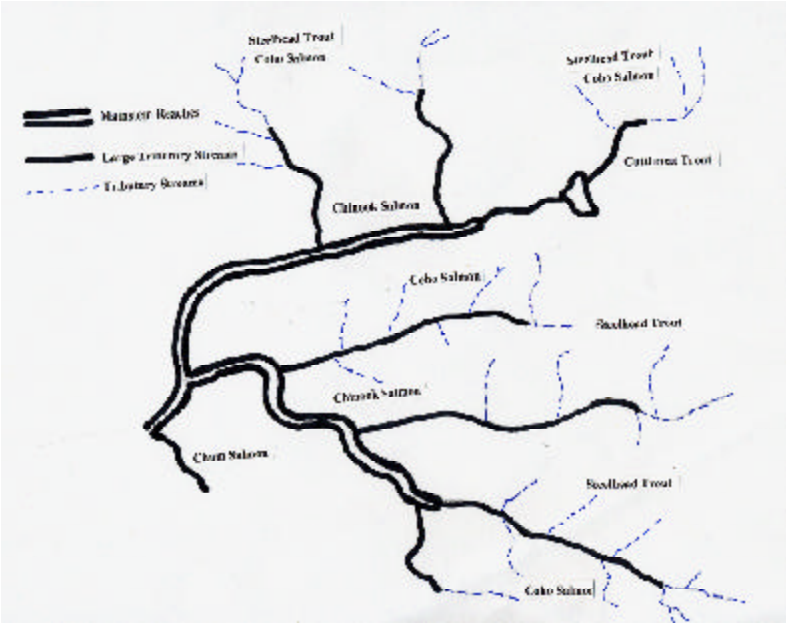


Figure 10.1C

The Interaction of salmonids in the Siuslaw

Salmonids separate to some degree spatially and temporally from each other. However, there are stages with considerable overlap. Chinook and coho salmon overlap in larger tributaries during spawning. This is particularly true now that there are fewer natural barriers, such as jams. The absence of jams has likely allowed chinook to move further upstream than they once did. Juveniles overlap in terms of time of emergence from the spawning gravel. This suggests that there may be greater competition for food during the first few months of life (before most of the Chinook begin moving downstream to the estuary). During most of the remainder of their life-histories, most salmon are effectively segregated in time and space. The early removal of logjams and later stream cleaning allowed anadromous species of all salmonids to encroach further upstream, into what had been resident cutthroat habitat. The effects of this can only be guessed at. However, the present effort to remove barriers should include guidelines to establish where barriers ought to remain to protect resident cutthroat.

Salmonids in the Siuslaw directly compete and at times eat each other. Larger coho smolts on their migration from the stream systems into the ocean eat large numbers of chum fry (when available) and chinook juveniles. Large cutthroat adults and smolts eat fry of all the other salmonids. It is likely that the major decline in coho production has thus also affected cutthroat production.

Causes of salmonid decline

Both natural (not directly caused by humans) and human actions affect salmonid populations in the Siuslaw basin**.** Natural factors that may affect salmon production include: weather conditions (including periodic floods and droughts,) earthquakes and tsunamis, ocean conditions, and predation.

There are a number of human factors that affect salmon distribution and production. These include: over-harvest, land development on the wider valley floors, development of the estuary, including; dredging, diking and filling wetlands, building jetties, pilings and buildings along the river, stream and river clearing, historic splash damming of timber down tributary streams, removal of riparian forest, over-harvest of beaver, construction of roads and railroad lines along the mainstem and major tributaries, construction of logging roads followed by timber harvest on steep unstable slopes. Additional causes, though intended to help augment fish populations, include stream cleaning and hatchery management.

Our team's approach to the issue of salmon management is to understand how factors outside of our control affect Pacific salmon populations, but focus most effort on issues that we can affect. We cannot change ocean conditions or weather patterns, nor can we prevent earthquakes, but our management strategies must include awareness of these issues.

Discussion of Available Salmonid Information:

In order to do an analysis of the factors that affect salmon populations, and to understand the relative importance of each of these factors, we need fairly specific information. Absent this information, we cannot do more than speculate about what has happened, and how past decisions may have affected the outcome. The most critical piece of the puzzle is "life-history"

information. This includes the number of fish alive at each developmental stage, as well as where they are located at each stage. For most questions we need this information over a number of years. Year-to-year variations in the relative importance of factors can be large. Also, relatively infrequent events, like floods or droughts, can significantly affect salmon populations for a number of years. Without knowledge of these events patterns can easily be misunderstood.

A second assumption that we are making is that salmon life-history is like a chain. At each stage of the salmon's life it must have a favorable environment to live in. However, all elements of the chain must be present to have a functional life-history. If a favorable environment at one stage is absent or of very poor quality, salmon production can be limited or zero at that particular stage. Biologists describe this as a bottleneck. An implication of this assumption is that efforts to increase salmon abundance that focus on other environmental factors or life-stages (not the bottleneck) will be of little or no benefit until the "bottleneck" is addressed. There is a connection between all the life-stages. If a bottleneck or limit exists at a life-stage it will affect all subsequent life stages and generations. For example, if only a small number of fish survive their first juvenile stage in a stream, this will be a small year class no matter how favorable the conditions later in their life-history.

We do not believe that life-histories are a chain in the sense that the strength of the chain is based solely on its weakest link. Unlike a physical chain, increasing survival at any stage can affect

Juvenile coho salmon

the overall production of that generation of salmon.

For salmonids, more than one chain or life-history is possible. For instance, most fall Chinook juveniles move from streams into the estuary during their first spring, then they subsequently move to the ocean and return to the original stream to spawn. Some fall chinook however, spend a full year in the streams before they migrate into the estuary, and then out into the ocean.

The information that we would ideally have to fully understand the population dynamics of each species of Pacific Salmon include: the number of adults that spawn, the number of eggs deposited, the number of parr that are produced, the number of smolts that migrate to the ocean, and the number of adults that return. With this information we could track the overall numbers of a salmon species, as well as track numbers and survival of each life-history stage. We could pinpoint how well the fish are doing in each environment as they move through the stream, and estuary, to the ocean. This information and also help us identify where problems are.

Unfortunately, it is not practical to try to obtain all the information directly. To attempt to determine the number of eggs deposited by coho salmon in the Siuslaw by counting is impossible. Yet without an estimate of the number of eggs we cannot determine the survival of the eggs to the next stage. We cannot determine if sedimentation is affecting the survival of those eggs without this estimate. Models are used to estimate the numbers of some life-stages.

Without a good estimate of smolt production we cannot determine if factors in freshwater or the ocean are controlling the production of a salmon species. So, information on smolts is critical to the analysis. Without it, our claims are only opinions unsupported by direct evidence.

Unfortunately, obtaining this information is time consuming and expensive. Fishery managers have not until recently put much effort into it, in part because there has been little money available for this work. The best long-term information we currently have for the entire basin are the ODFW adult spawning surveys. We have already used them to show part of the basin wide historical trends of salmon populations through the last century.

Information about the distribution of salmonids juveniles is sparse. The only systematic whole basin estimate aimed at determining both the abundance and the distribution of juvenile salmonids in the Siuslaw basin is the rapid

bioassessment conducted by the council and funded by OWEB in 2000 (Figure). Also during 2001, Ecotrust conducted a more limited survey on public lands in Indian and Deadwood Creeks.

These surveys are very useful for identifying areas that are currently important for rearing salmonids. In the case of coho it is best to have at least three consecutive years of surveys, since coho salmon have a 3 year life cycle. These survey generally isolate where the fish rear from early June to October. In smaller streams the riffles are dry, eliminating the possibility for migration, while in larger tributary streams, high stream temperatures and low oxygen also limits movement during this period.

Relatively long term Salmonid smolt estimates are available from only two sites within the basin. The BLM has maintained a smolt trap on Wolf Creek for 4-5 days/ week during the major migration season from 1996-2001. A number of cooperators have maintained a smolt trap on Knowles Creek for 7 days per week during the migration season from 1992- 2001. The results of these estimates are listed in Appendix A).

One of the most important recent positive steps taken was funding of the ODFW life-history project. As information comes out of this project over the next few years, we hope to gain a much better understanding of the complex factors affecting salmon.

The second most recent development has been the coastal monitoring project, designed to monitor the trends of juvenile coho in each of the five coastal coho Gene Conservation Areas. This

Juvenile Chinook Salmon

project was started in 1998. With additional years of monitoring this information will greatly help us isolate the relative importance of factors affecting coho populations. While this estimate is designed to estimate the populations juvenile salmonids within the GCA it is of limited use for examining the distribution of salmonids.

We have already noted that Chinook populations appear to be near their historical levels in the Siuslaw. This implies that Chinook salmon have favorable habitat at each of their life stages. But this should not be interpreted to mean that there are no problems at any life-stage. Rather the cumulative effect of favorable factors may outweigh current problems or limitations. It also does not indicate that all portions of the environment are in healthy condition. For instance, juvenile Chinook are found in the lower portions of large tributaries and mainstem streams during the spring. Here they move (some slow some fast,) from the spawning areas to the estuary. For Chinook these habitats must be acceptable, but they may still be in generally poor condition, and not favorable habitat for other species.

Chinook salmon primarily spawn in the mainstems of Lake Creek and the Siuslaw and in larger tributaries such as the North Fork. The most important spawning area in the entire basin is upper Lake Creek below Triangle Lake (Westfall). Few Chinook salmon move up into the lake. The water is generally too warm coming off the lake. The number of chinook salmon moving up the mainstem Siuslaw is believed to decline rapidly above Esmonds Creek (BLM staff, personal comm.). Although no hard evidence exists, it is likely the case that Chinook are now spawning farther up in the tributary streams than they did historically (due to the absence of log jams mentioned earlier).

Resident cutthroat trout populations in the basin appear to be healthy. Virtually every stream in the basin has a viable population of resident cutthroat, and there is no evidence that they are in decline. The sea-run life history form dropped from approximately 27,000 in the 1960's to below 1,000 during the 1990's. In recent years, these numbers have begun to increase again.

The available information we have on steelhead is largely based on catch records from punch data. The catch records are more compete for steelhead than for cutthroat trout. The stock is considered depressed (ODFW 1997). Steelhead spawn in winter to early spring. The juveniles live in the streams for 2 or more years. They migrate to the ocean and return after several years. ODFW identified the following factors as contributing to the decline: poor ocean conditions, predation by marine mammals and birds,

over harvest, habitat degradation, and hatchery influences. No specific information is available to establish the relative importance of these factors.

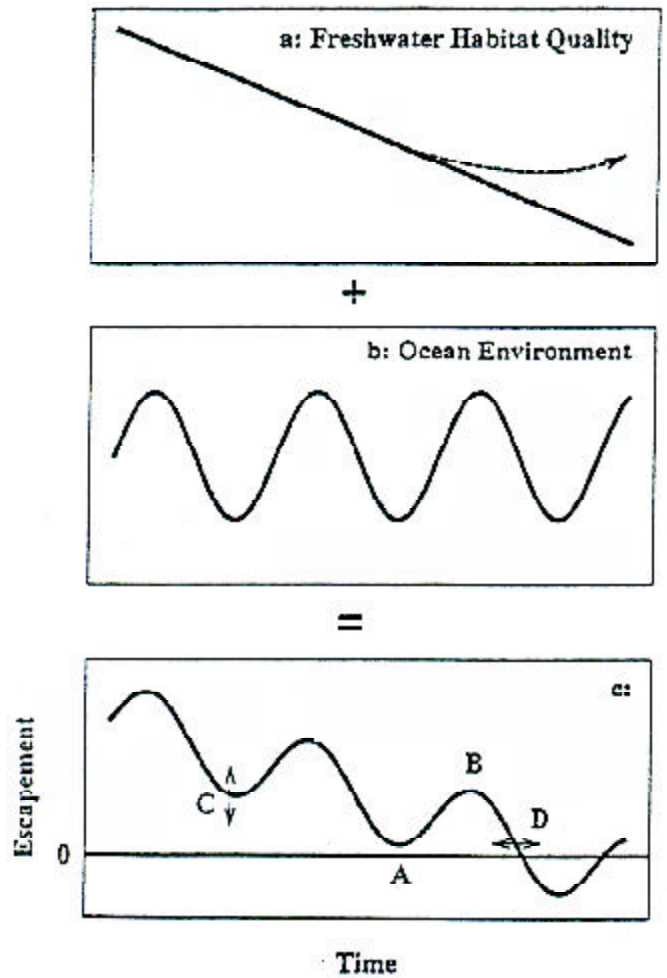
The decline of coho salmon populations along the Oregon Coast is one of the best documented fishery stories in the world. It is clear that the coho population in the Siuslaw is depressed from their abundance at the turn of the century. As mentioned, the current population of adult fish is no more than 5% of what it was at the turn of the century. Wild coho are currently listed as threatened under the Endangered Species Act. The best present estimates we have on coho salmon are from the adult spawner counts conducted by ODFW since 1951. Estimates of adult coho prior to 1951 are based on catch records and cannery records. Coho salmon spawn in late fall to winter. The juveniles reside in the stream for over a year, migrating to the ocean during their second spring. They remain in the ocean about a year-and-a-half.

While ODFW did not specifically list factors contributing to the decline of coho, the same list for steelhead is likely, including: poor ocean conditions, predation by mammals and birds, over-harvest, habitat degradation, and hatchery effects. In the case of coho, we are in a better position to prioritize this list. It must be kept in mind that the relative importance of these factors can change if we are looking at year-to-year variations, or trends over a decade or more. Also, keep in mind that a number of these factors interact with each other.

Based on the available information, we believe that ocean conditions are not primarily responsible for the decline of coho salmon. Ocean conditions do vary quite a bit, but the long-term trend in coho populations is best described by the oscillation of ocean conditions superimposed on a negative trending line (P. Lawson 93). (Figure 10.2). In other words, over short periods over the past century coho populations have gone up or down. But over the whole period the trend is clearly down. The crucial question is: what are the factors primarily responsible for the long-term negative declining line?

The effects of a dynamic ocean have been accounted for. What makes this analysis complex is that the predominant factors responsible for the decline probably has varied over the past century. For the early part of the 20th century we do not have estimates for any life-stage other than adults. However, at the turn of the century it is compelling to see over-harvest and mainstem habitat degradation as the likely main factors in salmonid decline, as opposed to predation by marine mammals and birds, or hatchery influences. The best estimate of the early harvest rate for coho salmon is in the range of 40-60%.

We also have good evidence for habitat degradation. The effects of splash damming and stream cleaning to drive timber are well documented. We also believe that marine mammal



Conceptual model of effects of declining habitat quality and cyclic changes in ocean productivity on the abundance of Oregon's coastal natural coho salmon. a: trajectory over time of habitat quality. Dotted line represents possible effects of habitat restoration projects. b: generalized time series of ocean productivity. c: sum of top two panels where letters represent the following: A = current situation, B = situation in the future, C = change in escapement from increasing or decreasing harvest, and D = change in time of extinction from increasing or decreasing harvest.

Figure 10.2

fish map
10.1

and bird populations were lower than they are today. They were often shot on sight. We know that there were no coho hatcheries in the basin at that time.

As we move closer to the present the situation changes. Our information is better, though certainly not complete. The collapse of the coho fishery in the mid-1970's is instructive. In 1976, 3.9 million coho were caught in the OPI (Oregon Production Unit). In 1977, only about 1 million were caught. Catch and escapement has generally continued a downward decline in until the present. These trends are reflected in Siuslaw adult counts throughout the 1990's.

What accounts for the decline of coho salmon from the 1970's to the mid-1990's? Available information suggests it was something in the ocean, since survival rates for the smolt to adult stage have been much lower than average. One possibility suggested by some is that it was primarily the growing effect of predation by marine mammals and birds. Marine mammals and birds are known to eat salmon smolts. In some locations they are known to have decimated populations of salmon. Indications are that populations of both marine mammals and birds are increasing.

But this argument is not compelling. While marine mammals and birds do eat salmon there is no indication that this predation alone is enough to account for the very steep initial drop seen from 1975 to 1976, followed by the rapid decline until the late 1990's. It is more likely that a complex interaction of a number of factors have created the decline. It is likely that what increased the influence of predation is the interactive role of the huge (over 2 million fish) introductions of hatchery smolts annually into the ocean.

As the wild fish abundance declined (with declining ocean productivity,) predators would have had to switch to other prey, or simply decline in abundance themselves. However, the very large, year-after-year introduction of hatchery fish during the period of wild fish decline may have disrupted the co-evolved predator-prey relationship. The large hatchery releases of large size smolts (which were poorly prepared to deal with life outside the protected confines of the hatchery raceway,) provided predators the means to keep increasing their numbers. This interaction of predators and hatchery fish is more plausible than focusing on predators alone. But as yet we do not have sufficient evidence for final conclusions regarding the extent to which predators have affected salmon.

Since 1998 the number of coho hatchery smolts released have dropped significantly (ODFW). Interestingly, the survival of wild fish in the ocean has increased, with escapement numbers higher over the past two years (Nickelson 2001). Is this mere coincidence, or have ocean conditions improved? We currently do not have the information to say. There is also the question of how accurate the models are. For instance, coho smolt numbers are not measured, but rather are modeled. Nickelson's estimate of the coho smolt numbers for the 1997-99 brood year on the Siuslaw were a low of 111,755 to a high of 393,622.

Smolt numbers have been measured at two sites in the Siuslaw basin over a period of years, Wolf Creek and Knowles Creek. Smolt production has been estimated in Knowles Creek since 1992. If we expand the Knowles smolt numbers to the Siuslaw (assuming that Knowles Creek has average smolt production,) we get a low of 113,000 and a high of 402,000 for the years in question. The fact that this different method yields similar conclusions suggests that the Nickelson model is probably a reasonable estimate of smolt production.

An argument might be made that since it is smolt survival in the ocean that seems to be limiting overall coho production at present, it would imply that factors in freshwater are not of high importance. In other words, as long as there is a strong limit in the ocean, efforts to improve conditions for coho in freshwater are not very important. Also, there is general agreement among state, federal and other biologists working in the basin that in-stream habitat is in better condition today it was in previous years. Therefore, nothing more is necessary in the freshwater portion of coho's habitat.

But this argument is not very compelling. At this date we have no clear indication that all our combined management efforts have stopped the long-term downward decline of coho salmon in the basin. In 2000 there was a clear increase in coho escapement, but one year improvement is hardly sufficient to claim we have stopped a century long decline. That being the case we should not claim that the current condition of any part of the habitat of coho salmon is acceptable. No one has clear evidence that this is the case.

Are spawning and rearing conditions in the streams comparable to conditions at the start of the century? We know they are different, and probably not as good. In-stream habitat surveys concluded that much of the stream habitat is in poor condition. Is survival of each of the stages in the coho life-history in freshwater comparable to those at the turn of the century? We do not know. But we have no direct basis for concluding that the freshwater habitat is in acceptable condition.

Since the 1950's, a number of efforts have been made to recover lost aquatic habitat in the basin. Early efforts in the basin emphasized stream cleaning and in-stream structures to create better habitat (Armantrout 1991, ODFW.1997). Beginning in the 1970s, road construction standards were improved. Riparian protection on all forest lands has been increased. And logging on Federal lands has been significantly reduced. There is some evidence that current in-stream conditions are better for coho than were those of a decade or more ago. The destructive practice of stream cleaning has ended, and considerable efforts have been made to improve habitat by placing large wood and/or boulders in selected channels. These efforts have had some success. More fish are rearing in areas that have been improved than in nearby areas that have not (Westfall, ODFW). Have these efforts increased survival of coho life-stages in freshwater? We do not know for sure, but it probably has to some degree.

Have these efforts in freshwater been sufficient? The answer to this depends on what the goal is. It might be argued that no level of freshwater improvement will overcome the periodic poor ocean survival of smolts. But there is evidence to the contrary. The existence of healthy populations of coho in dunal lakes adjacent to the Siuslaw basin suggests that increased survival and growth in freshwater is offsetting the difficulties presented in the ocean. But in basins without lake systems, we do not know if environmental conditions restored to excellent habitat will eventually overcome limits experienced during times of poor ocean conditions. We have no examples to point to.

Another argument made for the present adequacy of the tributary stream portion of the freshwater environment, is that the historical life-history that dominated coho production in the Siuslaw included rearing in the lower portions of mainstems or the estuary. But it is unlikely that coho ever relied on the large mainstem reaches or the upper reaches of the estuary for summer rearing. Mainstem Siuslaw stream temperatures can reach up to 80 F, so the water flowing into the head of the estuary is clearly too warm for salmonids during summer. It is also unlikely that the mainstem of Lake Creek was ever cool enough to support coho. And it does not seem compelling that that the lower mainstems or the upper portions of the estuary were cool enough to rear salmonids through the summer.

In addition, if we calculate the number of smolts necessary to produce the large coho runs at the beginning of the century we find that it is within the realm of possibility that the tributary streams could do the job. If we assume ocean survival of smolts was 8%, and that Knowles Creek represented an average habitat for the basin, Knowles share of smolt production would have been 50,000 coho. We have witnessed up to 16,000 in one year during smolt counts over the last five years. Only a portion of Knowles Creek has decent habitat at present. Therefore, it is easy to imagine it capable of producing 50,000 coho smolts in its historic condition.

Aquatic condition summary

Chinook and resident cutthroat populations are the healthiest salmonid populations within the basin. The chinook spawn during the fall. Centers of spawning include portions of the mainstem of Lake Creek and the Siuslaw River as well as the lower portions of major tributaries. The largest concentration is in Lake Creek below Triangle Lake (ODFW 1997). The high temperature of the water flowing from Triangle Lake at the time of upstream Chinook migration probably limits movement further upstream. Also, redds below the lake probably have higher survival rates because the lake captures and retains fine sediment. Most of the Chinook juveniles leave the stream systems and migrate to the estuary during their first spring. Thus, Chinook are only dependent on the streams for rearing during the spring months. They are more affected by factors in the estuary and the ocean than are other salmonids. We see very few Chinook juveniles (<10%) which stay in the streams for more than a year.

Resident cutthroat populations are also believed be at healthy levels. These fish are most abundant in small headwater streams. They are widely distributed in headwater streams throughout the basin. Cutthroat that include life stages in

larger rivers or the ocean are probably not in as good of shape. This is particularly true of the sea-run type.

In contrast, coho salmon numbers are severely depressed. Coho are found in all but the smallest headwater tributaries within the basin. They are also absent from the mainstem Siuslaw river and mainstems of major tributaries during the hot summer months. While our whole basin juvenile distribution for coho is scanty, available recent records from agencies and the one year of snorkel counts suggest that some areas are more important than other areas for the current production of coho salmon in the basin. Further research, especially two or three more years of juvenile snorkel counts will help identify the areas that are most important for coho rearing during the summer months. On the north side of the basin, areas that are currently recognized for high coho rearing during the summer are: Condon Creek and several of its tributaries (North Fork), a few tributaries of Indian and Deadwood Creeks, and the North Fork of Fish Creek. On the south side of the basin they are most abundant in Knowles Creek, Pugh, North, Dogwood and Bear Creeks.

Coho salmon and steelhead trout are the two most depressed salmonids in the Siuslaw basin. Both these species reside spatially in similar sized streams (however they differ in their preferred habitat). They both typically live for over a year in freshwater. The majority of Chinook salmon reside in freshwater for only a few months in the spring, then head to the estuary. This suggests that the existing freshwater habitat (below the headwater reaches inhabited by cutthroat) is likely not in good condition for summer and winter rearing. This thesis is corroborated by the fact that habitat surveys for these reaches note mostly poor quality.

It may also be more than coincidence that coho salmon and steelhead trout are the two salmonids that are most depressed, and they have had a history of the most significant hatchery programs within the basin. The two species that are considered to be in the best shape, Chinook salmon and resident cutthroat, are the two that have not had any significant hatchery program in the basin.

If we examine the health of the salmonids life-histories as a indicator of the health of the stream system it helps give us insights into the factors most affecting salmonids in the Siuslaw system. The headwaters appear to be in adequate shape. We do not have historic information on the abundance of cutthroat so we can only say that the cutthroat still appear to be distributed in stream reaches they historically were found. Cutthroat trout have also been able to prevent fragmentation of their distribution when debris flows destroyed populations in a particular headwater stream. There were adequate populations of cutthroat nearby to recolonize the reaches that had debris flow through them.

Smaller tributaries and the upper portions of larger tributaries appear to be in poor condition. These reaches are the most important spawning and rearing areas for steelhead and coho salmon. Historically many of the areas now occupied by steelhead and coho were cutthroat reaches. With stream cleaning and the decline in the input of large wood, the number of migratory barriers in these reaches has greatly decreased. Historically a major part of the function of these reaches was to provide favorable conditions for downstream reaches that were the high production reaches for coho salmon and steelhead trout. Some of these sections have temperature problems created by the removal of shade trees and the change in the sediment regime (Dewberry 1996). Because of the removal of barriers, Chinook salmon are now spawning in many of the lower reaches of these streams. Chinook salmon fare better because they are only reliant on the streams for spawning and up to 3 months of rearing in the early spring.

The lower portions of large tributaries are also generally in poor condition. These reaches may have been important coho salmon rearing reaches historically. Many of these areas are degraded by the cumulative effects from upstream reaches as well as in poor conditions within the reaches. Many have severe temperature, low flow, and oxygen problems during the summer months. These reaches continue to be important spawning areas for chinook salmon within the basin.

The mainstem Siuslaw and Lake Creek are important migratory routes through the stream system. During the spring they provide important habitat for migrating juvenile Chinook salmon, coho salmon, steelhead, and cutthroat smolts. In certain isolated pools they likely supported a riverine life history of cutthroat. During the summer these reaches may reach 80 F. Historically, it is unlikely that stream temperatures were cool enough except in deep pools near tributary junctions to sustain salmonids through the summer months. These reaches probably historically had more chum and Chinook salmon

spawning areas than they do now.

Prioritizing restoration efforts in the Siuslaw basin should focus to a significant degree on the factors affecting the coho salmon population because the Siuslaw was historically primarily a coho stream. At the beginning of the 20th century, the coho production in the basin probably surpassed the production of all other salmonids combined in most years. Coho salmon also depend on freshwater habitat for over a year before they migrate to the ocean. They currently, rear in the lower parts of headwater streams, small tributaries, and the upper reaches of moderate or large sized tributaries. It is also in this size stream that many of the cumulative effects from land use changes have occurred. Ultimately, we believe that restoration will be most effective if the major areas of current spawning, and rearing are identified and these areas be protected from further degradation. This includes protecting hill slopes and stream channels above the critical reaches from further degradation. Downstream emphasis should be placed on allowing natural processes to recover additional good habitat, with some direct improvements (LWD placement, riparian planting, wetland recovery).

THE SIUSLAW ESTUARY

Oregon's Estuaries

The Siuslaw estuary is one of 22 found along Oregon's coast. Estuaries are among the most biologically productive areas in the world. They are clearly important for economic and aesthetic reasons. Oregon's estuaries are major production areas for fish and shellfish, and serve as marine transportation hubs. They are also highly valued for their special beauty, where the sea and land intertwine.

The importance of estuaries lies in their strategic location between oceanic and terrestrial ecosystems. Many organisms with complex life cycles, such as anadromous salmonids and pacific lamprey, move from freshwater habitats through the estuary to the sea and back again. Other organisms, such as oysters, mussels and eelgrass, are more-or-less permanent residents of the estuary. Over fifty species of fin-fish are known to use the Siuslaw estuary (Johnson 1).

Estuaries are dynamic. They are high-energy ecosystems where fresh water mixes with salt water. Oregon's estuaries are located along the coastal plain and link forested watersheds with the sea. Estuarine organisms, both temporary and permanent residents, have adapted to these dynamic mixing zones. Estuaries, however, are more than a simple mixture of marine and terrestrial ecosystems; they possess unique properties not found in either off shore or terrestrial ecosystems.

Estuaries are created and maintained by physical and biological factors originating both in the upper watershed and in the ocean. As such, it is difficult and unwise to fully separate the estuary from actions occurring outside of it. For example, actions that affect water storage in the upper watershed (such as logging, road construction, dams, loss of wetlands to agriculture, and other land use changes.) can dramatically alter the timing and magnitude (pulses) of water, sediments, and organic material to the estuary. Exotic species, like the green crab (*Carcinus maenus*), a voracious predator, can enter estuaries on ocean currents and dramatically alter food webs by feeding directly on mussels, oysters, other crabs and a variety of other organisms or by competing with native organisms for food.

Estuary Subsystems

The Estuary Plan Book (Cortright) recognizes four major subsystems, differentiated primarily by geologic, riverine and marine forces, in Oregon's estuaries:

Marine
The marine subsystem is a high-energy zone located near the estuary mouth. This area is influenced by strong currents, and the substrate is primarily coarse marine sand, cobble, or rock. Salt content is generally high due to the dominance of ocean water, but may be greatly reduced during high river flows in winter. Kelp and other algal species often cover the rock substrates and form microhabitats for many species. Benthic invertebrates may include marine and estuarine species, while fish using the marine subsystem are mostly ocean based.

Bay
The bay subsystem is a relatively protected environment, often characterized by a broad embayment between the estuary mouth and narrow upriver reaches of tidewater. Normally the bay subsystem has a large amount of intertidal land. Since it is influenced by both the marine and river systems, bay sediments are primarily a mixture of coarse marine sands and fine river-borne silts and clays. Salt content during the summer is moderate to high, depending on the basin size, but may vary considerably with tidal stage and freshwater flow. Most bays have a wide diversity of habitats with extensive intertidal flats, eelgrass beds, algal beds, and marshes.

Riverine
The riverine subsystem includes the upper tidewater portions of the larger tributaries which enter the estuary. A large percentage of the subsystem is narrow, subtidal river channel. Current velocities exhibit dramatic seasonal changes that influence benthic communities. Salt content is low most of the year, and portions of the subsystem may be entirely fresh water. Sediments range from fine silts and clays to cobble and gravel. Small fringing marshes frequently occur on narrow, intertidal portions of the riverbank; forested riparian vegetation typically line riverbanks, where there are no marshes.

Slough
The slough subsystem is a sheltered environment, which is usually a narrow, isolated arm of the estuary with a very limited freshwater flow from uplands. Salinity is influenced by the proximity of the slough to the estuary mouth. Sloughs usually have fine organic sediments and high percentages of intertidal land consisting of flats, eelgrass beds, and marshes.

The ecological health of Oregon's estuaries experience a number of threats, including: enrichment by excessive levels of organic materials, inorganic nutrients, or heat; physical alterations which include hydrologic changes; introduction of toxic materials; and introduction of exotic species leading to direct changes in species composition and food web dynamics. Located at the terminus of the watershed, estuaries not only experience the cumulative effects of disturbances (both natural and man-made) within the watershed, but also direct impacts resulting from spread of exotic species, hydrologic modification (i.e., dredging, filling, diking, shoreline armament), and water quality impairment from a number of sources. Estuaries are often ideal places for human communities to form, thus they also often experience degradation associated with urbanization.

Analyzing Estuary Conditions

The noted ecologist, Eugene Odum contrasts two approaches commonly used in studying estuaries. The first approach is to consider the entire estuary as one unit and examine its behavior, particularly ecosystem processes like sediment delivery and transport, or production of invertebrates and algae. An understanding of ecosystem behavior is gained by observing general patterns over a period of time. Eventually, hypotheses can be generated that explain the observed behaviors. Studies may then be conducted that identify and examine individual ecosystem components (e.g., stream down cutting, land cover, amount of tidal marsh, etc.) believed to produce observed patterns. Whole ecosystem (hololological,) or 'black box' studies take many years to complete and require integration of data across large areas.

In the second approach, the parts of the ecosystem are studied separately in an attempt to better understand the whole. We have tried to manage estuarine resources for much of the past 60 years by relying on an understanding developed using this latter approach. Development of fish hatcheries and (fisheries) harvest restrictions represent attempts to control or influence a single ecosystem component (fish populations). But relying on the study of one, or only a few aspects of an estuary can lead to strategies that create unintended results. For example, fish hatchery programs were initiated to allow us to ignore fundamental changes to habitats in many of our streams and estuaries. When fish populations were relatively large, fish hatcheries seemed to be a viable solution. As wild stocks declined, hatchery programs dramatically added to the decline (Flagg). The crash of native coho populations in the 1980s and 90s thus took many biologists and the fishing industry by surprise.

The most reliable understanding of estuarine ecosystems comes from combining whole system and parts analysis. Recent advances in geographic information systems (GIS) and remote sensing give us new tools with which to examine watershed-wide patterns and develop an understanding of estuarine ecosystems (Garono 1).

Much of what we now know about Oregon's estuaries comes from recent scientific research. But we have also learned a lot simply through the process of living with these systems. This is the same way that native Indians learned about the estuary. The new name for this process is "traditional ecological knowledge." It is a process all cultures engage in. To some extent, science confirms what we already know, or think we know about local ecosystems. In other cases, it contradicts local knowledge, and forces changes in thinking and management decisions.

Scientific research can tell us much about how estuaries work. But natural resource managers and local communities cannot normally wait for the results of multi-year intensive research. In fact, comprehensive research on Oregon's estuaries is quite rare (Johnson 1). Pressing issues do not patiently wait for the completion of research that can take decades. Therefore, restoration and management actions that are responsive to present crises often must proceed based on the best available information. In the face of uncertainty, specific management goals should be established and a monitoring program established to help determine the results of various management actions. However, it is particularly difficult for understaffed, volunteer-based watershed councils to assess the integrity of the estuarine ecosystem holistically with normal monitoring programs. This is because it is difficult to link site-specific monitoring studies to the entire estuary, or move from the parts to the

whole. How can local communities use information collected from monitoring to better understand the estuary ecosystem, and make adjustments in management strategies as they go? One way is to identify key ecological indicators that most often show how the ecosystem is responding, based on a set of management or restoration goals.

Ecological indicators are relatively easy-to-measure attributes that are empirically correlated to subtle and complex ecological processes. Goode (2000) suggests the following indicators for Oregon's estuaries:

(1) Measure the change in the area of estuarine habitats including; overall change in the estuary, change in tidal marsh habitat, and change in eelgrass beds;
(2) Determine the amount of habitats that are protected from development;
(3) Estimate the presence and abundance of aquatic nuisance species;
(4) Record the amount of freshwater inflow seasonally
(5) Keep track of water quality trends.

One additional indicator is to track fish presence over time, through periodic, perhaps 5 year counts (Johnson 1).

The Siuslaw Estuary

The Siuslaw estuary is located about 200 miles south of the mouth of the Columbia River. The river system is characterized by a vast network of low gradient streams, extending to the upper reaches of watershed with few natural barriers.

The Siuslaw estuary is a long, relatively narrow one that contains all of the subsystems (riverine, bay, slough, and marine). Along the main stem, tidal influence is known to extend to the hamlet of Tide (about RM 26). Actual saltwater intrusion generally extends 17 - 22 miles up river during the summer, but only 5-7 miles during winter months. Along the North Fork, tidal influence is generally thought to extend to RM 7-10. Tidal influence also reaches up Sweet Creek, Knowles Creek, Berhnhardt Creek, Hoffman Creek, Karnowsky Creek, and the South Slough.

Water flow in the estuary is a daily tug of war between river flow and ocean tides. The amount of freshwater moving into the estuary from the Siuslaw River and its tributaries determine how far upstream saltwater reaches on an incoming tide. Patterns of fresh and salt water are affected by the combination of tidal amplitude, freshwater inflows and topography. The mean tide range for the Siuslaw is 5.2 ft. with a diurnal range of 6.9 feet. The extreme high range of tide is 11 feet. Fresh water inflow to the estuary has ranged from a recorded high of 32,300 cubic feet per second (cfs) on January 27, 1970, to a low of 70 cfs on August 30, 1970. The flow pattern varies daily, seasonally, and over longer time spans of decades or even centuries.

The movement of water from both sources (ocean and watershed) directly influences important biological variables such as temperature, salinity, depth, and current. Water movement also affects the concentration and distribution of nutrients, sediments and organic material.

As noted earlier in this assessment, there has been a drastic decrease in coho populations during the past century. Booker reports that the average number of Siuslaw coho declined from about 200,000 individuals in 1889-1896 to less than 4,000 over the period 1990-1995. Chinook salmon populations however, appear to have recovered to near historic levels.

Clearly, multiple factors are responsible for the observed decline in coho and other salmonid populations. A key question for the Siuslaw Watershed Council and local natural resource managers is; to what extent is the condition of the estuary a factor in the decline of salmonid populations, notwithstanding the apparent health of the chinook? Additional questions are; what is the state of health of the estuary, and what measures should be taken to protect or restore it?

The Siuslaw Estuary Historically

As the landscape history section of this report points out, the Siuslaw River watershed was for the most part a heavily forested one. Historical reports describe very large western red cedar along the main stem (Scofield), as well as large Douglas fir and western hemlock (Booker). Narrow stream channels were characterized by the accumulation of large woody debris in the form of logjams. Some of these may have been stable for centuries. Beavers were widespread (USDI 2). Early accounts from the area indicated that most of the tributaries and parts of the mainstem were impenetrable because of large,

downed wood. Bull Island (110 acres, currently owned by ODFW) on the North Fork is believed to have been the site of massive logjams (Westphal).

Mature forests and downed wood in the uplands and riparian areas probably contributed greatly to seasonal water storage. Valley bottom wetlands connected to stream channels also stored winter and spring rains. To the extent that storage has been lost, we can expect that summer base flows are lower, which in turn could affect fresh water input to the estuary. Substrates in the estuary were influenced by natural erosion processes. Tyee sandstone breaks down to fine sands and "fine skipping" stones, but larger cobbles and boulders are only found in association with magma extrusions (USDI 2). Debris jams and beaver dams were probably instrumental in desynchronizing flood peaks, increasing water storage, and retaining sediments in the watershed.

The fire history of the watershed probably resulted in contributions of large wood into the streams and estuary on a periodic basis. The presence of large wood in the estuary and along the beaches has declined significantly over the 20th century (Maser).

Timber harvest and clearing for agriculture, which began in the late 19th century, increased in extent throughout the first half of the 1900s. Modifications to the watershed made during this time have undoubtedly altered patterns in water and sediment delivery to the estuary in ways that persist to the present day. Logging and valley bottom settlement likely initiated several changes to the estuary. First, the timing and magnitude in delivery of water, sediment, and organic matter was altered. Large wood, a keystone part of the estuary system, was gradually lost. Sediment likely came in at different rates, and in different sizes.

The development of the transportation infrastructure also had a direct impact on the estuary. Railways and roads were located along the north shore of the estuary. Road and rail beds have undoubtedly affected the surface hydrology where they cross over small tributaries, such as Skunk Hollow, Saubert Creek, and Shulte Creek. In other areas they run adjacent to sloughs and old channels of the main stem, especially near Mapleton, Tiernan, and along Prosser Slough (RM 10). Rail and roadbed armament act to hold the main channel in place by preventing natural meanders (this may be especially true in the slough sub-system of the estuary). This resulted in a simplified shoreline habitat, as well as loss of wetlands.

The Siuslaw (River and Estuary) and its tributaries were also used directly to transport and hold logs. Stream channels were cleared of debris to allow logs to move unimpeded downstream. From Mapleton downstream to within 1 mile of the mouth pilings were placed along the riverbanks in order to defect logs from settling on off-channel wetlands or mud flats. This prevented accumulations of wood on the tidal flats, where they had been key parts of the aquatic food chain. Dredging of the river channel also restricts accumulation of wood. From 1957 to 1977, the channel from Cushman to Mapleton was dredged about every 3 years. Between 20,000 – 30,000 cubic yards of material were removed each time. Some of the tidal islands at the mouth of the North Fork resulted from dredge spoil deposits (Kartrude). Due to economic and environmental restrictions, the Cushman-Mapleton section has not been dredged since 1977, and the lower channel has only been dredged intermittently. The approved channel depth is 18 feet at the entrance, 16 feet upstream to the turning basin (RM 5.5,) and 12 feet for the river section. The design width is 150 feet. Dredge material is presently disposed of at approved off shore sites, except for one upland site (former wetland) owned by the Port of Siuslaw (Kartrude). Earlier spoils were disposed of along the shores, generally above the high water mark. The Army Corps measures channel depth each spring.

Log handling has probably been damaging to estuarine plants and wildlife. It often physically crushes or scrapes substrates. Log holding areas can experience release of toxic compounds (from the logs) and low dissolved oxygen concentrations (from release of biologically active organic compounds), which can be harmful to biota. Frequently, log handling sites are located in sheltered areas near mills that have sufficient freshwater flows to prevent wood-boring organisms (Sedell). Unfortunately, these are also biologically sensitive areas. In the Siuslaw estuary, log boom companies operated booms and holding areas near Point Terrace (Sweet Creek) and at South Slough. The Knowles Creek delta is also known to have been a log sorting area.

Clearing of debris from the river channel, construction of pilings, dredging of the channel, disposal of dredged sediments along the shore,

Exposed bedrock

and construction of rail and roadways, have all contributed to increased channelization and confinement of stream flows. As stream flows are confined, water velocities increase, especially during peak flows. As water velocity increases, so does the water's capacity to transport sediments. Increased channelization in the Siuslaw has created a stream that has been down cut to bedrock along much of its length. Exposed bedrock can be seen near Tide, and for some distance upstream. Severe down cutting is evident on the lower North Fork and Knowles Creek. Stream simplification has resulted in the loss of, or less connection between the sloughs, braided stream channels and the main stem. This has contributed to a decline in the water storage capacity of the basin, loss of pool and off-channel rearing salmonid habitat, and a likely increase in summer water temperatures.

Tidal marshes in the lower portion of the estuary (bay subsystem) depend on a continuous supply of sediments from the upper watershed. The Siuslaw River transports an estimated 103,000 tons of sediments to the estuary each year. At first glance, it would seem that rapid sediment loss in the upper watershed might actually benefit tidal marshes in the lower estuary. However, tidal marsh health depends on a delicate balancing of sediment delivery, accretion and loss. Sediments can be delivered to tidal marshes from both the upper watershed and the ocean. Recall, that the lower estuary is characterized by bi-directional water flow. On an incoming tide, marine sediments can be deposited within the estuary. Therefore, factors that can affect sediment delivery and accretion necessary for tidal marsh development and maintenance, include many of the same factors that affect patterns in freshwater inflow, as well as, factors that affect water velocities in the estuary itself, such as shoreline armament and dikes, vegetation condition, log jams, and channelization.

The ways in which sediment delivery patterns influence estuarine habitats are often not obvious. In a study of an estuarine river delta in Hood Canal, WA, Jay and Simenstad (1996) reported that freshwater inflows to the Skokomish marsh have decreased by 40% (compared with historical amounts) since the construction of two dams. The decrease in freshwater inflows did not seem to influence tidal flats because only a 2% loss in tidal flat area was observed. However, upon closer inspection, Jay and Simenstad found that there had been a 15-19% loss of low intertidal surface area due to decreased sediment transport capacity. Tidal flats angled off more steeply than they did historically. In many estuaries, low intertidal areas are areas that are colonized by eelgrass and important submerged vegetation beds. Salmonids use these areas as migratory corridors and for foraging.

Present Condition of the Siuslaw Estuary

An important source of habitat information for Oregon's estuaries is the Estuary Plan Book (Cortright,) available online at: (*http://www.inforain.org/mapsatwork/oregonestuary/*). The EPB contains maps and area extent of estuarine habitats. Habitat categories are arranged hierarchically. The first break is between subtidal and intertidal. For this assessment, important habitat categories are shown in parentheses. Sub tidal habitats are divided into unconsolidated bottom, rock bottom and aquatic beds (**algae** and **eelgrass**). Intertidal categories include shore, flats, aquatic beds (**algae** and **eelgrass**), and tidal marsh (**shrub**, **fresh marsh**, **high salt marsh**, and **low salt marsh**). There are many different ways to collect and display this type of information. As with any type of map there are limitations to how it can be used (Garono 1).

The area covered by the Estuary Plan Book for the Siuslaw begins at the mouth, and extends to just West of Tiernan, near Hoffman CK.

The Siuslaw estuary measures 1,698.5 hectares (4,197.3 acres.) Of the total area, 34.6% has been classified as subtidal, and the remaining area intertidal (Table 1). Keep in mind that areas, locations and status of these habitats were mapped in the 1970's and 80's and quite likely no longer represent actual conditions.

Table 1 shows that tidal marshes are the largest habitat type in the Siuslaw estuary. There is also

a significant amount of eelgrass beds (*Zostera marina*).

As mentioned earlier, there are five suggested indicators of estuary health: (1) habitat change, (2) amount of area protected, (3) presence of nuisance species, (4) freshwater inflow, and (5) water quality.

Tidal marsh habitat is very important to the estuary. Tidal marshes are generally composed of nutrient-rich, fine textured silts (Alaback and Pojar, 1997) and created as marine and terrestrial sediments settle in the bay subsystem of the estuary. Tidal marshes are dynamic. Their size and shape are constantly affected by wind and wave action. Tidal marshes are highly productive areas. They are often covered with aquatic plants, including; tufted hairgrass (*Deschampsia caespitosa*), Lyngby's Sedge (*Carex lyngbyei*), Pacific silverweed (*Potentilla anserina*), glasswort (*Salicornia virginica*), and sea arrow-grass (*Triglochin maritimum*).

Class	Intertidal		Sub tidal		Grand Total	
	ha	acres	ha	acres	ha	acres
Algal	8	19.8			8	19.8
Seagrasses	125.6	310.3	10	24.8	135.6	335.1
Submerged Aquatic Vegetation (unspecified)	0.6	1.5		0	0.6	1.5
Low Saltmarsh	24.3	60		0	24.3	60
High Saltmarsh	314.5	777.2		0	314.5	777.2
Saltmarsh (unspecified)	366.5	905.6		0	366.5	905.6
Freshwater Marsh	42.2	104.3		0	42.2	104.3
Shrub-Scrub Marsh	9.6	23.8		0	9.6	23.8
Bedrock	5.8	14.3	3.6	8.8	9.3	23.1
Boulder	8	19.9			8	19.9
Cobble/Gravel	0.4	0.9	2.2	5.5	2.6	6.5
Unconsolidated Bottom			135.5	334.9	135.5	334.9
Sand	99.9	246.9	276.1	682.2	376	929.1
Sand/Mud	41.5	102.5	158.9	392.7	200.4	495.1
Mud	56.3	139			56.3	139
Shoreline	8.4	20.6			8.4	20.6
Unclassified			0.8	2	0.8	2
Grand Total	1,111.50	2,746.60	587	1,450.70	1,698.50	4,197.30

Table 1. Estuarine Habitats (Types and Areas) of in the Siuslaw Estuary (SOURCE: EPB, Cortright et al., 1987)

Because of the nature of the sediments and the relatively high-energy ecosystem in which they occur, tidal marshes are often dissected with tidal channels. Dendritic tidal channels resemble a watershed's drainage system when seen from the air. Smaller tidal channels coalesce into larger tidal channels, and the larger channels into tidal streams that eventually leave the marsh and enter the estuary. Tidal channel systems are the subject of much research today because of the role that they play in the salmonid life cycle. Research suggests that tidal channels in salt marsh restoration sites do not quickly recover the same functions of natural tidal channel systems (Frenkel). Tidal channels in restoration sites may be used differently, or with less effect, by salmonids than in natural channels.

The structure of tidal channels is thought to be important to salmonids for several reasons. The dendritic channels create a complexity of varying elevations, and patterns in saltwater intrusion and inundation. These, in turn, can affect rates of primary (plants) and secondary production (organisms that eat plants), which are the base of the food web exploited by salmonids. That is to say, different plant species arranged themselves on tidal marshes according to their tolerance to saltwater and to drying (among other factors). Both living and decomposing plants (plant decomposition or organic material processing is an important ecosystem process in estuaries) are used by a variety of invertebrates.

Tidal marshes may produce much of the food resource used by young migrating salmon. Current thinking among ecologists is that the greater the structural complexity in the tidal marsh, the more material processing and invertebrate production that can occur. For example, multi-level plant heights on salt marshes may provide important areas for invertebrates to escape being washed away during high tides (Scatolini and Zedler, 1996). Tidal marshes that lack tidal channels or that are colonized by uniformed-height, homogenous vegetation (e.g., *Spartina*) may not produce adequate prey to support salmonid populations. Invertebrate diversity and abundance is often the most difficult thing to re-establish in tidal restoration projects.

In addition to providing food web support, tidal channels are also important places for salmonids to escape predators and high flow events, and to physiologically adapt to ocean conditions. Some species of young salmonids cruise around the tidal channels, not only in search of food, but also to escape their predators. Deeper tidal channels can provide cool places for salmon to escape from warmer water during low tides. Tidal channels also provide low flow environments for young salmon to escape fast moving water in the estuary proper, especially in the winter. Finally, the saltwater-fresh water gradient established during the tidal cycle in tidal channels can be very important for the requisite physiological

adaptation that young salmon under go before they move out to sea.

For the Siuslaw estuary and its tidelands, Good calculated the change in area of tidal marsh habitat using data from the Estuary Plan Book and other sources. He found that during the period of 1870-1970, there was a 63% loss in the acreage of tidal wetlands and a 29% loss in total estuary acreage (Boule). The range among Northwest estuaries is 50-95% loss, thus the Siuslaw is in relatively good shape from that standpoint.

According to data in the Estuary Plan Book, over 58% of the total historic tidal marsh area is reported as being diked. This is in agreement with Good's findings. Tide gates can also restrict the movement of water and sediments into tidal marshes. Tide gates are known to have been installed from Lindsey Creek on the North Fork (Robertson). A consequence of diking and tide gating is that marshes may no longer have tidal exchange to create and maintain tidal channels. These marshes may not be accessible to salmonids. Once cut off from tidal flow, many marshes under go a process of subsidence, that is, organic material decomposes (and is not replenished) and the surface elevation lowers and the sediment particles become compacted. Another consequence of diking is that once areas are cut off from saltwater, many exotic invasive plant species can become established (Callaway).

Since the data reported in the EPB, several dikes have breached, either naturally or with some assistance. These include the Lower Duncan Island on Duncan Inlet (S. Bank) in 1999 and the

An old tidal marsh that has been developed

Estergard property on N. Fork in 1995-96 and 2001 (Dunaway and Robertson).

The change in area of eelgrass beds is also another indicator of estuary status. There are eelgrass beds in the Siuslaw estuary (Table 1). Although an earlier map of eelgrass is present in an Oregon Fish Commission report (Gaumer et al., 1974), it is not possible to calculate change in area due to methodological differences (see Garono et al., 2000). Instead, the maps can be compared for areas that were present in the early 1970's and not in the later map or *vice-versa*. There are eelgrass beds reported from the near the mouth and near Florence from the earlier study that were not reported in the later. There are also extensive areas around Cox Island and the South Inlet that did not appear on the earlier map. It is difficult to say whether these represent actual changes in the distribution of eelgrass beds or differences in sampling (or reporting) effort.

Most wetland loss occurred from the time of Euro-American settlement up until the 1930s as a result of dike construction and conversion to agricultural use (Boule). All estuary wetlands have had a certain level of protection since passage of the Clean Water Act in 1977. However, many of these are still subject to habitat loss or alteration, though mitigation is now required.

Cox Island is a 188-acre salt marsh island in the Siuslaw River estuary about seven river miles from the Pacific Ocean and about two miles east of the city of Florence. This is an area of special interest for two reasons. First, it is one of only a few protected areas in the estuary, owned and managed by The Nature Conservancy (TNC). Second, it is home to a troublesome exotic species, *Spartina patens*. The TNC is making efforts to control or eliminate *Spartina* populations. Cox Island had also been home to *Spartina alterniflora*, another invasive salt marsh grass, but that species was successfully eradicated by 1997 (ODA, 2000). Protected areas and invasive species are both used as indicators of estuarine status by Good (2000).

Spartina patens is limited to the middle marsh which is composed of three closely related plant communities at Cox Island. It is most often found in the *Deschampsia caespitosa-Scirpus maritimus* community (Frenkel and Boss 1988). This area is characterized by abundant bare ground, a level surface ranging from 1.8 to 2.1 m above mean low water in elevation, and many developing tidal creeks." (Pickering, 2000).

Spartina is actively searched for along the Oregon coast (Noxious Weed Control Section, ODA, 2000) because it can dramatically restruc-

ture tidal marshes by excluding eelgrass and other estuarine plant species (Simenstad and Thom, 1995). In addition, *Spartina* grows as dense patches that can accumulate sediments faster than native vegetation (Pickering, 2000). This may make the tidal marsh prone to other weedy and shrubby vegetation.

Other exotic plant species also occur on Cox Island including, Scot's broom (*Cytisus scoparius*), English Ivy (*Hedera helix*), and Himalayan blackberry (*Rubus discolor*). These are not being actively controlled (Pickering, 2000). Finally, Spartina was also reported to occur near the boat docks in Florence. Fortunately, that population is considered to be eradicated (ODA, 2000).

Water quality in the estuary is of concern for several reasons. First, there is the general feeling that salmonid populations are 'nutrient limited.' Second, there had been numerous spills from the Florence sewage treatment plant (STP) in late 1990's until that plant was upgraded this past winter. Third long time residents observed an unusual algal bloom on the mudflats near Florence last year. Local residents know that the quality of the water affects not only the aesthetic values of the estuary, but also the quality and quantity of its natural resources.

Biologically, nutrient enrichment can lead to a condition known as eutrophication. Eutrophication, more common to east and gulf coast estuaries, results in algal blooms that can alter the entire estuarine food web. In addition, when algal blooms die off, available dissolved oxygen is used by microbes. Low oxygen concentrations

Cox Island

often result in fish kills. Contamination of water by waterborne pathogens is also a concern where contact recreation occurs and shellfish (especially oysters) are grown. Water borne pathogens are very difficult to measure directly. Therefore, a biological indicator used by regulatory agencies is fecal coliform bacteria (not pathogenic themselves, under most circumstances, they are easier to measure than waterborne bacteria and viruses).

Bidirectional water flow and multiple water sources (marine and fresh) make it very difficult to assess water quality in an estuary. Generally, there is very limited data from which conclusions can be drawn (Good). Thus innovative ways must be used to examine water quality trends (see Busse and Garono, 1996; Busse, 1998).

The 1972 Federal Water Pollution Control Act (amended as The Clean Water Act in 1977) established broad water quality goals for the nation's fishable and swimmable waters. The Oregon Department of Environmental Quality (ODEQ) is one of the agencies that monitors water quality in the State of Oregon. ODEQ is required by the federal Clean Water Act to maintain a list of steam segments that do not meet water quality standards, the so-called 303(d) list. Water bodies that do not meet water quality standards are said to be water quality limited or impaired. Water quality standards, levels or concentrations of water quality variables, such as fecal coliform bacteria, temperature, or dissolved oxygen, have been established to classify state waters as "supporting", "partially-supporting", or "not-supporting" certain beneficial uses.

The 303(d) lists are updated every few years. 1998 was the last time that Oregon's 303(d) was updated. The list will be updated again in 2002 (see *http:// waterquality.deq. state.or.us /wq/ 303dlist /303dpage.htm*). Most of the Siuslaw estuary and large tributaries are on the 303(d) list (Table 2). **Stream segments are listed for temperature, habitat modification, biological criteria, and sedimentation.**

Water quality data that are used to generate the 303(d) list eventually end up in two databases, STORET and LASAR. The STORET (short for Storage and Retrieval) database is a repository for water quality, biological, and physical data. STORET contains raw biological, chemical, and physical data on surface and ground water collected by federal, state and local agencies, Indian Tribes, volunteer groups, academics, and others. Data collected from all 50 States, territories, and jurisdictions of the U.S., along with portions of Canada and Mexico, are stored in the

system. If water quality was measured, it generally ends up in the STORET database.

Currently, STORET data are available as two separate databases, divided according to when data were originally supplied to EPA. The older of the two databases is called the STORET Legacy Data Center (LDC for short), and the more current is called Modernized STORET. Water quality observations made prior to 1999 are stored in the LDC database. Both data sets will soon be available via the internet (*http://www.epa.gov/owow/storet/*).

Earth Design Consultants, Inc. has obtained available STORET data on CD-ROM. The CD-ROM contains data that were available at the time the CD-ROM was created (May 2000).

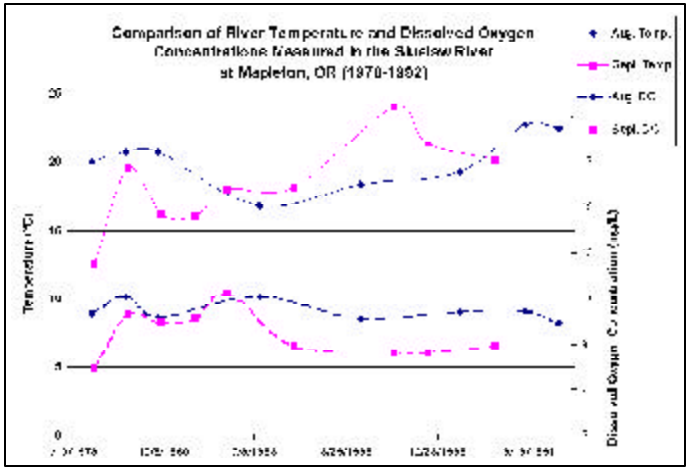
Name & Description	Segment #	Parameter	Criteria	Season	Supporting Data or Information
Siuslaw River Mouth to Headwaters	12C-SIUS0	Temperature	Rearing 64 F (17.8 C)	Summer	USGS Data (Site 14307620; near Mapleton): 63% (12 of 19) Summer values exceeded temperature standard (64) with a maximum of 75.2 between WY 1980 - 1992 with exceedences measured in 1980, 1982, and 1984 - 1992.
Siuslaw River, North Fork Mouth to Headwaters	12C-SINF0	Habitat Modification			Coho, steelhead and cutthroat populations have declined. Modification recently, lack of LWD and pool habitat has been identified as a concern in the watershed (N Fk Siuslaw Watershed Analysis, USFS, 1994).
		Sedimentation			Coho, steelhead and cutthroat populations have declined recently, sedimentation has been identified as a concern in the watershed (N Fk Siuslaw Watershed Analysis, USFS, 1994).
		Temperature	Rearing 64 F (17.8 C)	Summer	USFS (2 Sites: Downstream of campground and Under C) Huntington Bridge). 59 and 81 days were above 64F with maximum temperatures of 71F recorded at each site (North Fork of the Siuslaw River Watershed Analysis, USFS, 1994)
Siuslaw River, South Fork Mouth to Kelly Creek	12C-SISF0	Biological Criteria	Impaired Conditions		Streams are considered impaired with a Discriminate Criteria Conditions Score of <61 points. Discriminate Score was 42.
(addition from 1996)					

Table 2. Oregon's Final 1998 Water Quality Limited Streams - 303(d) List

In addition to STORET, the Oregon Department of Environmental Quality maintains an online database, Laboratory Analytical Storage and Retrieval (LASAR) database (*http://waterquality.deq. state.or.us/wq/lasar/LasarHome.htm*).

In addition to searching STORET and LASAR, regional DEQ and ODA offices were contacted. Unfortunately, there are only a few monitoring locations that have data that would lend themselves to summary.

STORET data are grouped by 5th field hydrologic unit codes (HUCs). The Siuslaw River HUC is 17100206. There were 61 sample locations listed for the Siuslaw River watershed. Fifteen samples were taken from the bay sub-system of the estuary and six from the riverine sub-system. Only two stations, LASAR # 10392 and STORET #402062, had more than three observations made later than 1990. Both of these sites are



Graph 1

located on the Siuslaw River on Hwy 126 at Mapleton and may contain duplicate observations since STORET contains data collected by ODEQ.

There were 77 temperature observations from the Mapleton site (LASAR # 10392). Dates of observation ranged from 1960 to 2001. For this assessment, average stream temperatures were calculated for each quarter of each year. An average is a measure of central tendency for a data set. Statistics are generally used to determine how well an average really represents the central tendency of a set of observations. The data presented in GRAPH 1 are too few to determine how well the average actually reflects stream temperature; therefore, use caution when interpreting these values.

Stream temperatures are high in the Siuslaw at Mapleton. According to a fact sheet published by DEQ (*http://www.deq.state.or .us/pubs/ water/Stream Temperature.pdf*) Oregon salmonids

require water temperatures to be 10° C for spawning and 17.8° C for all other life stages. In the fall and winter, stream temperatures exceeded 10° C, as far back as 1960. Summer temperatures generally exceeded 17.8° C from 1960 to present, especially in from July-Sep.

To determine if there were additional data available, especially on nutrient loading, DEQ was contacted (personal communication, Julie Berndt (800 844-8467 x 234). The Oregon Department of Agriculture was also contacted (Deb Canon, personal communication).

According to DEQ, there are three active discharge permit holders in the Siuslaw estuary (a fourth, the boy scout camp, was believed to be expired). The STP, with its outfall at Ivy Street, in Florence, has a history of having spills due to overflows at the pumping station. Recently, there were five overflows during 1996-97. These spills always occurred in the wintertime after heavy rains when flows were over 1 million gallons. It is not known what amount of rain would have triggered the spills. At that time, the STP was operating at capacity, in addition to the problems with the pump station.

To remedy the situation, the STP was upgraded and the pump station was overhauled. These changes came online Jan 1 of 2001. Since these changes have occurred, there have been no reported spills.

In addition to the STP in Florence, there is a STP in Mapleton, which has no reported problems (it is working well under capacity at this time).

There are two other permitted discharges in Florence, both package plants (activated sludge). There is a discharge in Florence at the Pier Point Inn, which currently has several permit violations for BOD (during past 4 years). This permit holder is working with DEQ to resolve the issue.

Finally, there is another discharge near the jetty, Driftwood Shores that puts out about 1000 gallons per day. There are no known problems with this permit.

The Oregon Department of Agriculture did not have any additional data on the estuary.

Mouth

The mouth of the Siuslaw estuary occurs in the marine sub-system. Like the rest of the estuary, it has been dramatically altered. Original accounts describe the entrance to the Siuslaw River as being 300 yards wide at ebb tide with a very deep strong current (Peter Skene Ogden's Snake Country Journal 1826-27. The Hudson Bay Record Society 1961). General Land Office surveys describe large amounts of wood on the beach all along the township as early as 1850's (before European settlement). This is consistent with earlier accounts of debris jams and beaver dams throughout the watershed.

The entrance to mouth has changed over time. Early maps show that the entrance to the Siuslaw River meandered about, sometimes having two channels.

In order to make ship traffic across the bar more safe, two jetties were constructed at the entrance to the Siuslaw River. The N. Jetty is 2,331 m and the S. Jetty is 1,573 m in length (Fox et al. 1994). Jetty construction was started in 1983 and completed 25 years later in 1918. The modern entrance to the estuary is 18ft deep and 300 ft wide (online report, *https://www.nwp.usace.army.mil/op/n/projects/siuslaw.htm*).

Findings and Recommendations

Based on the five key indicators, the condition of the Siuslaw estuary is clearly altered from its historic condition. The 58% loss of tidal marsh habitat is particularly bothersome, in that, compared with other Oregon estuaries, the Siuslaw does not have much acreage of tidal marsh to begin with. The amount of protected acreage is fairly low. Invasive species, while present, do not appear to be at levels of concern, such as is the case in Willapa Bay in Washington. Data on water flow and overall quality is simply too scarce to draw any conclusions at this point.

It is hard to determine whether the estuary is or is not limiting the numbers of salmonids in the Siuslaw system. According to research by NMFS (1998), juvenile chinook prefer protected estuarine habitats with lower salinity. During low tide they move to protected tidal channels and creeks from tidal marshes. As the fish grow larger, they move toward higher salinity waters and are found in less-protected habitats before moving out to sea. Chinook are opportunistic feeders, consuming larval and adult insects and amphipods when they first enter estuaries. As they grow, they come to depend on larval and juvenile fish such as anchovy, smelt, herring, and stickleback.

Juvenile coho, on the other hand, require large woody debris as an important element of their estuarine habitat. While in the estuary, juvenile coho salmon consume large planktonic or small nektonic animals, such as amphipods, insects, mysids, decapod larvae, and larval juvenile fishes. In estuaries, smolts prefer intertidal and pelagic habitats that are influenced by the marine sub-system. In the Siuslaw, species that spend much of their time in fresh water are at very low levels, while Chinook, which spend more time in the estuary, are at very healthy levels. Clearly, the estuary is a vital part of the Siuslaw aquatic ecosystem, since all anadromous fish (and up to 60 additional species) make use of it for at least some part of their life history. Protection and restoration of estuarine habitat should remain a high priority for the Basin Council.

We recommend that opportunities to restore salt marsh habitat continue, but in conjunction with careful monitoring to see if restoration meets objectives over time (see Gupta, 2000 for additional information on restoration strategies and data source). In a study on the effectiveness of dike removal on the Salmon River estuary, Frankel and Morlan made the following recommendations:

Duncan Island has good tidal channel habitat

- Full tidal connection by dike removal and creek excavation is probably the most important step to successful salt marsh restoration.
- Take the time to develop a precise elevation survey prior to restoration.
- Determine soil salinity and soil texture in order to predict species colonization.
- It is probably not necessary to re-plant restoration areas.
- Monitoring should be done for at least 10 years after dike removal.
- Realistic and explicit goals for restoration should be established.

The study concluded that we should expect to wait several decades before expecting full restoration of a “high” salt marsh to its pre-development condition. But interestingly, the “low” salt marsh that develops more quickly after restoration is considered to be of greater value to fish (Frenkel).

Existing marsh habitat that may be at risk should of course be identified and protected. This includes continued monitoring and actions at Cox Island to control or eliminate *Spartina* and other exotic species. There may be the potential to do some restoration at the West end of Duncan Island, and Bull Island. These are areas that have never been diked, but for some reason lack good tidal channels.

A dike breach at the North Fork

There should also be some focus on the expansive mud and sand flats at the South Inlet and North Fork. At least some of these are believed to be the result of dredge spoil deposits, and belong to the Port of Siuslaw (Kartrude). Allowing wood to accumulate along the flats, or perhaps placing wood there, are measures worth considering. This may mean eliminating or restricting firewood gathering where possible. In areas where dikes have recently been breached, or where future breaching is done, monitoring for invasive plant occurrence should be done. Shoreline habitats, particularly along transportation corridors or near Florence, may be at risk, given the projected growth of the Florence area. There are a number of under used or vacant industrial sites that can accommodate some commercial development without filling or draining new areas.

Estuary Map 11.1
(place holder)

Additional Recommendations & Data Gaps

- Produce an up-to-date map of habitat types in the estuary, especially eelgrass beds. Compare present extent with earlier surveys.
- Document extent of tidal channel on islands, especially in restoration areas.
- Measure invertebrate production at selected locations.
- Monitor water at several locations for: salinity, temperature, food web support (bugs,) and fish presence.
-Partner with the TNC in monitoring presence and spread of weedy species.
-Seek funding for a comprehensive estuary study in order to provide baseline data for comparative use in future years. The study should include an inventory of all fin fish, major benthic invertebrates, and shellfish over a one year cycle. Expected cost is $150,000. New data can be compared to a late 1970s study by ODFW.

WATERSHED CONDITION

At a workshop during the early stages of this assessment, Council members and supporters were asked to vote on which aspects of the assessment we should place the greatest emphasis on. Each person attending was given two votes. Nearly everyone present placed at least one vote on "watershed condition." Asked why so much emphasis here, rather than on for example, sediment, which received no votes, the response was; "because when you assess the overall condition you have to take everything into account."

Previous chapters of this assessment dealt with specific aspects of the aquatic ecosystem. What is the big picture when you put all these pieces together? In a word; hopeful.

A few years ago, in a radio interview Vaclav Havel, the newly elected president of the Czech Republic, was asked how he remained optimistic during his years in prison under the Communist government. No one could have known at that time that the Berlin Wall would fall so soon, and the Eastern European countries would soon be free to follow their own path to democracy. Havel replied that he was never optimistic. Given the circumstances that would have been a foolish position. But he had remained hopeful. "Hope" he said, "is when you retain the possibility that a good outcome may yet happen. Optimism is when you believe *it will* happen. Pessimism is when you see no possibility of success."

The condition of the aquatic ecosystem in the Siuslaw Basin is not good. In fact, by most measures we would have to conclude it is poor. Salmonids (except for Chinook salmon) are at historic lows. Water temperatures in many streams are high, and have been rising near the mouth. Lead levels in the lower mainstem are very high. There are few sources of large wood, a keystone element of the aquatic ecosystem. Lack of wood has cause many streams to cut down to bedrock. In others (particularly the North Fork) sandy banks are actively eroding, and it may take expensive and heroic efforts to stabilize them.

Streams have to a great extent lost contact with their floodplains in the lower valleys. This has in turn caused areas that once were prime aquatic habitat to act more as "funnels," sending water, nutrients, and organic material rushing downstream instead of storing them. Road density is high throughout the basin. A number of "problem culverts" still impede fish access for at least part of the year. The cost of replacing these may be an estimated average of $35,000 each. Riparian areas overall are in poor shape, with less than 35% of the total in mature forest condition. Upland forest areas that influence the aquatic system are fragmented, densely roaded, and lack mature trees. Many valley floors have been transformed from complex forest and wetland mosaics to simple pastures and fields. Significant areas of estuarine wetlands have been diked and drained.

We believe that the above factors have resulted in a significant change to the natural, historic dynamics of sediment and organic material delivery and storage in the tributary streams. The Siuslaw river system suffers from too much material pulsing through too rapidly. It has largely lost the ability to store and meter out this material over longer periods of time. The result is that several important species of fish, particularly; coho salmon, steelhead, and sea run cutthroat trout have been barely able to weather the latest natural down cycle in ocean productivity.

The socio-economic condition is also not very good. Small farms are struggling just to break even. The dairy farming industry is mostly gone. Some mills have closed, and those that remain open operate at reduced capacity. The salmon fishery has been greatly reduced. Remaining commercial fishermen are struggling to stay in business. Federal and state natural resource agencies have smaller budgets every year. They are gradually losing local aquatic resource specialists to retirement, office consolidation, or transfers. Some long time residents who have depended on the natural resource economy are bitter, angry, or just plan frustrated.

So why are we hopeful? The following list of attributes may explain:

- The Siuslaw Basin historically supported the highest populations of coho salmon for any basin south of the Columbia River. This means the basic potential of the aquatic system is very high.

- Chinook salmon are at near historic population levels. This may indicate a relatively healthy estuary.

road stream crossings
12.1

perceived threats
12.2

- There are no large hydroelectric dams in the basin. But for a few culverts, anadromous fish can access nearly the entire stream system.

- 55% of the land area is in public ownership, with most of that presently managed under very protective measures. This will result in recovery of mature forest in much of the basin if the Northwest Forest Plan remains in place.

- The landscape of the Siuslaw basin is very resilient. Trees grow faster here than just about anywhere else on earth. Thus forests can recover fairly quickly.

- There are no large cities in the basin. Urbanized watersheds are the most difficult ones to restore, because the basic hydrology is usually irrevocably altered. The largest local community, Florence, is located on the coastal dunes, where there are few or no streams. Most storm water is directed into the aquifer. Even though the growth rate of Florence is rapid, if development can be directed away from the estuary, impacts on the aquatic system will be minimal. Growth pressures in other parts of the watershed do not appear to be great.

- The small scale, part-time agricultural economy does not require large fields. It is not a "till" agriculture, thus soil cover is much higher than in Willamette Valley or Columbia Basin watersheds. One recent study indicates that 90% of the farms are part time operations. Part-time farmers are not completely dependent on farm income, and thus may be open to restoring parts of their land to wetlands or riparian habitat. A few former dairy farms have recently expressed interest in selling their lands to allow for dike removal and tidal wetland restoration.

- The Siuslaw Watershed Council has established a strong cooperative network of local landowners, timber industry managers, and agency representatives. A good number of people are actively trying to correct past mistakes or initiate land practices that are supportive of the aquatic ecosystem.

- Natural resource managers have learned a great deal about aquatic ecosystems over the past few decades. While early efforts at stream restoration may not have been successful, they did teach valuable lessons that are being applied now.

- The fish are still here, and we can assume that they want to survive. If we can retain the genetic pool, they will eventually repopulate much of the basin, assuming the aquatic habitat recovers.

ECOLOGICAL CAPITAL

A basic premise of our assessment of the Siuslaw Basin is that the health of aquatic ecosystems is largely dependent upon the state of "ecological capital". We define ecological capital as: *attributes of the landscape that support ecosystem health*.

We evaluated ecological capital using three basic categories, as follows:

1. High Functioning: This is everything in the landscape that clearly contributes to the aquatic ecosystem, such as mature forests, intact wetlands, and areas with good habitat and high concentrations of fish.

2. Moderately Functioning: These are landscape attributes that may have some positive, or some negative aspects relative to the aquatic ecosystem. On balance they may not enhance the system, but neither do they degrade it.

3. Low Functioning: These attributes are for the most part acting to degrade the quality of the aquatic habitat. Examples include: recent clearcuts or burned areas on unstable topography, riparian areas without trees, roads on unstable mid-slopes, and drained wetlands.

Mature upland forest moderates storm run-off, retains moisture in summer, and can contribute wood to the streams

Given current information, we are not able to measure every landscape attribute that affects the aquatic ecosystem. But there are a number of key ones that are measurable. We chose to focus on the following:

Contributing Upland Forests
These are forests that have the potential to directly impact the aquatic system. They are located directly upslope of streams, within high and moderate risk shallow landslide zones, or on potential debris fans. We defined three basic forest conditions: mature (over 24 " diameter with conifers,) recovering (8-24" or pure hardwood stands,) and open (less than 8", or without trees). The key aspects of the contributing forests that we are concerned with is their potential to contribute large wood to streams, and their tendency to reduce the negative effects of slides. A recent study in the Elk River near Port Orford concluded that in steep coastal forests, virtually the entire upslope area appears to contribute wood to streams (Burnett) (chapter 6).

Riparian Vegetation
Mature forests in riparian areas provide shade, erosion protection, and filtering of excess nutrients or chemicals. They also are a key source of large wood to streams, either by falling directly into streams or from being carried down debris flow channels. They provide wildlife corridors, resting zones, nitrogen and organic matter. Recovering forests also provide shade, some filtration, and a source of small wood to the streams. Open riparian areas may result in high stream temperatures, low filtration (except for open wetlands,) and high erosion rates from failing banks. Pure alder stands have some positive and some negative effects on streams. They are important contributors of nitrogen, but may also reduce summer base flows and inhibit conifer regeneration (chapter 6).

Freshwater wetlands
Intact freshwater wetlands in stream valleys provide important storage of water, filtering of nutrients and chemicals, and habitat for aquatic wildlife, including insects that fish feed on. Wetlands that are partly intact may provide one or more of these functions, particularly water storage, but might not provide much habitat. Drained or filled wetlands result in negative impacts to aquatic systems. GIS data on freshwater wetlands is lacking for most of the basin, but may be available in the near future (chapter 6).

Tidal Wetlands
Wetlands along the estuary are key areas for filtering pollutants, storage of nutrients, food, and other habitat needs of fish. They also are also sources of shellfish for humans and wildlife.

Lake Creek Valley wetlands help store water and filter pollutants

Intact wetlands have been mapped through the National Wetlands Inventory. Partly altered wetlands can be inferred from local information. Wetlands lost to diking and draining have been mapped based on historic records (chapter 11).

Channel Habitat
Stream surveys identify the condition of in-stream habitat by counting pools, noting presence of large wood, and identifying spawning areas. While surveys have been conducted by various agency biologists, we lack a basin-wide map of in-stream conditions. This is essentially because different surveyors used various methods, and did not always create accessible information. The Forest Service is developing a comprehensive database of past habitat surveys that should be available in 2002 (Chapter 10).

Fish Presence
Annual spring and summer surveys indicate where salmonids consistently find the best habitat. Where these fish are present in relatively high numbers, we can infer that the habitat is the most intact in the basin. Where the fish are present in moderate numbers, we can assume there is at least some usable habitat. Where there are no, or only a very few fish, we infer the habitat is not very good. We do not yet have enough years of monitoring, or a complete enough picture to rely on this factor however (Chapter 10).

Natural stream habitat types
Some streams have inherently higher or better habitat capability than others. The OWEB assessment manual puts emphasis on understanding the natural variability of streams as one way of prioritizing where protection or restoration efforts might have the greatest effect. We mapped "channel habitat types" using OWEB descriptions (Chapter 7).

We also considered potential threats or factors acting to degrade the quality of the aquatic habitat:

Roads
Numerous studies have identified the potential negative effects of roads on aquatic ecosystems. They can disrupt natural drainage patterns by intercepting groundwater and accelerating run-off, contribute sediment to streams, block access to fish, trigger debris flows, and displace habitat in riparian areas. The Siuslaw Basin has roads throughout its 504,000 acres, at an average of 3.7 miles of road per square mile. There are no areas that could be considered "roadless". However, some catchments have only ridge top roads, which usually have little impact to aquatic ecosystems. Other areas may have well-built or storm-proofed roads that traverse midslopes, but

Upper Siuslaw mainstem has mature hardwoods in riparian area and wood in the river

riparian areas are unroaded. Some areas have very dense road networks (Chapter 8).

Debris flow hazards
Although there are long term positive effects associated with debris flows originating in forested ravines, debris flows originating in deforested ravines bring only soil and gravel. The soil can fill pools and smother spawning beds. In systems where log jams are absent, debris flows tend to keep moving down the stream, often scouring the sides or bottom of the channel degrading fish habitat even further (Chapter 8).

Other characteristics we did not analyze which might effect the condition of the aquatic system for any given area include:

Streamside "flats"
These can be visualized as "beads on a string" along stream valleys. They are key areas within the aquatic ecosystem, where sediment and organic matter collect behind log jams, and are later released downstream. Each flat in a given

area may be at different stages of succession, depending on the timing and content of debris flows or riparian zone inputs. Areas with high frequency of streamside flats could be some of the best places for aquatic conservation measures. We were unable to map these from GIS topographic information. But they could be identified through aerial photo interpretation

Shoreline habitat
Areas along tidal reaches where that habitat is "complex," or a mosaic of wetlands and forest, provide important food web support. Shorelines that have been developed or simplified do not provide aquatic support.

Submerged beds
These are areas in the estuary that have rich assemblages of plants which may provide important corridors for fish movement. They are not mapped at present.

Landscape Position
Certain areas may be in key positions relative to overall aquatic function. For example, an area could lie between two high functioning "anchor habitats". Or it might lie above an important habitat and thus potentially impact it. Our analysis was not able to identify these key areas. But future work could do so.

Social Network
This is the community of people and institutions that understand the local aquatic ecosystem, and actively support efforts to protect or restore it. The social network in the Siuslaw basin includes: watershed council members, supporters, landowners and managers who practice good stewardship, federal, state, and local agency aquatic specialists, schools that have watershed stewardship programs, libraries that have information on the watershed, and long time area residents who have tracked changes in the area over time. We were not able to identify this network as part of this assessment, but have recommended that the Council initiate a project to do so.


Upper Knowles Creek has some of the best ecological capital and aquatic habitat

Ecological capital can be both "natural" and human made or influenced. A natural wetland is capital that may support the aquatic ecosystem. A restored wetland can also be considered as capital. It is widely acknowledged within the field of restoration ecology that undisturbed natural sites are in almost all cases superior to restored ones (at least over the short term of a few decades). Restored wetlands typically lack the full complexity and richness of natural ones for example. A planted riparian area will take many years to provide shade, nutrients, and particularly large wood, whereas an existing mature riparian forest already has these attributes. This is not to disparage restoration efforts, but rather to acknowledge that protection and restoration go hand in hand. If the goal is to re-build ecological capital to a point where the aquatic ecosystem is once again at a robust state of health, then the question is not how much riparian area gets planted each year, but rather, how much has the total riparian condition improved.

Looking at the 14 'ecological capital' factors and threats described above, we were able to adequately assess 7 at this time, given the limits of the available data. These include: contributing forest, riparian condition and streamside shading, tidal (and to some degree) freshwater wetlands, fish presence and abundance, channel habitat types, debris flow hazards , and mid-slope roads. Our team focused on identifying where the relatively highest quality ecological capital is located. We then identified concentrations of overlapping capital at the catchment scale and compared this information against potential threats (see appendix C) Catchments with the highest amounts of capital and minimal threats are good candidates for future consideration as "anchor habitats." Anchor habitats are those that provide a disproportionately large share of aquatic production relative to the whole basin. Selected anchor habitat catchments should be widely distributed across the basin in order to preserve genetic variability and life histories. Map 13.1 shows combined ecological capital / threats summarized to the catchment level in comparison to known fish abundance.

We evaluated ecological capital concentrations against channel habitat types and existing information about fish presence. This information as

cumulative ecological capital 13.1

well as general landscape characteristics can be found for each 7th field catchment in appendix B. Future analysis could incorporate habitat condition surveys and wetland data as these become available. By combining this information, the Council should be able to begin identifying anchor habitats and other areas of interest.

How much ecological capital should the Siuslaw Basin have? There is no clear answer to this question. Historically, 25-75% of the coast range was in a mature or old growth forest condition at any given time. Riparian areas appear to have had extensive groves of old growth cedar, and near the coast, sitka spruce. When beavers were abundant, so were valley wetlands, braided channels, and logjams. Clearly, we have less highly contributing ecological capital than at any time in the past several hundred, or perhaps several thousand years. The Northwest Forest Plan, if continued, should result in a gradual rebuilding of ecological capital on most of the federal lands in the basin. Much of the State forestland will also mature as a consequence of adoption of the new management plan. Finding creative ways to build forest and wetland capital on private lands, about 45% of the total area, will be an important challenge.

The central goal should be to conserve ecological capital where it presently exists, and to begin rebuilding it from the highest functioning areas out. Hopefully, over time the fish will be able to tell us when we have done enough by returning to abundant levels.

Retain existing mature riparian trees while planting new ones

ONGOING EFFORTS TO RESTORE THE AQUATIC ECOSYSTEM

As has been discussed earlier, efforts to protect and restore aquatic habitat have been ongoing in the Siuslaw Basin since the late 1960s (Armantrout 2). As part of this assessment, we hope to profile the work that is already being done. Then we will offer a suggested strategy that may help focus and coordinate efforts.

Multiple efforts have already been made to help protect and restore the aquatic ecosystem. Some of the more significant of these are profiled below:

- The Federal Clean Water Act of 1972. This legislation resulted in some protection for existing wetlands, monitoring of streams for various water quality parameters, and funding to control point source pollution. One result in the Siuslaw has likely been a decline in the rate of wetland loss. Another is the recent upgrading of the Florence treatment plant.

- The Northwest Forest Plan of 1994. This plan resulted in greatly reduced timber harvest on federal lands in the basin, and in increased attention and funding for efforts at reviving the aquatic system. The North Fork and Upper Indian Creek were both designated as "key watersheds".

- Improved road construction and maintenance standards on federal, local, and private lands since the 1970s have likely reduced the occurrence of debris torrents, and lowered sedimentation problems. Roads built before the new standards were in place may continue to contribute problems however, though many miles of these have been "storm-proofed" or removed altogether.

- Fish harvest has been regulated since 1899, when the first gillnet licenses were required. Further restrictions were placed on total harvest in the 1930s, followed by a complete ban on commercial harvest on the river in the 1950s.

- In-stream restoration projects have been built in the basin since the 1960s, and possibly earlier. From 1969 to 1993, the BLM alone worked to improve habitat on over 23 miles of streams, and opened up an additional 107 miles through culvert improvements (Armantrout 1). Since 1993, many more projects have been initiated, including those in Whittaker Creek by ODFW, and in the North Fork and Deadwood Creek by the Forest Service.

- Over 30 culverts identified as barriers to fish passage have been replaced or modified. More than 80 culverts are now identified as "high priority" to improve or replace. Problem culverts are typically either too steep, or "perched" and inaccessible to fish.

Continue efforts to improve organic material and sediment storage

- The State Forest Practices Act was strengthened in the 1990s, with new riparian buffer standards. There are some present efforts being made to further strengthen these in response to the listing of multiple fish runs as threatened (IMST).

Alternative Approaches to Habitat Restoration

Attempts to restore habitat directly in streams dates from at least the 1930s (in the Columbia basin,) through efforts of the Civilian Conservation Corps (CCC). Apparently biologists at that time believed that the limiting habitat factor, particularly for coho salmon, was the volume of pools or amount and condition of spawning

gravel. Early in-stream work progressed under the assumption that it is possible and desirable to treat the effects of overall habitat degradation in a watershed while working only on the stream itself. Typically, then and now, numbers of salmon rearing in and around habitat structures showed at least short term increases. But also, the overall numbers of salmon in our region continued to decline (Dewberry 4). Clearly there are complex and numerous causes of salmon decline. Construction of in-stream habitat structure has probably helped more than it has hurt, and biologists have gained a lot of knowledge about streams and fish in the process. Ultimately, it is clear that good habitat in streams is essential for salmon, trout, and other aquatic wildlife.

There are three broad alternative methods to restoring aquatic habitat that are presently being tested in the Siuslaw basin. All of these have merit, and should form the basis for consistent monitoring and adaptation.

The first method is to pursue an aggressive approach at stabilizing and building in-stream habitat to compensate for problems related to past and present land use. The best example of this approach is the recent work on Whittaker Creek, planned and coordinated by ODFW, and implemented with contributions from numerous partners. The central idea is to use large boulders at multiple locations to trap sediments and organic material, thus allowing the streambed to build up, or aggrade, and eventually reconnect with the adjacent floodplain. At Whittaker Creek, ODFW and its partners have installed 40-60 boulder structures per mile. If successful, the creek will more easily overflow its banks and create more complex habitat, cooler water, healthy pools and spawning gravel, and higher base flows (Westfall).

Disadvantages of this approach may include: high cost, initiation of undesirable changes to channel morphology (streams cutting around structures,) and risk of loss of the investment if upland land use results in debris flows or other problems that overwhelm the system. In other words, since this approach deals with the problem at the bottom of the system (the channel) rather than at the source (the hillslope,) it may provide more short term rather than long term benefits. In addition, some object to the aesthetics of multiple basalt boulder weirs as “unnatural” appearing. Lastly, these efforts tend to focus scarce resources on the most damaged areas, rather than on areas that already have functional habitat.

There are also clear advantages to this method. It is consistent with traditional fish and game management, and builds on a body of knowledge and experience. It has proved to be successful in some localized areas. It has the advantages of focused effort and simplicity. You basically concentrate on one stream section at a time. It also has the advantage of accountability. One can set a goal of so many structures, get funding, get the work done, and have something positive to point to.

Photo monitoring by ODFW over the past few years indicates that many of these projects are having some success. In areas with in-stream structures, gravel and wood are accumulating, with streams having aggraded 4-7 feet over one ¾ mile stretch. Various aquatic species are using the new habitat. ODFW has completed over 60 miles of in-stream work since the middle 1990s (Westfall).

A second method is to plan and execute “cluster” projects within sub-watersheds that address multiple issues. The BLM and Forest Service have both adopted this approach. It allows them to develop one environmental assessment to cover multiple activities, which may include: forest thinning or alder conversion to accelerate development of conifer trees, storm-proofing of midslope roads to reduce debris flow risk, replacement or modification of culverts to facilitate fish passage, wetland restoration, and combination boulder and log in-stream structures designed to mimic natural cascades. These projects are often concentrated in larger streams, but designed to also influence smaller tributaries. Monitoring by BLM suggests that spawning counts in project areas have been higher than for the basin as a whole, which suggests that these projects are having positive effects (Armantrout 2).

The disadvantage of this method is that cluster projects often rely on association with timber sales, particularly when road removal or storm-proofing is included. This may skew priorities to areas that have commercial value, but very poor aquatic habitat. There are also aesthetic objections to the engineered in-stream structures, and controversy over the practice of removing streamside alders to make way for conifers. (Existing alders provide shade and nitrogen, but may reduce base flows and inhibit conifer establishment).

Advantages include: efficient use of planning and construction resources, the ability to limit disruption of a given area to a short period of time, and the potential to address a number of issues simultaneously. Two areas that have seen these multiple project approaches in recent years include: the upper North Fork (Forest Service,) and Wolf Creek (BLM). In the latter, 17 miles of stream restoration has taken place. Recent monitoring suggests that aquatic habitat is improving in these areas, with aggredation of the streambed and formation of pools observed. Fish appear to respond favorably, though overall stream fish numbers have remained low (Armantrout 3). In-stream structures appear to have longer survival rates in small to moderate sized streams (Plumley). Full establishment of riparian conifers is expected to take 10-20 years, and requires control of competing vegetation.

A third method can be called "assisted natural recovery." The focus is on modifying land use practices in key areas in order to allow the land to "heal itself". Engineered improvements, like in-stream structures, are minimized. The first step is to identify the highest functioning parts of a stream system, which in most cases will be areas with mature forest, low road density, and high numbers of fish (high ecological capital). These are the "anchor habitats". The second step, if needed is to modify or remove problem roads. The third step is to establish conifers, particularly cedar or spruce on the valley floor. Taken together, these three steps are expected to secure and enhance important aquatic habitat for the long term. The fourth step is to place simulated debris torrent deposits near historic "flats" in order to reset the natural capacity of the stream to

Retain existing tidal wetlands while restoring additional areas

retain sediment and nutrients. These are essentially unanchored bits of large wood. Once all this is accomplished, restoration efforts can be extended upstream or down to increase habitat range.

Upper Knowles Creek has been one location where the assisted natural recovery method has been tested. The Forest Service, Champion International Timber (now Hancock,) and the Pacific Rivers Council coordinated efforts in this area in the early 1990s. Subsequent monitoring has shown positive response in terms of logjams forming and resetting nearby flats, with significant accumulations of gravel observed after a severe storm in the winter of 1995. It is too early to tell if fish numbers have increased (Dewberry 6).

There are disadvantages of this method. First, natural recovery may take a long time to show clearly positive results. Second, it may require fairly significant changes to valley floor and upland land use practices to be successful. Third, it goes against the social grain of our desire to make visible physical changes to the land. We are after all, part of a culture that likes to go out, get dirty, and build things. There are also advantages. First, this method is rooted in working with the processes that created and established good aquatic habitat in the first place. Second, it is low cost, though it may raise the cost of land use in general by requiring more restraint on upland logging.

The three methods described above are not mutually exclusive. Assisted natural recovery methods can be augmented with more aggressive short-term projects. For example, projects on federal lands are nested within well-protected uplands. Multiple boulder structures may be the only practical way to work in larger streams, where high flows blow out wood structures. Grouping projects in a specific area makes good operational sense. The key is not which is the best method, but rather which method makes the most sense in a given situation. And to what extent the aim is quick versus longer term recovery.

One issue that needs to be addressed in comparing restoration methods is what to monitor for. Visually, we can see gravel and organic material accumulating on some projects. But is the food web in turn building up? This could be determined through monitoring aquatic bugs. If bugs increase, but fish abundance does not, then we can assume there is some other factor at work, most likely downstream. We believe it is important to develop and implement some common monitoring procedures for each restoration method, so that the Council and area land manag-

ers can make wise choices in the future. We offer suggestions for this in a later section of this chapter, but the one piece that is essential clearly must be: are the fish populations rebounding over a period of years?

Landscape Considerations

There are a few additional aspects of aquatic restoration that are important to consider. First, there is modification of basic land use. This includes improvements to agricultural practices, like fencing livestock away from streams, and additional changes in forest practices. The latter have received far more attention than the former over the past few decades, and steps have been taken to strengthen provisions in the state forest practices code that deal with the aquatic ecosystem. For example, forestland owners must protect a 20' minimum buffer on fish bearing streams. And they are required to retain a variable amount of large conifers within an adjacent area. Road construction and maintenance standards have also been toughened. Further strengthening of forest practice standards to protect aquatic habitat is a controversial subject, since any requirement to leave trees takes options away from landowners.

The IMST report states that present riparian standards are not adequate to result in aquatic recovery, but that road and culvert practices probably are. Two key issues that the IMST raised are the need to extend riparian conservation to upper tributaries, and the need to take a landscape scale approach to forestry. Specifically, they recommend leaving trees in high-risk slide zones, and finding ways to manage harvest

Consider forestry at the landscape scale

patterns over large areas. This would require coordination among many landowners.

Agricultural practices have been less regulated than forestry. Wetlands on farms have had some protection since the Clean Water Act, but riparian buffers, and tree conservation in general are not required. Given their key location within the low gradient, unconfined valleys of the basin, it is likely that farms have impacts on the aquatic ecosystem disproportionate to their area of land coverage. Space is at a premium in mountain agriculture, and the only space to be had comes at the expense of streams, wetlands, or riparian areas. A rule making process to improve agricultural practices is under way in the Siuslaw basin, initiated under Senate Bill 1010, and led by the Department of Agriculture and the local Soil and water Conservation Districts. The local farm economy is in decline for a variety of reasons. This is resulting in some farm owners seeking opportunities to take part in restoration or conservation easement projects. Clearly, there are significant opportunities to retrofit Siuslaw farms by fencing livestock away from streams, restoring wetlands, planting riparian areas, and perhaps "going organic". Small scale, organic farms catering to local markets are virtually the only farms experiencing economic growth in our region.

Modifications to right-of-way corridor management are also important in an overall aquatic restoration strategy. Road surfacing, ditch and culvert cleaning, vegetation control, and hazard spill mitigation are all areas to pay attention to.

Building a Restoration Vision

In the long run, restoring the aquatic ecosystem of the Siuslaw basin may require building a new vision for the entire landscape. Instead of aiming at directly manipulating specific numbers of a few species of fish, one could envision a landscape condition that would best support fish (and people,) and then go about creating this image on the ground. This has been the most common practice in restoration ecology internationally, though its practice has been at the site, rather than at the landscape scale.

One first identifies the composition and structure of a desired ecosystem condition. For example, we have good evidence that an old growth forest system, without roads or other development, would produce good fish habitat. So if we removed roads and grew a significant portion of the forest to a mature state, over time the habitat should improve itself and the fish return in large numbers. In effect, this is similar to what the Siuslaw National Forest and the BLM are presently doing on much of the land they manage in the basin. Not all roads are being removed, but

many are, with others being stabilized. The forest is being thinned in places, but the long-term goal is to redevelop a mature or old growth forest over time. On a more limited scale, riparian and wetland establishment on private, valley-bottom or tidal land also represents structure-based restoration. Forests owned and managed by the State have adopted a modified "structure-based" approach, which will attempt to mimic natural disturbance patterns and forest age classes. Some private forest land owners in the basin use selective harvest methods that preserve the forest canopy and allow at least some trees to reach large sizes (Di Paolo).

But there are clear challenges to developing and implementing a basin-wide landscape vision. First, the present pattern of land ownership is largely set. The larger tributary creek valleys with unconfined streams probably were the highest productive areas for salmonids historically, yet these are also where farms and homesteads must remain. These valley landscapes can be modified to help improve aquatic habitat, but they cannot realistically be restored to their former character.

The checkerboard pattern of forestland ownership in the central and east parts of the basin results in high road densities and awkward logging patterns that do not reflect the underlying landform. Ideally, the most sensitive uplands and riparian areas would be protected, while the relatively stable areas were more intensively managed for timber. In addition, if natural topographic barriers were used to re-plat forest ownership, "extra" roads could be closed, and logging made less expensive. But the lands are not divided up this way. Perhaps a representative "land board" could be established to facilitate exchanges. Another creative idea is to develop a "master transportation plan" that can minimize stream crossings and midslope roads across land ownership (Chapman).

Even if land ownership patterns could be rearranged to better fit the underlying natural landscape, nature still gets last bats. The periodic large, stand replacing fires that have been the historic norm in the area will return from time to time. These may ultimately thwart any attempt to "lock-in" mature forest reserves. What if we are 50 years into recovery and then a large fire sets much of the forest clock back to square one? In any case it will take many years for the landscape to "grow" into a new paper vision.

Lastly, in an area as large as the Siuslaw basin, it is a daunting challenge to build a common landscape vision. Each landowner or manager has their own experiences and motivations with regard to their patch. Most desire the freedom to make their own decisions. Many firmly believe they are already doing their share or more. But at a minimum, all should begin to see their land as part of a larger whole, and may be open to modifying their vision if given the right information.

Identify areas with high ecological capital and intact aquatic areas as "anchor habitats"

Key Processes to Restore

The goal of a restored landscape is to a great extent linked to the need to restore key natural processes that ultimately shape the aquatic ecosystem. Among these are:

Debris flow cycle

In the approximately 75% of the basin where debris flows are believed to have played a crucial role in "recharging" sediment and organic delivery to the aquatic ecosystem, it is very important that this process be restored to its historic role. This means modifying upland forest management strategies to avoid accelerating debris flow risk. Additionally, organic matter in high risk ravines, debris fans, and on deep rotational slides should be allowed to develop in place and eventually discharge into the stream system. Federal lands in the basin have already adopted practices that meet this recommendation. State managed lands have recently adopted strategies that also do so to an extent by encouraging "green tree" retention in these areas (McCoy). Private forestland owners should be encouraged to move in a similar direction. In some cases, private owners are already working hard and investing resources in stabilizing existing mid-slope roads that cross high-risk terrain. An important additional measure is to leave enough trees in steep headwalls, ravines,

and fans to maintain root strength, lessen the scale of flows, and contribute large wood to streams when debris flows inevitably happen.

There are four possible ways to achieve the goal of leaving trees in these areas. First, private landowners can simply do so on voluntary basis, to demonstrate their commitment to good stewardship. Typically in the Coast Range, high-risk terrain occupies only 3-8% of the land area (IMST). Second, they could modify overall forest management to either extend rotations, or adopt single tree or group selection silviculture. Either of these methods would result in greater continuous forest cover on unstable lands. Third, they could sell or donate "conservation easements" to non-profit land trusts. This method offers financial incentives to private owners in the form of tax savings and/or direct payments. Fourth, the State could choose to toughen regulations, and require private owners to leave trees in these areas. Political pressure to establish further restrictions might ease if enough private owners chose one or more of the first three options.

Organic and sediment storage

Once debris flows or other processes contribute gravel and organic matter to streams, it is critical that there be places to store it so that it can contribute to aquatic habitat. As already mentioned, resource managers with the Forest Service, BLM, and ODFW are well aware of this issue, and are taking a variety of approaches to address it. We recognize that different resource managers have their favored methods, and that there is more than one way to be effective in rebuilding a stream's capacity to store sediments and organic material. In cases where streams are

Work with private forest land owners to retain or regrow mature upland forest

severely down cut, extreme measures may be needed, including boulder weirs, re-aligning channels, and bio-engineering of banks. In other cases, softer methods, like unanchored logs, will be sufficient. Long term rebuilding of large conifers in the riparian zone and in contributing upland areas should eventually eliminate the need for in-stream work altogether.

Water storage

As pointed out earlier, the Siuslaw basin is naturally "flashy," and has limited capacity to store winter and spring rains to augment summer base flows. The processes that allow a portion of winter rainfall to become trapped on valley floors is very important in this basin. To a great extent, valley water storage is linked to organic material and sediment storage. As streams are able to "re-aggrade" and connect with the former floodplain, they will create wetlands and improve water storage. Active restoration of wetlands on valley floors is also desirable, particularly where wetlands connect with streams.

Agriculture is generally in a long-term economic decline throughout Oregon and the Northwest. One study concluded that over 90% of the farms in the Siuslaw basin gross under $10,000 per year. Thus a good number of local farmers may be willing to participate in wetland restoration projects. We know this has already been the case with several property owners along Deadwood Creek. The return of beavers as residents of valley floors may ultimately be more important than implementation of wetland restoration projects. Beavers are a keystone species that can create and maintain valley wetlands at low cost, though admittedly some inconvenience. Even though they can be hard on riparian trees, in most cases beavers should be encouraged to re-populate much of the basin (Wilson).

Riparian connection to streams

Another process that is very important to restore in many parts of the Siuslaw basin are the multiple functions provided by healthy, mature riparian forest. Key among these are: shade, food web support, water quality maintenance, and eventual large wood input. Elevated stream temperatures appear to be a problem in much of the basin. The food web is likely a limiting factor relative to fish populations. And as has been pointed out elsewhere, large wood is a keystone element missing from many streams. Based on the CLAMS data, only 36% of the total riparian zone (measured at 200') presently has large conifers. Protection and further active restoration of riparian forests is a critical activity that should be supported throughout much of the basin.

Estuary Functions
Since the estuary is clearly a key part of the overall aquatic ecosystem, protection and restoration of key functions there is also recommended. In particular, the Council should try to insure that the remaining salt marsh habitats are protected from development, either through purchase, easements, or other agreements. Building a partnership with the Nature Conservancy, which manages Cox Island and has good staff expertise in estuarine ecology, would be useful. Restoration and careful monitoring of formerly diked marshland is also recommended.

Geographic Considerations

The discussion above focussed on what to protect and restore. The discussion below will address the where, or at least the "where first". As mentioned earlier, to our knowledge no community has ever successfully restored an aquatic ecosystem as large as the 504,000 acre Siuslaw basin. In the smaller Mattole watershed in Northern California, the local community has been at this work for 20 years now, with little to show for it in terms of increased fish numbers (Zuckerman). Total investment in Siuslaw recovery is running at about three million dollars a year, counting state, federal, and private contributions. To put this in perspective, wetland restoration runs about $50,000 per acre (done professionally) and forest road culvert replacement costs about $35,000 each. For these reasons, we recommend that the Siuslaw Council consider developing a more focused geographic strategy.

There are several key considerations in selecting priority areas for protection and restoration. First, though the entire Siuslaw basin has experienced negative impacts to the aquatic ecosystem, these impacts vary in their severity and location. Generally, mid elevation, moderately confined streams embedded in areas with high concentrations of federal land ownership have the most intact habitats. Lower valley, low gradient, unconfined streams in agricultural areas have the most damaged habitat. This is not entirely true, but is largely so (e.g. portions of the main-stems of Indian and Deadwood creeks). There is a temptation to respond to visual problems by wanting to "fix" the worst areas first (i.e. the lower North Fork). But most restoration practitioners suggest the opposite approach. The accepted principle is to first, secure the best habitats and protect these from degradation. Then go to the next best areas and take modest improvement measures. Work your way towards the worst areas gradually.

One reason to follow this priority method is that aquatic productivity is not evenly distributed across the watershed. Some areas are inherently better habitat. Some are just in better shape by chance. Typically, 75% of the total productivity might be found in only 25% or less of the stream system. And those areas that have the highest present productivity may be key to rebuilding fish populations in other parts of the basin. In the case of coho, the best present habitat and (we believe) best long term potential lies in the moderately confined, low to moderate gradient stream areas. The lower valleys have serious challenges to habitat restoration. The largest ones (mainstem Siuslaw and Lake Creek) likely have naturally high water temperatures. In others, frequent high flows tend to blow out habitat improvements.

Second, the numbers of returning fish are at dangerously low levels, and they are not concentrated equally in the landscape. Based on long term ODFW data on adult spawners and peak counts (and supported by recent snorkel surveys on juveniles), there are a few areas that appear to show consistently high numbers of fish. These may account for a significant amount of the best present habitat.

We recommend evaluating North Fork Fish Creek, Nelson Creek, Condon Creek, Mcleod Creek, Porter Creek, West Fork Indian Creek, Upper and Middle Knowles, and several small tributaries to Dogwood as potential "anchor habitats" because they show consistently high numbers of adult spawners and / or juveniles. In most cases these streams fall within catchments with relatively abundant ecological capital (Middle Knowles and West Fork Indian Creek are the exceptions) and relatively few potential threats or passage problems (Nelson Creek and Fish Creek are the exceptions) (see appendix B: catchment summaries for detailed information about specific catchment characteristics). We do recommend that the Council look at these areas in more detail, determine whether there are any immediate risks to the aquatic habitat, and then make whatever efforts necessary to secure these areas. For example, one older, badly built midslope road crossing high-risk terrain could fail, and wipe out the habitat in one of these areas. Encouraging strategic land exchanges is one way to help protect anchor habitats.

ecological capital fish 14.1

In addition to the areas mentioned, several catchments should also be considered that may not presently have abundant fish presence, but are strategically located to maintain the life histories of aquatic species. These should include Chickahominy Creek, the Hult Reservoir area of Lake Creek and Sandy Creek in the Upper Siuslaw.

Not only are these areas important to maintain the life histories of salmonids but they also possess either relatively good ecological capital, limited threats or have significant public ownership.

The catchment summaries provided in Appendix B give the council information about potential and existing threats (location of problem culverts, amount of potential landslide hazards etc.) as well as other valuable information pertaining to habitat surveys, ecological capital, fish surveys and general landscape characteristics. These catchment summaries can be used to identify other potential anchor habitats as well as determine what restoration or protection activity is most adequate for any given area.

Focusing on these areas as potential "anchor habitats" does not mean neglecting the rest of the basin in the meantime. We also suggest expanding the snorkel program for at least 2 more years, and combining this data with the ODFW adult surveys to locate additional refuges. Ideally, these will become part of an expanded anchor habitat system that is well distributed across the basin. The estuary, particularly areas with remnant salt marsh habitat, should also be considered as anchor habitats.

Retain existing social capital while also building for the future

If good opportunities arise to improve valley wetlands, riparian areas, or replace culverts in other parts of the basin, these should be pursued. For example, the County roads department may be planning a project outside of the high priority catchments. That may be the best time to address culvert replacement and riparian or wetland enhancement in that particular area. Or a key valley bottom property may become available for purchase or a restoration project. If resources can be found for this project that do not impact higher priority areas, then why not pursue it? Riparian restoration in degraded areas is particularly important in that elevated stream temperatures are such a widespread problem.

Following the completion of this assessment, the Council should focus some of its scarce resources on developing a more detailed analysis (at a finer scale) of the potential threats to the aquatic habitats in potential anchor habitat areas. This analysis should include: road stability and placement, upland logging practices and schedule, and valley floor land use. Potential projects to secure the habitat should then be identified and pursued as quickly as possible. For example, a private forest owner may be planning to clearcut an area that includes high-risk terrain above a potential anchor habitat. Could the Council work with them to develop a logging plan that leaves sufficient numbers of trees in the higher risk areas? Perhaps this would involve bringing in the MacKenzie Land Trust to negotiate a long-term easement or purchase. Once the aquatic habitat of anchor habitats is secured, then projects that further enhance or restore additional habitat could be planned.

Anchor habitats will most likely be identified at the "sub-catchment" level. Thus they will require fairly detailed, on the ground analysis before final identification.

Building Social and Ecological Capital

It took about 150 years, beginning with the decimation of the people who were the original occupants of the land, to drive the aquatic ecosystem down to the level where it now stands. It may well take 150 years of restoration and new forms of land stewardship to get productivity back near to where it once was. This will take an effort that must be sustained over several generations. Yet our modern culture rarely makes decisions based on long-term goals. We have removed a lot of

natural capital from the Siuslaw Basin over the years. This capital has built fortunes in San Francisco, Portland, and elsewhere. It has also built neighborhoods, churches, schools, barns, warehouses (now being converted to lofts,) the Florence waterfront, and the small hamlets that line the valleys of the Coast Mountains. Our challenge is to find ways to rebuild the natural capital of the Siuslaw while not impoverishing ourselves in the meantime. If we spend enormous amount of money with little to show for it, we will soon tire of the project and move on to other things. This is exactly what happened in the case of Atlantic salmon in New England (Bottom)

Building ecological capital will require paying close attention to social capital. The Council has taken great strides towards creating a "watershed community." People in the basin are gradually becoming more aware of the aquatic conservation issues. They are opening their minds and adjusting their own roles and responsibilities as land stewards. We see three key areas that the Council should focus on over the next few years to further this effort.

First, expand the network of aquatic habitat supporters valley hamlet by valley hamlet. As in the case with "anchor habitats," start with the strongest areas first. Make sure you nurture those communities that provide your base of support, and meet their needs. For example, Deadwood Creek residents have up until now shown more interest and support for aquatic recovery than have residents of Indian Creek or Lorane Valley. Make sure you keep the Deadwood community on board while you expand your outreach efforts. Focus near term expansion efforts in areas tied to

Work with local schools to develop the next generation of watershed council supporters

potential anchor habitats, where possible.

Second, do not neglect the potential of losing local expertise, presently provided by ODFW, OWEB, BLM, the Forest Service, and the Soil and Water Conservation Districts. All of these agencies are faced with repeated, long-term budget cuts. There is a real risk that the Council will lose aquatic specialists who know the most about how the system works, and how to plan and execute beneficial projects. Take the time to write to or call your legislators and area administrators to let them know how much you value and need this expertise. Consider working with Oregon Department of Forestry and other partners to develop an Extension Forester for the basin, with special expertise in ecological forestry and alternative silviculture methods.

Local "experts" can also be found among long time Siuslaw residents. Take the time to hear their stories and ask for their council. In many cases, their view of the problem may be at odds with the technical experts. Take the time to find out why before you dismiss them. In Newfoundland, it was the "uneducated" in-shore fishermen who warned the agency biologists that modern bottom trawlers were wiping out the cod. They noted that they were catching smaller and smaller fish every year since the trawlers had started. A near shore fishery that had been sustainable for nearly 500 years at a very high rate of harvest was ruined in a mere 20 years (Kurlansky).

Third, work with the local schools and the kids. There are few better ways to reach people throughout the basin than through the children. Take the time to get them out into the landscape, to help with monitoring, or planting. The immediate benefits of these efforts may not be worth the time, but the long-term benefits may be substantial. They will be the future Watershed Council.

In building natural capital, it is very important to emphasize protection, or conservation of the capital that already exists. If too much effort is directed at restoration, while neglecting areas that are already contributing to the aquatic system, you run the risk of sliding backwards rather than forwards. Our team believes that it is possible to have a strong natural resource economy in the Siuslaw basin, while at the same time conserving and building natural capital. But the starting point should be to hang onto what already works.

The short-term (10-20) year goal of the Siuslaw Basin Council should be to secure a solid foundation of both ecological and social capital that the next generations can build upon. That foundation must be built on community, science, and faith that you will succeed. You must nurture the relationships you are building with each other, and with the land.

Monitoring and Adaptive Management

Thirty years of efforts to restore stream habitat has not resulted in increased numbers of fish. In fact, up until the high runs of this past year, coho populations reached their lowest known historical point. This is mentioned not to disparage restoration efforts, but rather to maintain humility as we chart a path for restoring the Siuslaw. Two activities that are very important to build into present efforts are improved monitoring and adaptive management.

Monitoring is expensive, time consuming, difficult to fund, and by itself will not restore a single fish or piece of landscape. But if done well, monitoring can help us understand if we are making any progress, and perhaps tell us what is working and what is not. We believe that the surest way to monitor is to use indicator species, and that salmonids are good indicators of the health of the aquatic ecosystem. The ODFW adult surveys, done over a 40-year period, and the life history surveys in Knowles Creek over the past decade, have provided key insights into how the aquatic system is working.

The Siuslaw basin has experienced a flurry of restorative work over the past 10 years. Logging on federal lands is way down. Roads have been storm-proofed. Yet the overall fish numbers are still dismal. We recommend that the Council find ways to support or initiate increased monitoring of fish populations in the basin. In particular, the adult surveys by ODFW must be continued. The basin-wide juvenile snorkel counts should be supported for at least the next two to three years. And life history surveys should be expanded to include Whitaker, Knowles and at least one creek from the north side of the basin, possibly Rogers or Porter creeks. We recommend Whittaker because it has been the area of the most complete in-stream restorative efforts. We need to know how well the fish respond.

Stream gauge and quality monitoring also needs to be expanded. The single gauge operating at Mapleton is not sufficient to tell us what we need to know about the water. Additional stations need to be developed at the upper Siuslaw, Lake Creek, and the North Fork at a minimum. Suggested additional monitoring for the estuary is spelled out in our estuary chapter.

We also recommend development of a monitoring program for “ecological and social capital”. Are these being built up over time? And if they are, can we see results in the aquatic ecosystem? This will require some sort of periodic accounting of forest cover, roads, and wetlands.

Adaptive management simply means that we use monitoring results to continue to improve the aquatic conservation strategy. If we see that increased forest cover in areas now off limits to logging begins to show clear improvements in the aquatic ecosystem, then that builds a case for stepping up forest conservation efforts. If the Whittaker Creek work results in measurable increases in fish, relative to the rest of the basin, then that makes the case for focusing on in-stream projects. The key point is that none of us fully understands the complexities of the Siuslaw aquatic ecosystem at this point, so we all need to be willing to adapt our efforts to new information as it develops.

To sum up our main recommendations:

- Focus on ecosystem processes as well as structure.
- Find ways to get overall land use more in synch with these natural processes.
- Use mitigation and restoration projects strategically, but focus more on protection at first.-Take the time to identify potential anchor habitats, and secure these.
- Support strategic land exchanges to help secure good habitat, perhaps by forming a cooperative “land board”.
- Develop a cooperative “Master Transportation Plan” to facilitate removal of surplus roads.
- Continue riparian planting efforts in areas with identified temperature problems.
- Increase monitoring of salmonid populations, water quantity and quality (particularly temperature).
- Build ecological and social capital that supports the aquatic ecosystem.
- Be willing to adapt to new information.
- Dig in for a long haul. Do not expect immediate results.

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Appendix A: Coho smolt counts from the Siuslaw Basin 1990-2000.

Wolf Creek Smolt Count 1990-2000.

Year	Smolt Count *
1995	629
1996	87
1997	590
1998	660
1999	187
2000	456

*These are the actual numbers of smolts captured in the trap.
-The trap was run 4-5 days per week.
-Trap efficiency estimated to be 3%

Knowles Creek Smolt Count 1990-2000.

Year	Smolt Estimate **
1992	6,685
1993	497
1994	3,723
1995	16,415
1996	1,088
1997	2,884
1998	10,158
1999	1,484
2000	10,439

** These are smolt population estimates based on number caught and the weekly efficiencies of capture for the trap.
- Trap is run 7 days per week.

Appendix B: GIS Data layers used, resulting from or compiled for this assessment.

	Description	Name	Scale	Source	Type	Metadata	Detailed Metadata
Environmental quality data / monitoring information							
	Dredge material disposal sites (1980's)	dmd	NA	Oregon Estuary Plan Book	poly	yes	yes
	1998 DEQ 303d water quality limited lakes	LAK303_98	1:100,000	DEQ	line	yes	yes
	1998 Nationally Permitted Discharge Sites	NPDES	NA	DEQ	point	yes	yes
xx	1998 DEQ 303d water quality limited streams	STR303	1:100,000	DEQ	line	yes	yes
	STORET monitoring sites	storet		EPA	point	yes	yes
	Temperature gaging sites						
	USGS gauging stations						
Geomorphilogical							
xx	general geology	GEO500	1:500,000	SCCGIS	poly	yes	yes
sx	NRCS soils data (ssurgo) with associated relational tables	SOILS24	1:24,000	NRCS	poly	yes	yes
sx	NRCS general soils	SOILS250	1:250,000	NRCS	poly	yes	yes
	10 meter filled digital elevation model	DEM10	10 meter	REO	grid	yes	yes
	10 meter shaded relief	SHD10	10 meter	Derived	grid		
	QT values as derived from shalstab model phi = 35	DEAD_QT	10 meter	Derived	grid		
	QT values as derived from shalstab model phi=45	WOLF_QT	10 meter	Derived	grid		
	slope grid	SLP	10 meter	Derived	grid		
	aspect grid	ASPCT	10 meter	Derived	grid		
	steep slopes contributing to the aquatic system						
	valley floors						
	Areas of potential shallow landslides 100 mm of rainfall or less						

Hydrologic

	Major rivers	RIVS250	1:250,000	Ecotrust	Line	yes	
	Fourth field Hucs (Basin Boundary)	SHED4	1:24,000	BLM	Poly	yes	yes
	5th field hucs	SHED5	1:24,000	BLM	Poly	yes	yes
	7th field hucs	SHED7	1:24,000	BLM	Poly		
s	routed streams	STR24	1:24,000	USFS	routes		
	Lakes and major river banks	banks	1:24,000	USFS	Poly	yes	yes
	coastline	COASTLINE	1:24,000	NOAA	Line		
xx	Areas of water rights usage	pou	1:24,000	OPRD	poly	yes	yes
xx	Points of water diversions	pod	1:24,000	OPRD	point	yes	yes
xx	Points of in stream water rights	ispt	1:100,000	OPRD	point	yes	yes
xx	In-stream water rights segments	insln	1:100,000	OPRD	Line	yes	yes
	USGS gaging station - upstream basin areas	ga_up_bnd	1:24,000	Ecotrust	Poly		

Infrastructure

	Major highways	HWYS	1:100,000	Ecotrust	line	yes	
x	roads	RDS24	1:24,000	BLM	line	yes	yes
	Railways	rlwy	1:100,000	USGS	line	yes	yes
	Power lines	power	1:100,000	USGS	line		
	Culvert data for lane county				point		
	USFS lands culverts	culvusfs	1:12,000	USFS	point	yes	yes
	ODOT culverts				point		
	BLM culverts	culvblm		BLM	point	yes	yes
	ODFW culverts				point		
	Tom Black Culvert surveys				point		
x	ATM rds	atm_rds	1:24,000	USFS	point	yes	yes
	Road crossing fish bearing streams	rsx_fish					
	road crossing 2nd order and greater streams	rsx_ordr2					

Landcover / vegetation

xx	Estuary habitat types	EST_HAB	1:12,000	Oregon Estuary Plan Book	poly	yes	yes
xx	Estuary management units	MUNIT	1:12,000	Oregon Estuary Plan Book	poly	yes	yes
xx	Significant Estuary habitat	SIGHABS	1:12,000	Oregon Estuary Plan Book	poly	yes	yes
sx	National wetlands inventory	SIUS_NWI	1:58,000	USFWS	poly	yes	yes
xx	1996 General vegetation (Coastal landscape assessment)	CLAMS96	30 meter	CLAMS	grid	yes	yes
x	Seral stage informaion (1988)	DNRGRID	25 meter	WaDNR	grid		
xx	Forest service vegetation types	fs_veg	1:12,000	USFS	poly	yes	yes
sx	State lands stand inventory	stand99	1:12,000	ODF	poly	yes	yes
sx	Forest cover operations inventory for BLM lands	blm_foi	1:12,000	BLM	poly	yes	yes
xx	Option 9 forest plan	Plans		USFS		yes	
	Riparian vegetation on forest service lands	fs_rip		CLAMS			
	Vegetation withen 250 feet of 2nd order streams			CLAMS			
	Valley floor vegetation			CLAMS			
	Mature mixed and coniferous forest			CLAMS			
	Mature mixed and coniferous forest contributing to the aquatic system			CLAMS			
	Mature mixed and coniferous riparian forests			CLAMS			
	Potential vegetation	pag		USFS	grid	yes	yes
	Historic Vegetation (1900)	veg1900	1:1,000,000	OSU		yes	yes
xx	Fire History (1850)	fire1850	1:500,000	BLM		yes	yes
xx	Fire History (1890)	fire1890	1:500,000	BLM		yes	yes
xx	Fire History (1920)	fire1920	1:500,000	BLM		yes	yes
xx	Fire History (1940)	fire1940	1:500,000	BLM		yes	yes

Habitat and project information

sx	Aquatic habitat surveys	odfw_hs99	1:100,000	ODFW	line	yes	yes
	Coho snorkel surveys	fish_cnt	1:24,000	Ecotrust	dbf		
sx	Land Type associations	fs_lta	1:250,000	USFS	poly	yes	yes
	BLM Napweed removal	blmnapw	na	BLM	point		
n	BLM projects, polygons	blmpoly	na	BLM	poly		
n	BLM projects, points	blmpts	na	BLM	point		
n	Projects from OWEB database, lines	owebline	na	OWEB	line		
n	Projects from OWEB database, points	owebpts	na	OWEB	point		
n	Projects for FY 2000.	proj2000	na	USFS	point		
nx	Siuslaw instream projects, thru fy 2000	fs_instr	1:24,000	USFS	line	yes	
nx	Siuslaw road projects 1998, arcs.	fs_rds98	1:24,000	USFS	line	yes	
nx	Siuslaw road projects 1999, arcs.	fs_rds99	1:24,000	USFS	line	yes	
nx	Siuslaw road projects 1999, points.	siurd99pts	na	USFS	point	yes	
nx	Siuslaw riparian planting, thru 2000.	siuriparian	1:24,000	USFS	point	yes	
	All instream projects through 2001	Projects2001	NA	Ecotrust/SW Council	Point		
sx	Location information for spawning surveys	segment	na	ODFW	dbf	yes	yes
sx	Fish observed in individual surveys	spawn	na	ODFW	dbf	yes	yes
s	Channel habitat classification						

Political information

	Counties	COUNTIES	1:100,000	sscgis	poly	yes	yes
	General major industrial land ownership	OWN	1:100,000	osu / ecotrust	poly	yes	yes
	USGS 1:24,000 quad boundaries	QUADS24	1:24,000	USGS	poly	yes	yes
xx	Shoreland zoning units	SHUNITS	1:12,000	Oregon Estuary Plan Book	poly	yes	yes
	Taxlot information	sius_lot	1:1,200	Lane County	poly		
	General zoning	ZONING	1:100,000	DLCD	poly	yes	yes

	Oregon Dunes national Rec area boundary	odnra	1:24,000	USFS	poly	yes	yes
	Public land survey	sius_pls	1:24,000	USFS	poly	yes	yes
nx	Land use allocations	lua	1:24,000	Ecotrust	poly	yes	yes
	State owned lands	st_own	1:24,000	USFS	poly	yes	yes
x	Late seral reserves	lsr	1:24,000	ODF	poly		

Regional Information

	City limits	CITY_LIM	1:24,000	SSCGIS	Poly	yes	yes
	Coastline	COAST	1:24,000	NOAA	line		
	County boundaries	COUNTIES	1:100,000	SSCGIS	Poly	yes	yes
	Highways	HWYS	1:100,000	SSCGIS	line	yes	
	USGS 1:24,000 quad boundaries	QUADS24	1:24,000	USGS	Poly	yes	yes
	Major rivers	RIVS250	1:250,000	Ecotrust	line	yes	
	Shaded relief	shd_40	40 meter	Ecotrust	Grid		

Derived information

	H2 hydrologic analysis characteristics tied to 7th field watersheds	shed_h2	na	Ecotrust	grid		
	H1 hydrologic analysis characteristics tied to 7th field watersheds	SHED_H1	na	Ecotrust	dbf		
	Slopes greater than 25%	ST_SLPS	10 meter	Ecotrust	grid		
	Ecological captial summarized to the 7th field	capital.dbf		Ecotrust	dbf		
	Perceived threats summarized to the 7th field	threats.dbf		Ecotrust	dbf		

Remotely sensed data

	Mr. SID compressed digital raster graph of entire basin area	DRG_SIUS.SID	25 meter	Ecotrust	image	yes	yes
	1 meter, 1994 panchromatic digital ortho photography	sius_ortho.drg	1 meter	BLM	image	yes	yes
	2000 Satellite imagery (lansat7)	ls7.drg	30 meter	EROS	image		

Appendix C:

Procedures for determining ecological capital within the Siuslaw watershed

Ecological capital was computed on a per catchment basis, summarized using existing and derived information including:

- Large and potentially large wood available for recruitment into the aquatic system
- Streamside shading
- Potential and existing wetlands
- Fish presence and abundance
- Channel habitat types
- Riparian roads
- Mid slope roads
- Shallow landslide hazards (contributing sediment to the aquatic system)
- Problem culverts

Large and potentially large wood available for recruitment into the aquatic system

A 10-meter digital elevation model (DEM) was created for the Siuslaw sub-basin from USGS elevation data using a GIS. A shallow landslide model (Montgomery and Dietrich 1994) was used to identify areas in the DEM that were of greatest risk for landslides. The shallow landslide model draws upon the TOPOG hydrologic model (O'Loughlin 1986) which calculates upslope contributing areas in determining shallow subsurface flow convergence. Debris flow hazards are those areas that will fail after 100mm (or less) rainfall events based soil bulk density of 1700 kg/m3 a friction angle of 45 degrees. Cohesion was not considered.

A debris flow routing algorithm was applied to the DEM and used the areas identified as high risk by the shallow landslide model as starting points for debris flows. The algorithm created down slope debris flow routes based on DEM slope gradients. The routing process terminated when slope gradients no longer exceeded 5 degrees.

All high risk areas and run out zones were then over-laid with riparian corridors (100 feet on either side of all streams) to determine areas that have potential to contribute to the aquatic system (run out areas that do not eventually intersect with riparian areas were not considered). The resulting data was then compared against CLAMS forest cover classes of large and very large mixed and coniferous stands (large and potentially large wood with dbh of 50cm or greater). Information was summarized to the catchment level and a

percentage of total areas was calculated for each catchment. Percentages of resulting information was then statistically compared using quantile breakdowns and categorized into 3 classes and assigned values of 1,2 or 3 assigned (low, medium and high respectively).

Determination of stream side shading.

Shading of streams is essential for regulation of stream temperatures. Shading can occur essentially from two features, vegetative cover or landforms. Vegetation is best analyzed using aerial photography and determining a percent cover over streams. For a basin the size of the Siuslaw however, this method proved to be too time consumptive and an alternative method was required. The CLAMS data, although at 30 meter resolution, is the only basin wide vegetation cover adequate to evaluate streamside shading resulting from vegetative cover. CLAMS vegetation types were categorized into specific percent cover groupings as follows:

- Open / barren / water = 0% cover
- Small coniferous = 0 – 25% cover
- Medium coniferous stands and small mixed stands = 25 – 50% cover
- Medium mixed stands = 50-75% cover
- Large mixed and coniferous stands and deciduous stands = 75 – 90% cover
- Very large mixed and coniferous stands = 90 – 100% cover

(Please see CLAMS documentation for size class parameters)

Shading from landforms was determined by calculating shadows occurring at 10 different periods during the day on summer solstice (when the sun is at it's highest altitude (67.3 degrees). % shading was then applied depending on the %time each location is in shadow.

This information was then added with the shading resulting from canopy cover to get an overall % shading (with nothing over 100%) resulting in overall % cover throughout a day. The resulting information is an index approximating the shade potential for any given location within the basin averaged throughout the day. %cover for each stream segment within individual catchments were summarized to get an average %cover over streams for the entire catchment. Resulting information was then statistically compared using quantile breakdowns and categorized into 3 classes and assigned values of 1,2 or 3 assigned (low, medium and high respectively).

Potential and existing wetlands

Existing wetland information was obtained from National Wetlands Inventory for much of the estuary as well as for all Douglas County. Freshwater wetland information was derived using soil survey data to identify all hydric soils as well as poorly drained soil types from the D hydrologic group. This information was then overlayed with slope data derived from the digital elevation model (DEM). Areas of low slope (lt 5%) and areas with convergent landforms were evaluated for soil characteristics. All open water bodies were removed from the results.

Potential Threats

Potential threats used in this analysis include: Mid-slope roads (intersection of roads and areas of slope gt 10% not within 250 feet of the valley floor or ridgetops (modeled)), riparian roads (intersection of roads with a 200 foot riparian zone), road-stream crossings, potential problem culverts (identified by council) and landslide hazards (intersection of barren or young stands from CLAMS data and results of shalstab model, see above). Each threat was summarized to the catchment level, statistically analyzed relative to other catchments and assigned a value representing the degree of effect any specific threat might or might not have (1 being low and 3 high).

Fish presence and abundance

Presence and abundance were evaluated using two different survey methods: Available spawning surveys from the 1990's conducted by ODFW and snorkel surveys conducted by Dewberry et all, Ecotrust, 1999. Spawning surveys summarized adult peak counts by survey segment for any year within each catchment whereas snorkel surveys represent coho juvenile densities (/m2). All information was averaged within individual catchments for all streams where surveys were conducted. A high overall fish index was designated based on high abundance of either peak counts, spawners or juveniles or a combination of moderate values of any two factors. Low and medium abundance values were assigned using quantile breakdown of all 3 factors weighted equally.

Channel habitat types

Channel habitat types (CHT's) give us a better understanding of how land use impacts can alter the channel form, and to identify how different types of channels will respond to restoration activities. Both channel modifications and restoration will ultimately effect fish habitat. Channel habitat types are not necessarily an indication of habitat quality (eg: most less confined reaches in the Siuslaw basin

are seriously downcut resulting in poor habitat quality) but rather give us a sense of the inherent capacity for any given reach to support different populations (at different life stages) of salmonids.

Several assumptions have been made effecting how CHT's were analyzed:

- Certain fish species utilize different habitat types for different purposes.
- Stream channels form specific patterns in response to the surrounding geology and geomorphology, and these patterns can be used to identify cht's
- Channel habitat types have consistent responses to changes in inputs of sediment, water, and wood.

Steps

Identify stream gradient

Stream gradient classes are as follows

<1%
1-2%
2-4%
4-8%
8-16%
>16%

Estimate channel confinement

Channel confinement = the ratio of bankfull width to the width of the modern floodplain.

Confinement classes are as follows

Unconfined = > 4 times bankfull width
Moderately confined = 2 – 4 times bankfull width
Confined = < 2 times bankfull width

Confinement was previously mapped for approximately 2/3 of the basin (USFS). For the remaining third, flood plain mapping was conducted using areas of low slope intersect with stream corridors (to avoid benches and ridgetops) and compared against predicted bankfull width. Predicted bankfull width was mapped by graphing locations of known width from habitat surveys (acw) and correlating against accumulation and stream gradient. Regression analysis (non-linear) was conducted to predict acw correlated to known accumulation / gradient combinations.

Identify stream size

Size is based on odf stream classes of small, medium and large.

Small = < 2 cfs
Medium = 2 – 10 cfs
Large = > 10 cfs

Stream sizes were modeled using flow accumulation (derived from digital elevation (10m dem)). Correlation between accumulation amounts and points of known flow quantities were graphed and a regression analysis was used to predict output flow corresponding with known accumulation values.

Identify general area in the system

Estuary (manually assign)
Mouth / large floodplain (determined by floodplain size)
Alluvial fans (stream junctions where small streams run perpendicular to large streams)
Canyons (3rd order + not in close proximity to mouth)
Headwaters (all first order streams)

Assign cht

Channel habitat types were assigned based on above criteria into 14 habitat classes as described in table 1. Aerial photography, topo maps (drg's) and elevation (shaded relief) were used to evaluate and edit results.

Combined capital index

Insufficient literature exists identifying the relationship between and the importance of any given component of ecological capital or key threats. Therefore, no attempt was made to weight capital or threats. Each catchment was assigned a value (1 to 3) depending on the quantile break down of each individual component. A total value was determined by adding all capital components and subtracting the value for each threat to get an overall ecological capital / potential threats score. This information was then compared against salmonid survey information and channel habitat types to identify potential anchor habitats.