Benefits and Costs of Riparian Habitat Improvement in the Tualatin River Basin

August 1995

A Publication of the:

Oregon Water Resources Research Institute
The Tualatin River Basin in Washington County, Oregon, is a complex area with highly developed agricultural, forestry, industrial, commercial, and residential activities. Population has grown in the past thirty years from fifty to over 270 thousand. Accompanying this population growth have been the associated increases in transportation, construction, and recreational activities. Major improvements have occurred in treatment of wastewater discharges from communities and industries in the area. A surface water runoff management plan is in operation. Agricultural and forestry operations have adopted practices designed to reduce water quality impacts. In spite of efforts to-date, the standards required to protect appropriate beneficial uses of water have not been met in the slow-moving river.

The Oregon Department of Environmental Quality awarded a grant in 1992 to the Oregon Water Resources Research Institute (OWRRI) at Oregon State University to review existing information on the Tualatin, organize that information so that it can be readily evaluated, develop a method to examine effectiveness, costs and benefits of alternative pollution abatement strategies, and allow for the evaluation of various scenarios proposed for water management in the Tualatin Basin. Faculty members from eight departments at Oregon State University and Portland State University are contributing to the project. Many local interest groups, industry, state and federal agencies are contributing to the understanding of water quality issues in the Basin. This OWRRI project is based on all these research, planning and management studies.

This publication is one in a series designed to make the results of this project available to interested persons and to promote useful discussions on issues and solutions. You are invited to share your insights and comments on these publications and on the process in which we are engaged. This will aid us in moving towards a better understanding of the complex relationships between people’s needs, the natural environment in which they and their children will live, and the decisions that will be made on resource management.
BENEFITS AND COSTS OF RIPARIAN HABITAT IMPROVEMENT
IN THE TUALATIN RIVER BASIN

by
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The Tualatin River Basin studies are being done under a grant from the
Oregon Department of Environmental Quality to the Oregon Water Resources
Research Institute at Oregon State University. Published by the Oregon
Water Resources Research Institute.

Tualatin River Basin Water Resources Management
Report Number 10
ACKNOWLEDGEMENTS

This report was prepared by Erik Knoder as a part of his 1993 internship with the Oregon Department of Environmental Quality. It is being published as a Tualatin River Basin Report by the Oregon Water Resources Research Institute because of its close association with other activities that were simultaneously underway within the Institute. The influence of David Ervin, Fred Hansen and Mitch Wolgamott in this effort is gratefully acknowledged.
ABSTRACT

The Tualatin River in northwest Oregon has been designated as water quality limited by the Oregon Department of Environmental Quality. Restoration and enhancement of riparian areas to improve water quality is one task to be pursued by management agencies.

This paper examines some of the potential costs and benefits of undertaking riparian restoration and enhancement on two tributaries of the Tualatin. In general, the potential costs are likely to be more identifiable and have market prices associated with them. The potential benefits of riparian restoration are often public or non-exclusive in nature. Measuring and estimating prices for benefits was found to be more difficult. Although costs of restoration depend on the standards adopted, the costs for the two study areas were found to be approximately $6,000 per stream mile at one site and $21,000 per stream mile at the other site. The cost of retiring agricultural land from production was a major influence on the total costs and was significant in explaining the cost difference between the two sites.
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PROBLEM

The area encompassed by the Tualatin River basin is largely the same as the area encompassed by Washington County, which has a population of over 311,000 (Ervin, et al., 1993). The river and its tributaries provide irrigation and drinking water, fishing and other recreation, effluent removal, esthetic benefits, hydroelectric power, wildlife habitat and other uses. Healthy riparian areas are important for good water quality. "Healthy riparian zones can create diverse aquatic habitats, reduce light levels, moderate temperatures, serve as barriers to erosion into the stream, and provide travel corridors for wildlife species." (Li and Gregory, 1993)

Although high phosphorous levels in the river may affect some of these uses, residents are also concerned about other aspects of water quality that affect their many uses such as flow, temperature, turbidity, oxygen level, pollutants, etc (Cass and Miner, 1993). Water quality standards for dissolved oxygen, pH, temperature, bacteria, and sediment have not always been met (Wolgamott, personal communication, 1993). There also exist many concerns beyond just water quality (Cross et al., 1993). The health of the river affects and is affected by wildlife populations, human population and urban development, agriculture and forestry. It is certainly not within the scope of this paper to address all issues related to the river; it is important to keep in mind the complexity of the subject.

Although progress has been made in reducing the amount of phosphorous and improving water quality the Environmental Quality Commission (EQC) has adopted a Department of Environmental Quality (DEQ) staff report, the Tualatin River Nonpoint Source Management Implementation/Compliance Schedule and Order, (Wolgamott, 1993) calling for fourteen tasks to be implemented by the appropriate Designated Management Agencies (DMAs) in an effort to further improve water quality.

Task #5, Riparian Area Management, requires DMAs to "identify and prioritize opportunities for enhancement and restoration of
riparian areas." and to "Develop management or restoration strategies for high priority riparian areas."

Related to Task #5 is Task #3, Site Specific Problems. This calls for the DMAs and DEQ to "coordinate on a watershed-wide basis and identify all (problem) areas of the basin that have not yet been inventoried." and to "rank all problems identified."

The ability of a healthy riparian zone to reduce soil erosion by trapping particles from overland flow of surface waters and by stabilizing stream banks may be of particular importance in the Tualatin basin. Phosphorous is applied as fertilizer to cropland in the basin. Some phosphorous is then absorbed by sediment and small organic particles and is subsequently carried to waterways with eroded soil (Cross et al., 1993). Although the amount of phosphorous entering the Tualatin via soil erosion is not known, Washington County has identified 85,000 acres of cropland outside the Urban Growth Boundaries which need erosion protection treatment. Of this cropland, 11,200 acres have been classified as Highly Erodable Lands. (Washington County SCS, 1991)

One of the undesirable effects of high phosphorous levels in the Tualatin is that it promotes algal abundance. This contributes to eutrophication of the river and degrades the health of the river (Ervin et al., 1993) Temperature also affects algal growth. Li and Gregory report that data taken from 1986-1989 suggest warming occurs as it flows from headwaters to its confluence with the Willamette and data taken from 1990 and 1991 indicate that warm tributaries contribute to raise mainstem temperatures. (Li and Gregory, 1993) Healthy riparian zones provide shade to streams and slow the increase in water temperature which can, in turn, slow algal growth (Li and Gregory, 1993).

However, riparian areas along the Tualatin may not be healthy. The main channel has been modified, dammed and cleared of obstructions. Extensive logging, drainage of wetlands, farming and urban development has occurred on surrounding land (Cass and Miner, 1993).

Overall, the water quality and the health of the riparian areas is limited.
OBJECTIVES

The general objective of this study is to estimate the potential costs and benefits of adopting Best Management Practices (BMPs) to achieve healthy riparian zones in portions of the Tualatin Basin. The emphasis is on establishing the procedure and locating sources of data. The analysis will not attempt to be geographically comprehensive. The specific objectives are as follows:

1. Select specific study areas and evaluate certain existing riparian conditions.

2. Determine appropriate standards for healthy riparian zones and determine specific BMPs to achieve these standards in the study areas.

3. Estimate the likely costs of implementing the BMPs.

4. Estimate the potential benefits of the riparian restoration.

PROCEDURES

The amount and quality of data available dictate that the costs and benefits be estimated using largely different approaches.

The general BMPs required for riparian restoration are fairly well documented (Connin, 1991; Honey et al., 1984; Johnson et al., 1985) and existing conditions can be evaluated first-hand or by aerial or satellite images. In addition the costs of the BMPs are often determined in markets with observable prices.

Estimating economic benefits is a much less certain process. Since the BMPs have not been put into practice the degree to which the physical effects occur may not be estimated precisely. In
addition, the physical and biological effects often have characteristics that preclude them from being traded in markets at observable prices. The problem then arises of how to correctly place a value on them. As a result it may only be possible to describe the direction of an impact (whether it is a benefit or a cost to society) or the scope of likely impacts.

Accordingly, the study is done in two parts. Instead of providing a benefit and cost for each BMP, the costs alone are estimated for each BMP and presented as a budget for riparian restoration. Then, utilizing data from studies of other riparian areas, likely effects of restoration are presented and possible benefits are discussed.

In other words, available scientific information allows us to put greater reliability on the costs. However, benefits should not be omitted from the analysis even if effects and values are difficult to estimate.

**Costs**

Discussions with Dave Ervin, Agriculture and Resource Economics, OSU; Judith Li, Fisheries and Wildlife, OSU; and Mitch Wolgamott, DEQ, led to the selection of two study areas. Criteria used in the selection were that the areas drain forest, agricultural, and suburban lands. Other considerations were that the Oregon Department of Fish and Wildlife has a project to improve wild cutthroat trout and steelhead populations on Gales Creek, and that the West Fork and mainstem of Dairy Creek is part of the Dairy-McKay Hydrologic Unit Area making both tributaries of special interest.

Following selection of the areas, it was necessary to evaluate the existing condition of the riparian zones. A tour of the general area was made by car and several specific sites were examined with DEQ staff. The U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service provided aerial photographs of the two study areas taken in 1990. The photographs are taken at a 1 inch to 660 feet scale that allows measurement of horizontal distances. With initial assistance from ASCS personnel, the study
areas were located and measured. The photographs were first covered with a transparency and different portions were marked with a colored pen. This was done to prevent duplication in measurement of areas of interest.

Six categories of measurement were made: (1) total length of stream; (2) length of stream bank adjoining cropland in which the tree canopy has a width of 0-25 feet, (3) 25-50 feet, (4) 50-75 feet; (5) length of stream bank adjoining pasture; and (6) length of stream bank with less than 25 percent canopy. The 'Other' category includes land that had a canopy width greater than 75 feet or that was judged not suitable for restoration; such as bridges, roads, and residences. It was not measured but was calculated as a residual. The area along the stream covered by the tree canopy is used as a proxy for the existing riparian zone.

The measurement of different categories of existing land use allow the estimate of costs for different management practices. Measuring the existing width of the riparian zone adjoining crop land allows an estimation of the acreage to be retired from production. Measurement of the riparian zone adjoining pasture allows an estimate of fencing requirements and reduction in pasture acreage. Measurement of areas with little or no canopy allows an estimate of revegetation requirements.

Further dividing the measurements into three different width categories (for cropland) allows examination of what happens if different standards are adopted.

The measure of the less than 25 percent canopy category does occasionally overlap with the measure of the 0-25 feet canopy adjoining cropland. Selections for the less than 25 percent canopy category were made by measuring any section of stream bank with a minimum length of 100 feet in which less than 25 percent of the length had canopy coverage, regardless of the width of the canopy. For example, a 130 length of stream bank bordering a field that was plowed to the edge of the bank would be entered in both categories; less than 25 percent canopy and a narrow, 0-25 feet, riparian zone. In this example the land would require both revegetation and to be retired from production. However, a thin but continuous riparian
zone, say 15 feet wide, would not be marked for revegetation, but some land would be retired from production.

An attempt was then made to ground-truth the measurements made from the aerial photos. The selection of a portion of one study area was made based on accessibility and possessing measurements in five of the six categories. Specific sites were selected and verified visually and by hand measurement with a tape. In addition, site specific conditions were noted.

Determining standards for a healthy riparian zone and the BMPs to achieve the standards was the next step.

Land in the study areas is classified by the State of Oregon as either urban, forest, or agricultural. Management standards and BMPs for forest land are contained in the Forest Practice Rules published by the Oregon Department of Forestry. Costs and benefits of adopting these existing standards is not addressed in this study nor are the predominantly forested areas of the streams measured. Washington County Land Development Division staff was interviewed to determine if standards and practices for urban lands would significantly affect the study areas. Both streams border the Urban Growth Boundaries (UGBs) of Hillsboro and Forest Grove for short distances. The Land Development Division staff person stated that he was unaware of any specific standards relating to riparian habitat although municipal development plans would be subject to water quality standards. Costs and benefits of adopting these existing standards is not addressed in this study. Most of the land in the study area is agricultural and there are no set standards for what constitutes a riparian zone on agricultural land. There are water quality standards that may limit certain agricultural practices but there are few, if any, laws designed to protect riparian areas in general on agricultural land. Judith Li, OSU Department of Fisheries and Wildlife; Ronald Miner, OSU Department of Bioresource Engineering; Paul Adams, OSU Department of Forest Engineering; and Mitch Wolgamott, DEQ, were interviewed regarding riparian standards and BMPs to achieve them. In addition a literature review was conducted to investigate standards and BMPs in other areas.
Many of the costs of implementing BMPs have market prices. Interviews with timber service contractors, nurseries, the Washington County ASCS and others provided estimates of per unit costs for goods and services required. Enlarging riparian zones often requires land to be removed from agricultural use. Tim Cross, OSU Department of Agricultural and Resource Economics, and Washington County ASCS staff were interviewed to estimate these costs.

The existing conditions in the study areas were compared to different standards to generate estimated requirements for riparian restoration. Estimates for requirements are based on photo interpretation, limited ground observation, interviews with Washington County ASCS, SCS and Extension staff and a survey of local farm operators (Rambo and Buckhouse, 1993). The area selected for ground truthing was not randomly selected and may not be representative of other portions of the study area. (Although it did well in predicting the number of irrigation pumps in the study area.) Also, many technologies and management practices that may have worked equally well or better were not examined. For example, electric fencing, alternative irrigations systems and different crops were not considered.

Finally, the per unit costs were applied to the estimated requirements to estimate the costs of adopting differing standards of riparian restoration for the two study areas.

Benefits

As noted earlier, estimating the benefits associated with riparian zone restoration requires a different procedure. Ideally, models would allow the accurate prediction of the effects of restoration. These effects might provide goods and services, such as clean drinking water, to people. Then the value of the goods and services would be estimated by finding similar goods and services that are sold in a market at a price or by estimating with economic techniques what people would be willing to pay even though no market exists.
Although many of the general effects of restoration are known, the magnitudes of the changes that would occur in the study areas are not known. In addition, no specific economic studies have been done in the study areas to determine what people would be willing to pay for the potential goods and services which are not customarily exchanged in markets.

Studies of other restoration projects and of other wetland areas were reviewed to estimate and discuss potential benefits of restoration in the study areas.
RESULTS

Study area selection and evaluation

The areas selected for study were portions of Gales and Dairy Creeks. Gales Creek was measured from its confluence with the Tualatin River to Trolley Park. Dairy Creek was measured from its confluence with the Tualatin River to the point where the East and West Forks meet, then up the West Fork to the confluence of Cummings Creek and the West Fork above the village of Buxton.

Measuring the aerial photographs gave the following results:

<table>
<thead>
<tr>
<th></th>
<th>Gales Creek</th>
<th>Dairy Creek</th>
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</thead>
<tbody>
<tr>
<td>Total length</td>
<td>207,900'</td>
<td>275,880'</td>
</tr>
<tr>
<td>50-75' canopy</td>
<td>15,840'</td>
<td>11,320'</td>
</tr>
<tr>
<td>7.6%</td>
<td>4.1%</td>
<td></td>
</tr>
<tr>
<td>25-50' canopy</td>
<td>20,130'</td>
<td>76,000'</td>
</tr>
<tr>
<td>9.7%</td>
<td>27.5%</td>
<td></td>
</tr>
<tr>
<td>0-25% canopy</td>
<td>1,110'</td>
<td>82,170'</td>
</tr>
<tr>
<td>.5%</td>
<td>29.8%</td>
<td></td>
</tr>
<tr>
<td>&lt;25% canopy</td>
<td>30,460'</td>
<td>20,170'</td>
</tr>
<tr>
<td>14.6%</td>
<td>7.3%</td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td>19,800'</td>
<td>23,400'</td>
</tr>
<tr>
<td>9.5%</td>
<td>8.5%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>120,560'</td>
<td>62,820'</td>
</tr>
<tr>
<td>58.1%</td>
<td>22.8%</td>
<td></td>
</tr>
</tbody>
</table>

The total length refers to the length of stream bank, which is twice the stream length.

A portion of Gales Creek from the village of Gales Creek to Roderick Road was selected for ground truthing in mid-July. This portion is a little over 12 percent of the total measured. Ten
specific sites were pre-selected for measurement and identification. Total length and 0-25 feet canopy were not measured on the ground. The interpretation of the photographs was verified at all ten sites. It is the opinion of the investigator, however, that of all categories the least confidence should be placed in determining pastures from aerial photographs. In addition it was impossible to determine if a pasture was being actively grazed by examining a photograph.

In addition to verifying the photographs, other information was gathered from the ground truthing. Canoeing the 2.44 mile stretch revealed six irrigation pumps placed in the stream, four barbed wire fences across the stream, four irrigation ditches leading from the stream with rock diversion dams at each site, and twelve cleared stream access sites including one road which forded the stream. Although no expert investigation was done, the irrigation ditches seemed to be a site specific source for erosion. In most cases the ditches had steep banks of bare topsoil that could wash into the stream. Large, woody debris was encountered at only two locations. The stream banks were generally steep but appeared to be stable except in two or three places. The streambed was fairly wide, 20-50 feet, and usually shallow, less than a foot deep. There were some pools 5-6 feet deep. The streambed was scoured to bedrock in many places. At the lower end of the section the stream becomes slower, deeper, narrower and more shaded as it enters the valley. Numerous trout fry and 50-100 carp were observed. Several fisherman encountered stated they caught cutthroat trout from the stream.

Selection of standards and BMPs

The ideal in riparian restoration would be to restore the biological integrity of the ecosystem. This may not be completely possible in the Tualatin Basin for legal and economic reasons and in selecting any standards for restoration an intuitive benefit-cost analysis is performed to help select standards that have a reasonable chance of being accepted.
Standards for a biologically healthy riparian areas along streams are characterized by zones of given widths, vegetative cover necessary within the zones, and land use practices that are required or forbidden in each zone.

Although a great deal of literature exists describing possible standards for riparian areas and several government agencies have adopted some standards, there are few legal limits on land use in riparian areas currently in effect for agricultural land in Oregon. For the purpose of this study several possible standards will be examined and the costs for several scenarios using the standards will be estimated. First, a review of several existing standards is in order.

Department of Environmental Quality

The DEQ has draft Riparian Requirements to Achieve Water Quality Standards (DEQ). For perennial streams with fish the recommendation is for 100 foot buffer zones or of a width sufficient to maintain the natural forest canopy and large woody debris recruitment. The natural canopy will shade about 80-90 percent of a typical western Oregon stream (Beschta et al.,1987)

Oregon Forest Practices Act

The current Oregon State Forest Practices Act (Oregon Department of Forestry, 1992) call for a riparian management area to be three times the high water width of the stream with a minimum of 25' and a maximum of 100'. In addition, down wood and snags are to remain in the area, an average of 75% of the existing shade is to be retained, machine activity within 25' of the stream is to be minimized and any stream structures must allow for the upstream passage of adult fish. Proposed rules are more stringent and call for 75% uniform shade, disallow all machine activity within 40' of a stream and require stream structures to allow for upstream and downstream passage of adult and juvenile fish.
United States Department of Agriculture

The Agricultural Stabilization and Conservation Service of the USDA has standards for riparian buffer strips and management practices as part of its cost sharing program (ASCS, 1993). The buffer strip is divided into three zones: Zone 1 begins at the top of the stream bank and extends for 15 feet, zone 2 begins at zone 1 and extends a minimum of another 60 feet, zone 3 begins at zone 2 and extends for another 20 feet. Zone 1 vegetation is to be composed of native trees and shrubs necessary for stream bank stabilization, shade and leaf litter. Zone 2 vegetation is to be composed of trees and shrubs (with an emphasis on native species) necessary to uptake nutrients. Timber is to be harvested to remove stored nutrients. Zone 3 vegetation is to be composed of dense grasses and forbs necessary for sediment filtering and to convert concentrated flow to sheet or subsurface flow. The total riparian buffer strip is to be from 95-155 feet wide and, although the program has just been offered in Washington County this year, the wide buffer requirements may be part of the reason that no land owners in the Dairy-McKay HUA have participated in the ASCS program.

Selected Standards

The standard for the purpose of this study will be to have a narrow (25 foot), relatively undisturbed zone, Zone A, next to the stream comprised of shrubs and native trees for shade, large woody debris, and stream bank stabilization. Timber harvest, grazing, construction or road building would not be permitted (Hicks et al., 1991). A wider (50 foot) zone, Zone B, adjacent to the first would be planted in either grass or trees and shrubs for nutrient uptake and to slow the flow of surface water (Lowrance, 1984). The land could be utilized for certain types of production.

Management practices necessary to achieve and maintain zone A would be to retire land from crop or pasture use where the canopy is less than 25 feet wide (ASCS, 1993), plant trees where there is less than 25% canopy cover (Beschta et al., 1987), fence out livestock.
where the stream borders pastures (Platts, 1991), provide alternative livestock watering systems (Honey, 1984), stabilize the stream bank biologically (Connin, 1991), remove blackberry bushes (Li, 1993) stabilize access corridors and irrigation ditches, install longer supply pipe to irrigation pumps, and decommission field drains (Miner, 1993).

Management practices in zone B would be to retire land from crop production and use the land as either pasture or timber land (ASCS, 1993), stabilize access corridors and irrigation ditches, and decommission field drains.

Costs of Riparian Restoration

Fencing (Zone A)

Fencing requirements were estimated by measuring the distance that a stream borders a pasture. It is assumed that the remaining sides of the pasture are already fenced. This was the case for the pasture checked during ground truthing and it was confirmed by the Washington County SCS (Gordon, 1993) that there is no open range grazing in the county. The cost of building a five strand barbed wire fence which meets SCS standards is approximately $1 per foot (Cross, 1993), though SCS (Gordon, 1992) estimates range from $.50-$4 per foot. The Farm and Forest Operation Survey of Water Quality Issues/Dairy-McKay HUA (Rambo and Buckhouse, 1992) shows that 18 percent of farm owners and 13 percent of forest land owners have installed fencing to protect stream banks. The survey did not ask what percentage of pastures were fenced but it may be reasonable to assume that 15 percent of the total pasture/stream border is already fenced.

Tree planting (Zone A)

Tree planting requirements were calculated by multiplying the length of the stream bank that had less than 25 percent canopy
coverage by the width of the area to be planted. The cost of planting, including the stock, is estimated at $160 per acre. This figure was given by the SCS (Gordon, 1992) and Miller Timber Services (Miller, 1993). An estimate from Hoedads, a tree planting cooperative based in Eugene, was $150 per acre (McCombs, 1993).

Blackberry removal (Zone A)

Blackberry removal requirements were calculated by subtracting the length of the stream bank with less than 25 percent canopy from the total length. It was then assumed that 25 percent of this remaining length would require blackberry removal, based on personal observation. Costs are calculated for a 25 foot width and are based on Miller Timber Service's estimate of $320 per acre.

Field drain decommissioning (Zone A and B)

It is difficult to estimate how many field drains exist and should be taken out of service. One alternative would be to simply do nothing and wait for the drain tiles to clog and become less effective. This would minimize costs and allow farmers time to adjust their farming practices to the changing field conditions. Another low cost method would be to plug the end of the drain with concrete. This could be done at a cost of approximately $50 per drain. The disadvantage with both of these methods is their detrimental effect on field conditions upslope of the riparian zones which may decrease yields. Their advantage is that they may provide for more natural conditions in the riparian zone. A third alternative would be to replace just the drain tiles in the riparian zone with solid wall pipe. This would transport the water from upslope fields but not drain the riparian zone. However, installed costs for 8" drain tile is approximately $7 per foot (Gordon, 1992). Costs for solid wall pipe are comparable, making this approach improbable.
expensive. An estimate will be presented only for plugging the drain tiles.

The Farm and Forest Operation Survey (Rambo and Buckhouse, 1993) showed that 38 percent of the farmers used drain tiles. Assuming that 20 percent of the population had property bordering the West Fork of Dairy Creek, there are 2,700 farm and forest owners in the survey area of which 60 percent are farmers, which would imply approximately 123 farmers using field drains in the West Fork of Dairy Creek. How many drains each farmer uses and how many transect the riparian zone is unknown. If it is assumed that all drains cross the riparian zone and allowing one drain per farmer would mean that 123 drains would need to be decommissioned in the West Fork of Dairy Creek. Proportionally Gales Creek is 75 percent as long as the Dairy Creek study area which would imply 92 drains to be decommissioned.

Livestock watering (Zone A)

Requirements for livestock watering are difficult to estimate. The Farm and Forestry Operation Survey shows that 43 percent of the farm respondents and 16 percent of the forestry respondents owned livestock. The survey did not ask how watering was accomplished but it did show that 41 percent of the farm and 64 percent of the forest respondents had year-round streams on their property. Only those livestock owners who also had access to year round streams could currently be without a mechanical livestock watering system. Accordingly 41 percent of the farm and 16 percent of the forest land population would be the upper bounds on an estimate of watering systems required but a more reasonable estimate might be calculated from the product of the percentages of each category. That is, only 43 percent of the farm respondents own livestock, it is assumed that 41 percent of this group will also have year round streams. This would yield about 18 percent of the total farm population and about 10 percent of the total forest land population as needing stock watering systems. Extrapolating these
requirements to the total population as was done for field drains would yield a requirement of 79 watering systems for Dairy Creek and 59 for Gales Creek.

There are three main alternatives to uncontrolled livestock watering in a stream: restricted access to the stream, a stock tank fed from a domestic supply and a stock tank fed from the stream. Watering livestock in a stream is not considered a withdrawal and no water right is needed but a water right is required to withdraw the water for use in a stock tank. Some legislation has been proposed to change this situation but to date none has been enacted, so installing a stock tank fed from the stream is an option only for those also holding a water right who could transfer some of their current use to their livestock. Water right owners may make an application to include livestock in their right if their existing water right is not for livestock. The cost for a 600 gal. stock tank, pump with automatic shutoff, water line, and 100' of electrical service is approximately $430 (Fritz, 1993). This cost would also apply to a stock tank and 600' of water line for connection to a domestic supply. Using a domestic water supply would likely be an option only for a few head of livestock kept close to the supply. This may be the case for many farms. The average number of horses kept, for the farms who kept any horses at all, was three (Rambo and Buckhouse, 1993). Neil Rambo, OSU Extension, and Jerry Rodgers, the local water master, stated that many of the domestic wells in the area have low capacity and some even run dry in the summer. Because of problems ensuring a source of water and the high cost, an estimate is not presented for using stock tanks.

The third option is to construct restricted access to the stream, called a water gap. A narrow corridor to the stream is fenced and often a gravel ramp to the stream is built to minimize erosion. Costs for the fencing is $2 per foot and the cost for gravel is $1.25 per foot (Hogensen, 1993).
Irrigation pipe (Zone A)

An unknown number of irrigators may be able to install longer supply pipes to their pumps in order to move the pumps out of the riparian zone altogether. Each particular pump has a particular negative suction head capability which determines how far it can pull water vertically and horizontally. This distance can be increased somewhat by using larger diameter supply pipe. The upper limit on the potential applications would be the number of pumps currently supplied by the streams. The district water master, Jerry Rodgers, has recorded 75 diversion points on Gales Creek and estimated 80 diversion points on Dairy Creek. Six inch pipe is often used and, if that were the case, 8 inch pipe could be substituted. Eight inch PVC pipe costs $3 per foot (Bevandich, 1993). Using the pipe could also reduce the need for irrigation ditches or access roads. Improvements to ditches and roads costs about $1.25 per foot leaving a net cost of about $1.75 per foot for the larger pipe. No estimate is given for the extra electricity required.

Irrigation ditches

Ground truthing a section of Gales Creek showed an average of one irrigation ditch per 3,217 feet of stream. Extrapolating these results to the entire length of Gales and Dairy Creeks would yield 35 ditches on Dairy Creek and 33 ditches on Gales Creek. The length of the ditches is unknown but the upper limit for the length to be reshaped and seeded would be the width of the riparian zone, as a result this estimate will probably be higher than the actual cost. Gordon estimates that the cost of constructing an irrigation ditch is about $1/ft. A similar cost is assumed to reshape an existing ditch to allow it to be seeded with grass. Seeding costs are estimated to be $40 per site, based on Gordon's estimate for seeding one acre.
Access corridors (Zone A and B)

Ground truthing Gales Creek showed an average of one dirt access road to the creek for every 1072 feet of stream. Extrapolating this would yield 97 sites for Gales Creek and 129 sites for Dairy Creek. The estimate for the cost of graveling a one lane access road with 4 inches of gravel is $1.25 per foot.

Cropland loss (Zone A)

Cropland loss in zone A was calculated by multiplying the length of the stream bank in the 0-25 feet canopy category times twenty feet (the width of the zone less five feet). This was based on the observation that crop fields did not run right up to the edge of the stream. In fact even this allowance likely overstates the loss somewhat, in many places a 15-20 foot canopy exists but farmers probably have the right to plow to the stream bank as long as this does not lead to a violation of water quality standards.

The cost of removing the land from production depends on how valuable it was in production and how valuable it would be if retired from crop production. This in turn depends on assumptions about the land's usefulness once it is retired from production. If land owners in the area derive a high benefit from owning land even if it is not producing a crop then its value will not fall much when it is retired. This may be the case if the land is held for its esthetic beauty, to provide buffer for privacy, for prestige or for other non-income earning reasons. If farmers valued cropland mainly for its income earning potential then the value of retired cropland would change in proportion to the change in income the land earned.

One scenario for cropland in Zone A is that land is held primarily for non-income earning reasons. This would tend to imply that farming the land is simply a hobby and there would be little or no cost if it were retired from production. A second scenario is that the cropland is held solely for income earning reasons and that
removing cropland from production would render it valueless to the farmer. Accordingly, the cost of this practice is estimated to be the fair market price for irrigated land, about $3,500 per acre (Cross, personal communication, 1993). In reality, these two assumptions represent points on a continuum of possible costs; costs that depend on the portion of the land's value due to its income producing ability.

Some insight may be gained into the question of what accounts for the price of cropland by examining the income that cropland can generate to see if it is high enough to account for the market price of the land. If income from cropland is very low but the market price for land is very high it may be likely that land is being purchased for reasons other than generating income. Cross et al. (1988, 1991) have estimated budgets for producing certain crops in the Willamette Valley. The budgets were not done for particular farms nor were they based on conditions specific to the Tualatin basin but they be indicative of values farmers in the Tualatin region face. Net returns per acre for cauliflower, bush beans and broccoli were estimated at $927, $522 and $689 respectively. The question is, what is the most a person would pay for an asset that generates this amount of income? If it is assumed that a farmer needs to make a return of 8 percent [approximately the cost of a farm or small business loan (Benton County Bank staff, 1993)], then the farmer could afford to pay $11,587, $6525 and $8612 per acre for land to grow cauliflower, bush beans and broccoli. This is not to suggest that these figures would represent the price of land for these crops, because not all the net returns should necessarily be attributed to the productivity of the land. It would represent an upper bound on land prices where demand reflects the land's value in producing income. Since the current price of irrigated cropland is less than these bounds it is possible that cropland is held solely for its ability to produce income and not for esthetic beauty, privacy or other non-income reasons. Of course, it is also possible, as noted before, that the land is held almost entirely for non-income reasons. In reality the values people place on their land will vary from person to person and perhaps change with time. The most conservative approach is to
assume that farmers buy land primarily to generate income and that retiring land from production reduces its value to zero. This is one scenario used in this study.

A third scenario is that an entirely different use will be found for the land after it is retired from production. Although this possibility is speculative it is an important one to investigate. Retiring cropland (or pasture land) from production and restoring its riparian functions may be similar to what happens in wetlands mitigation projects. Washington County has standards for development in wetlands (Larry Svart, 1993). In general, these standards prohibit development in wetlands. If development is to be allowed, it must minimize the degradation done to the wetlands and in some cases other wetlands must be created or other degraded wetlands improved. It is not the purpose of this study to delve into wetlands mitigation standards and practices but it may be possible to use restored riparian areas along Gales and Dairy Creeks as a type of wetlands mitigation bank for wetlands damaged by future development. Larry Svart, Washington County Land Development Department, estimated that current mitigation projects restored about five acres per year or less, although this figure may increase as the county population increases. One possible institutional barrier is that current standards require the mitigation to take place close to the development. Development is concentrated inside Urban Growth Boundaries and Gales and Dairy Creeks lie largely in rural areas. Another potential source of demand for restored riparian areas, similar to wetlands mitigation, could be as stormwater mitigation areas. Currently the Unified Sewerage Agency (USA) manages stormwater inside the Urban Growth Boundaries. It may be possible to use restored riparian areas along Gales and Dairy Creeks to offset water quality degradation done by stormwater inside Urban Growth Boundaries. John Jackson, USA, stated that the agency collects fees in lieu of on-site mitigation for some developments. The fees are to be used for off-site mitigation, although they are currently restricted to projects inside Urban Growth Boundaries.

The use of wetlands mitigation banks is still in its infancy. The City of Eugene, Oregon operates a public wetlands mitigation bank...
and a private bank exists in the Portland area. An analysis of mitigation banking (Shabman et al., 1993) found that mitigation banking provided greater predictability to developers, reduced compensation costs, provided long-term management that more effectively maintained ecosystem integrity, and increased the certainty that the compensation would be realized.

If cropland and pasture land was used for wetlands mitigation it would likely retain significant value to its owner. In other parts of the country restored wetlands have sold for $5000 to $15,000 per acre (Shabman, 1993). The price for restorable wetlands in the Tualatin basin would be highly dependent on the regulatory framework of mitigation banking. For the purpose of this study it is assumed that in this scenario the price would be the current market price, that is, farmers could retire land from production and receive the full market price for the land. This might be the case in a voluntary land retirement program.

Cropland loss (Zone B)

The cropland loss for the 50 foot wide Zone B was calculated as a sum using the three canopy width categories. First, multiplying the stream bank length in the 0-25 canopy category by the full 50 foot width, plus the length of the 25-50 feet canopy category multiplied by 37.5 feet (this assumes that the average canopy width was 37.5 feet), plus the length of the stream bank in the 50-75 feet canopy category multiplied by 12.5 feet (assuming the mean width to be 62.5 feet). The cost per acre of the lost cropland is not as high as in Zone A, however. Farm activity could be accommodated in Zone B. Grazing, timber or pulp wood production would be acceptable uses of this Zone. Other uses, such as orchards, may also be possible as long as ground cover is intact. The major limit to alternative uses may be that the parcels are likely to be small, possibly precluding economies of scale. The value of pasture land in the area is approximately $1,500/acre (Cross, 1993) yielding a loss in value of
$2,000 per acre. This loss may be partially recouped over time as farmers learn high value, low impact uses for the land.

If the cropland in Zone B were used for wetlands mitigation it is assumed that no loss in value would occur.

Pasture land loss (Zone A)

Pasture land loss was calculated by multiplying the length of the stream bank in pasture times the width of Zone A. Livestock would be excluded from Zone A and this would represent a complete loss of the value of the land to the farmer under normal circumstances. Pasture land is valued at approximately $1,500 per acre in the area. If pasture land in Zone A were used for wetlands mitigation it is assumed that no loss in value would occur.
Cost estimates for riparian restoration.

<table>
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<tr>
<th>BMP</th>
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<th>DAIRY CREEK</th>
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<tr>
<td></td>
<td>ZONE A 25' Width</td>
<td>ZONE B 50' Width</td>
<td>ZONE A 25' Width</td>
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<tr>
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<tr>
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Other costs

Non-biological structural modifications are generally not desirable both because of their expense and their interruption of natural stream processes. There may be some sites, however, where the stream bank cannot be stabilized by biological methods. Even for these sites it may be prudent to restore the surrounding area naturally then wait several years to insure a minimum of intervention and that modifications will conform to the restored stream.

The DEQ's bio-engineering demonstration project on the West Fork of Dairy Creek has initially identified twenty-four sites for restoration, three of which require rock rip-rap. In the initial budget the average cost for the three sites for rip-rap alone is $1,466. The
average cost for all twenty-four sites is $745, not counting a 40% contingency budget.

The Oregon Department of Fish and Wildlife has a Salmon and Steelhead Production Plan for the Tualatin River which calls for two improvements to Gales Creek. The Plan recommends that fish passage structures be installed on the Balm Grove Dam and the Clear Creek Dam. ODFW estimated the cost of these actions to be $5,000 at each dam. One of the co-authors, Eric Olson, stated that figure was for budget purposes and that he did not recall how it had been generated.

Cost Sharing Program

The Washington County Agricultural Stabilization and Conservation Service has recently been authorized to release funds for Water Quality Incentive Projects (WQIPs) in the Dairy-McKay HUA (ASCS, 1992). The program is designed to encourage farmers to incorporate management practices that will improve water quality. The program will pay farmers to adopt certain practices. No farmers in Washington County are currently enrolled in the program and ASCS staff indicated the exact maximum subsidies available have not been determined since no projects have been done (Boldt, 1993). Guidelines for implementing WQIPs indicate that payment for all practices is not to annually exceed an average of $25 per acre. Costs were not estimated for adopting ASCS standards but based on adopting the more conservative standards in this study the $25 per acre payment would represent 1-3 percent of the cost of restoration. It should be noted that the WQIP cost sharing program does not reduce costs, it transfers some of the costs to national taxpayers.
Summary of Costs of Riparian Restoration on Gales and Dairy Creeks

The total projected costs of restoration depend on the standards adopted and assumptions made. Costs for non-biological structures and ODFW projects are excluded.

Costs for the 19.7 miles of Gales Creek average to about $6,000 per mile; for the 26.13 miles of Dairy Creek costs averaged to about $21,000 per mile.

It can be seen that a major influence on cost is the value of land once it is retired from production. The cost of achieving this level of protection without an alternative such as mitigation banking is approximately $540,000 greater than if a mitigation program paid farmers the full cost of retiring land from production.

Benefits of Riparian Restoration

Proper estimation of the economic benefits of restoring a riparian area would require two things to be known; first, all of the physical and biological effects of the restoration and, secondly, how much people would pay for these effects. This information is not available for Gales or Dairy Creek, nor is it likely to become available. Information is available on other areas and this can be used to learn what might happen if riparian areas were restored along Gales and Dairy Creeks. It would be preferable to only examine areas that are quite similar to Gales and Dairy Creeks, however, the paucity of sound studies necessitates the examination of wetland areas that are physically and geographically different from either Gales or Dairy Creeks. A good deal of the economic research on wetlands is concerned with coastal wetlands and the riparian areas of arid grazing lands. An effort was made to exclude these studies from consideration.

The beneficial functions of riparian zones have been investigated and described from a variety of different perspectives; timber and forest management, agricultural, fishing and hunting, civil engineering, land use and others (Meehan, 1991). Benefits that are
commonly associated with riparian zones include trapping sediment and nutrients, providing shade to reduce stream temperature, providing food and cover for wildlife, providing large organic debris to the stream, and moderating cumulative watershed effects (Belt et al., 1992).

This diversity of perspectives when valuing riparian areas increases the difficulty in trying to estimate what a total value would be. There appears to be limited systematic description of the relationships between a riparian area's specific physical characteristics to human uses to economic values. Instead, valuation studies can be lumped into different types; sediment, recreation, land price, and what might be called 'total value'.

Sediment studies tend to be concerned with civil engineering impacts. Recreation studies focus more on fishing, hunting and general recreation values and tend to ignore the specific riparian characteristics that give rise to these values. Likewise, land price studies tend to use aggregate riparian characteristics to explain differences in land prices. Total value studies carry this aggregation one step further; not only is the riparian area considered as an aggregate of all its characteristics but all uses are aggregated as well. The question simply becomes, what is a riparian area worth?

This paper will review previous studies by type and apply the results to Gales and Dairy Creeks where possible.

Decrease in sediment

Sediment has both in-stream and off-stream impacts. In-stream impacts include biological, recreational, water storage in lakes and reservoirs, navigation and mechanical. Off-stream impacts include flood damage, water conveyance, water treatment, agricultural and mechanical (Clark et al., 1985)

Sediment can reduce the recreation value of a water way by decreasing its esthetic quality and by making its use more hazardous. Clark et al. estimate that as many as 200 swimming or boating deaths nationally per year could be a result of turbid waters. Although no estimate is made of this impact some of the
recreational value of clean water may also be expressed in land prices if people pay more to live on a less turbid section of a stream.

Sediment impacts water storage in Lake Oswego by slowly settling and filling the reservoir (Schaeffer, 1993). Lake Oswego managers hired a consultant to examine the sediment problem in the lake in 1985 or 1986. The analysis estimated that approximately 700 truck loads of sediment per year settled in the lake. Chuck Schaeffer, the Lake Oswego warden, estimated that about 75 percent of the sediment is from the Tualatin River. The lake managers have started dredging operations in recent years and are now budgeting money for periodic dredging. Mr. Schaeffer stated that their goal is to fund a dredging operation about every five years. He stated that he is well aware of the upstream causes of sediment in the Tualatin River and is concerned about overall water quality in the river. In 1988, 3,000 cubic yards were suction dredged from the main canal into Lake Oswego at a cost of $40-$60 per yard or $120,000 to $180,000. In 1992, 20,000 cubic yards were removed as dry material when the lake was emptied at a cost of $250,000 or about $12.50 per yard. Although the dredging actually performed by Lake Oswego management is limited by their budget, the economic cost of the sediment must be calculated based on the sediment that is deposited in a year even if it is not dredged that year. Assuming 75 percent of the 700 truckloads of sediment is from the Tualatin and that each truckload is 6 cubic yards (Schaeffer, 1993), the Tualatin is responsible for approximately 3,150 cubic yards of sediment per year deposited in Lake Oswego. The cost of dredging in highly dependent on the method used. Although using heavy machinery to remove the sediment as dry material is a relatively inexpensive earth moving method, there are costs associated with draining the lake necessary prior to using this method such as loss of hydro-power, recreation and esthetics. The $40-$60 cost per cubic yard may be a more accurate estimate of dredging cost in Lake Oswego. This would suggest the annual cost of sediment from the Tualatin to be $126,000 to $189,000. Capitalized at 8 percent this would represent a cost of $1.5 to $2.3 million. Although this figure may
appear high Mr. Schaeffer mentioned in conversation that the cost of dredging the entire lake to remove the historical sediment build-up would cost millions.

Sediment affects navigation by filling in channels which then must be dredged. Operating the Port of Portland requires the lower Willamette River to be dredged at an average annual cost of $270,125 (1984 dollars) or $0.85 per ton of sediment removed (Moore and McCarl, 1987). The Washington County Soil and Water Conservation District estimates that Gales Creek and the middle fork of Dairy Creek contribute more than 5,000 tons of sediment annually to the waterway from stream bank erosion. They have also classified 85,000 acres of cropland in the county as having erosive soils in need of protection (Washington County SWCS, 1991). The Washington County Soil Conservation Service has established soil loss goals for much of the area's cropland in the range of 3 to 5 tons per acre (SCS, 1993). If all conservation practices are adopted on county cropland and we assume an average loss of 4 tons per acre this would yield annual soil loss of 340,000 tons from the 85,000 acres. Little information was found that would relate cropland soil loss in Washington County to the amount of sediment that would need to be dredged from the lower Willamette. Sheryl Carrubba of the U.S. Army Corps of Engineers stated that most of the material dredged is fine sand and it was her opinion that little if any material came from the Tualatin (Carrubba, 1993). If it is assumed that one percent of the eroded soil would later be dredged this would be a cost of $2,890 per year or $36,125 if capitalized at 8 percent.

In-stream mechanical impacts of sediment could include the wear on the turbines at the hydro-power facility at Lake Oswego and wear on boat motor cooling systems and propellers used anywhere downstream of the sediment source. Mr. Schaeffer, the Lake Oswego warden, stated that no action had been taken on the turbines as a result of sediment. No estimate of this impact was made.

Sediment can increase flood damage by both filling and altering a stream channel to make flood waters higher and by covering the flooded area even after the water recedes. Although a destructive flood is possible, Gales and Dairy Creeks are higher than the
adjoining Tualatin Valley and the soils have greater infiltration capacity (Miner, 1993). The Tualatin River did have a major flood in June of 1991. No estimate of increased flood damages due to increased sediment was made.

Sediment can impact irrigated agriculture by forming a crust on the soil which can inhibit water infiltration and seedling emergence (Clark et al., 1985). This is more likely to occur with furrow irrigation which is uncommon in the Gales or Dairy Creek areas. Neil Rambo, the Washington County Extension agent reported that he had seen no evidence of this problem in the study area (Rambo, 1993).

Sediment can impact water conveyance by filling in ditches and clogging pipes. Irrigation ditches are used from Gales and Dairy Creeks and the local water master stated he believes they are cleaned periodically, probably once a year. Although riparian zones may be 90-95 percent effective at removing sediment from overland flow (Lowrance et al., 1985), this is not the only source of sediment in a stream so ditches would still require maintenance. Considering just the case of the short irrigation ditches used to connect the stream to the irrigation pumps and assuming an average ditch length of 25 feet, cleaning requirements to be reduced by half due to improvements in the riparian zone, normal cleaning costs to be $0.50 per foot (half of construction costs), savings for Gales Creek would be $206 per year and savings for Dairy Creek would be $269 per year, capitalized at 8 percent these would be savings of $2,575 and $3,362, respectively. Much of the irrigation water in the area is delivered by high pressure pipes. The Washington County Extension agent, Neil Rambo, reported that sediment is rarely a problem in these systems although sand will occasionally clog smaller sprinklers. A study of a water quality improvement project for Rock Creek in Idaho (Young and Magelby, 1986) estimated a benefit of $185,000 per year for an 18,000 ton per year reduction in sediment in irrigation ditches. Unfortunately, the authors did not state their methods, the management practices undertaken or how many miles of ditch were involved.

Off-stream mechanical impacts include wear on irrigation pumps and the increased use of electricity to pump sediment along with
irrigation water. No estimate of these impacts was made for Gales and Dairy Creeks although one estimate of increased electrical use nationwide is 5 to 6 million kilowatt hours (Clark, et al., 1985).

Sediment must be removed from municipal drinking water supplies. This is often done by settling, filtration and the use of chemicals such as aluminum sulfate and lime (Moore and McCarl, 1987). An regression analysis of water treatment costs in Corvallis yielded a cost elasticity for turbidity which revealed that a 1 percent decrease in turbidity would reduce treatment costs by approximately 1/3 of a percent (Moore and McCarl, 1987). Treatment costs for sediment were estimated at $20 per million gallons. Karl Borg at the City of Hillsboro water treatment plant estimated that their plant treated 15-16 million gallons per day on average for the city's population of about 43,000 (Borg, 1993). Plant capacity is 40 million gallons and the peak day so far this year has been 35 million gallons. The treatment plant does not calculate sediment treatment costs separately but it uses a treatment process similar to that modeled by Moore and McCarl with the exception that it also operates drying beds for the sediment removed. This represents an additional cost not accounted for. Using the Moore and McCarl model, a 1 percent reduction in the turbidity of the Tualatin River would mean the City of Hillsboro could reduce its treatment cost by about $0.066 per million gallons or about $1 per day at the current level of water use. Capitalized at 8 percent this would be a benefit of $4562, however the relationship between establishing riparian zones and percent reduction in turbidity remains unknown.

Although not strictly concerned with sediment or economics, several studies have been conducted on a site near Tifton, Georgia relating riparian zone management to nutrient cycling. One study (Lowrance et al., 1985) measured nitrogen and phosphorous inputs to a riparian zone and stream outflows and estimated that denitrification and storage in woody vegetation in the riparian zone accounted for six times more nitrogen removed than occurred in stream outflow. About equal amounts of phosphorous were taken up by vegetation and removed by stream outflow. A second study (Fail et al., 1987) measured nutrient uptake and riparian forest biomass
production. A test site that was adjacent to and downstream of a pigpen yielded roughly twice the total biomass per hectare as the next highest site and also about 50 percent more biomass production per year. The authors noted that trees in nutrient rich areas may be maintained longer in the 'bloom' stage of their successional cycle yielding higher growth rates longer.

Land Price

Restoring riparian areas may make them more attractive to live close to. The trees, cleaner water and possibly an increase in wildlife viewing are esthetically pleasing to some people and they may be willing to pay relatively more to purchase a home near a riparian area. If this occurred for Gales and Dairy Creeks, property values near the streams would rise as the areas were restored and this would constitute a measurable benefit of restoration. A common method for measuring this change in land prices or property values is to sample house or land prices at different distances from the riparian area and analyze any correlation between price and distance while adjusting for other characteristics, e.g. lot size, number of bedrooms. This is accomplished by multiple variable regression analysis.

An analysis of property values and wetlands proximity in Minnesota (Doss and Taff, 1993) compared the relative value of four different types of wetlands; forested, scrub shrub, emergent vegetation, and open water. Their results did not lend themselves to calculating a total value for any particular wetland but did seem to indicate that scrub shrub and open water wetlands were preferred, in the housing market at least, to forested and emergent vegetation wetlands. The authors indicated this may be due in part to the greater 'visual variety' that scrub shrub and open water wetlands provide. The authors compared six different models of the price/distance relationship and as a result generated different estimates of what the relationship was. Homeowners were willing to pay from about $80 to minus $90 to live 10 meters closer to scrub shrub wetlands. Two of the six models showed homeowners
paying less to be closer to scrub shrub wetlands while four models showed homeowners paying more to be closer. Homeowners were willing to pay from $69 to minus $47 to live 10 meters closer to open water wetlands. One model showed homeowners paying less to be closer to open water wetlands while five models showed the homeowners willing to pay more. Although the results were statistically significant the additional price that homeowners were willing to pay to be closer to wetlands was not large when compared to the total property price, which averaged $88,000 in the sample taken. However, a wetland's total influence on property values would be determined by aggregating the benefits (or losses) from all affected properties.

Recreation

Gales and Dairy Creeks provide opportunities for fishing, hunting, canoeing and other recreation, however, these opportunities may be limited by poor water quality and lack of public access to the streams. As stated earlier a canoe trip was made down a portion of Gales Creek to verify photographic interpretation. No other canoeists were encountered but several fisherman were observed. There is very little public access to the streams; usually just where public roads bridge the creeks. This was where the fishermen were encountered. There are at least two small public parks along Gales Creek. One, just below Roderick Road, appears to enjoy light use by fishermen since there is no parking area, just a pull-off on the shoulder of the highway. The other is much farther upstream where the creek is quite small and the area is forested. No public parks were identified on Dairy Creek although they may exist.

The Oregon Department of Fish and Wildlife wrote a Salmon and Steelhead Production Plan for the Tualatin River in 1990 (ODFW, 1990). The costs of implementing the steelhead plan include those already listed in the restoration budget for Gales and Dairy Creeks plus and additional $860,000 for work on the Lake Oswego canal and dam. This is expected to yield a steelhead harvest of 3,122 fish. For the period 1980-1986, the average annual harvest in the basin was
about 330 fish and ODFW estimated the out of basin harvest at 149 steelhead. Adopting the plan would yield an additional 2,643 steelhead. The actions required for implementing the salmon plan were similar to those required for the steelhead plan and no additional expenditures were required. Coho salmon harvest for the period 1980 to 1985 averaged 7 salmon per year in the basin and the ODFW estimated the out of basin harvest at 6,412 salmon per year. ODFW planners stated that the model used to determine potential salmon harvests showed that there would be no improvement in those harvests if the plan was adopted. They felt this was an unreliable forecast due to poor data and that the harvest could possible increase by 2,541 salmon per year. In personal communication, one of the authors, Eric Olson, stated that undue confidence should not be placed in the harvest forecasts since some data used in the model was not generated within the Tualatin Basin (Olson, 1993).

In sportfishing the economic value of fish is highly dependent on the harvest site and species (Loomis, 1989). Travel cost and contingent valuation techniques have been widely used to estimate the value of fish. Of course, values differ somewhat between studies. Loomis (1989) used a travel cost method to estimate the value to an angler of an additional fish caught if small increases in the steelhead harvest occurred in twenty-one Oregon rivers. These values, called marginal values, ranged from $18 for a fish caught in the Coos River to $333 for a fish caught in the Willamette. Values were generally high in more urban areas. Values for the Clackamas and Sandy Rivers were $176 and $115 respectively. A study by Olsen et al. (1991) used the contingent valuation method, a survey in which respondents are asked how much they would be willing to pay to gain something, in this case a doubling in size of steelhead and salmon runs in the Columbia River basin. They surveyed angler and non-users (who would pay just to ensure the existence or viability of the runs) and estimated the total value of additional salmon or steelhead (no distinction was made) to be $68.49 per fish. In separate analysis they estimated just the sportfishing values of salmon and steelhead in the Columbia basin and estimated the marginal value of steelhead
to be $54.84 and the marginal value of salmon to be $18.47. Johnson and Adams (1988) used a contingent valuation survey to analyze the marginal value of steelhead in the John Day River as part of a study to estimate the value of increases in instream flow. The authors estimated the value of additional steelhead to be $6.65 per fish. In personal communication with Dr. Adams he stated that the value may have been lower than in other years due to high harvest levels while the survey was being conducted. If anglers are already very successful they may not be willing to pay as much for additional fish. Loomis (1989) estimated a value of $41 per steelhead for the John Day. Factors that might lower the value of fish in the Tualatin basin could include poor public access, water quality, esthetics and reputation. On the other hand restoring riparian areas along the river might improve some of these conditions to the point that a reputable sportfishery would be established close to a metropolitan area. In this case the Tualatin may yield relatively high marginal values for fish. It cannot be over emphasized that the marginal values for fish are site specific and that no analysis has been presented for the Tualatin. If a marginal value of $60 per steelhead and $20 per salmon were assumed the annual value of adopting the ODFW production plan would be $209,400. Capitalized at 8 percent this would be a total benefit of about $2.6 million.

The ODFW no longer collects hunter information on a county basis and their waterfowl personnel could provide no estimate of the number of hunters that might use riparian areas. Although different types of hunting can occur in a riparian area the most common use may be waterfowl hunting. The value of a bagged bird in the Pacific flyway has been estimated at $3.10 to $3.29 (Hammack and Brown, 1974). Payments for farmland set asides for breeding habitat are also used. A three county program in Minnesota restored 1,460 acres of wetlands and 3,700 acres of adjacent uplands at an average annual lease cost of $64 per acre (Madsen, 1986). A survey of Canadian landowners by van Kooten and Schmitz (1992) revealed that farmers would be willing to set aside wetlands for waterfowl production if they received $61.80 per acre annually. The Canadian
set aside program at that time was only paying $40 per acre annually.

Other recreation values of Gales and Dairy Creeks or the Tualatin are more difficult to estimate but potentially very high. One difficulty lies in the fact that the streams are not currently being widely used for recreation (Wolgamott, Personal communication, 1993) therefore a large, identifiable population does not exist from which to gather information. Another difficulty is that changes in recreation values resulting from riparian and water quality improvements may not be the small marginal changes that economic analysis is designed to handle. Improvements in riparian and water quality may lead to increased demand for public access to the streams and for public facilities along the streams which would increase recreation values in a dynamic process.

Total value

Many of the benefits of riparian areas may arise in a dynamic fashion yet many of the specific physical and biological processes that provide the beneficial characteristics are not completely known. Some studies have used methods that attempt to address these concerns.

One method used to handle the dynamic nature of change is to model the relationships that exist between the different sectors of the economy, especially the ones affected by the riparian area in question. For example retiring land from agricultural production may decrease fertilizer sales. Decreased fertilizer use may help improve water quality and increase demand for residential land. Analysis of this type might be used to investigate if total land value in the county would increase or decrease. Leitch and Scott (1984) used this type of analysis, called input-output, to examine the effects of wetlands improvements on local economies. Programs existed in their study area, north central North Dakota, to pay farmers to retire land from production to improve wetlands, primarily for waterfowl production. The authors intended to find if additional payment should be made to compensate residents for losses due to dynamic or
indirect effects. Their results indicated that a wetland provided annual personal income of $29 per acre from recreation, flood protection and construction activity but that income from uses prior to restoration had generated $83.41 per acre, implying that an additional payment of $54.41 per acre was required to make everyone in the region as well off as they had been. A significant limitation in their analysis is the types and scope of values they attribute to wetlands. The total recreation value is assumed to consist solely of local hunting. No values were included for changes in property values nor were esthetic values estimated. Although input-output studies are very useful, they have limits in valuing all types of benefits.

Contingent valuation analysis is used to estimate benefits of riparian areas, among other things, when these benefits are not normally exchanged in a market at observable prices. For example, one benefit of restoring Gales and Dairy Creeks would be that a person could go swimming there five years from now. No market exists to sell a swimming trip in the future, at least on Gales or Dairy Creeks, yet area residents may be willing to pay some small amount to do just this. The contingent valuation method uses a structured interview to determine a person's willingness to pay for the benefits that result from a specific scenario, in this case, restored riparian habitat. No such analysis has been done for Gales or Dairy Creeks but other studies may be illustrative.

A study of Colorado rivers (Sanders, et al., 1990) estimated the total value residents of the state would be willing to pay to protect certain rivers under the Wild and Scenic Rivers Act of 1968. The authors estimated not just recreation value but also preservation value as well. The benefits of preserving a river could arise from having the option to use the river in the future, simply knowing its existence is secure or from leaving the river as a bequest to future generations. Fifteen rivers were studied. The total annual value of protecting the top three was $39.80 per household or about $47.1 million dollars for the entire state. As more rivers were offered for protection, the total amount people were willing to pay increased but at a decreasing rate. Residents were willing to pay $74.32 per
household per year for protecting the top seven rivers. The authors estimated the recreation value of the rivers separately from the preservation value. The top three rivers had a recreation value of $7.54 per household and a preservation value of $32.26. The top seven rivers had a recreation value of $14.08 and a preservation value of $60.24. Although the Colorado rivers are quite different from Gales or Dairy Creeks, and the Tualatin as well, it is important to note that people may be willing to pay significantly more to preserve a river for non-uses than they would pay to protect it for recreation.

A contingent valuation study of the San Joaquin Valley in California (Hanemann, et al., 1991) estimated the annual amount California households would be willing to pay to make improvements to valley wetlands and to increase instream flows for salmon and riparian habitat improvement. The estimated willingness to pay for wetlands improvements was $251 per household annually. The estimated willingness to pay for increase in water flows was $181 annually. The authors did not attempt to estimate the benefits of different uses or non-use as the Colorado study (Sanders et al., 1990) did but instead estimated a single value that respondents would place on wetland and instream flow regardless of why the respondent would benefit. In this respect, contingent valuation is a much more direct method of arriving at the value of riparian areas. Instead of attempting to determine every specific characteristic of a riparian area and how it may be beneficial or detrimental to people and then estimating the value of the benefit or detriment, contingent valuation assumes that individuals understand how a riparian area affects them and only attempts to elicit their final willingness to pay.

A contingent valuation study of the The Nature Conservancy’s Hassayampa River Preserve in south central Arizona estimated the value of the Preserve in its current condition, and its potential value if streamflow was increased from intermittent to perennial (Crandall, 1992). A travel cost survey of visitors was used to estimate the current annual value of the Preserve at $613,360. The additional value resulting from increased streamflow was estimated
to be $520,000 per year. For the 8,000 annual visitors to the Preserve this represents an additional willingness to pay of $65.

In Kentucky, forested wetlands are threatened with destruction by surface coal mining. A contingent valuation study (Whitehead, 1990) estimated the annual willingness to pay for preserving the wetlands to be $6.31 or $12.67 per household depending on the model used to explain the underlying relationships. This represents a total value of $2.94 million or $5.91 million for all Kentucky residents. The willingness to pay per acre of wetland was $588 or $1182. Using less conservative aggregation assumptions the willingness to pay was estimated to be $1896 or $3810 per acre. Although the study did not specifically test for the reason respondents valued wetlands, the author attributed a large portion of the total value to non-use value held by recreationists that had not used the specific wetland being studied.

One of the limits to the usefulness of examining studies of other wetlands is the degree to which they are similar to Gales and Dairy Creeks or the Tualatin. The value of high quality trout streams in the mountains of Colorado may be quite different from the value of Dairy Creek, even in a fully restored condition. One study to be examined estimates the willingness to pay for improvements in river quality for "ordinary" rivers in the cornbelt of Iowa and Illinois (Lant and Roberts, 1990).

The study area included several river basins and sampled the residents of fourteen towns located in the basins. No biological analysis was done of the existing condition of the rivers but "Clark et al. (1985) estimate that 100% of the river basins in the Cornbelt are significantly affected by agricultural nonpoint pollutants". The Lant and Roberts (1990) note that many wetlands in the areas have been drained and that "Riparian environments (floodplains) are now the most forested and ecologically unique landscape feature in much of the region."

A contingent valuation survey was used to examine the willingness to pay for three different steps in improvement to river quality; from poor to fair, from fair to good, and from good to excellent. The study estimated separate values for recreation and
The mean annual values per household for recreation were $30.50, $37.10 and $41.51 for the three river quality steps (P-F, F-G, G-E) respectively. The mean annual values for non-use were $37.61, $47.16, $43.22 for the three steps. Total values were $68.11, $84.26, $84.73.

Lant and Roberts (1990) provide additional evidence that a region’s residents may place significant value on a riparian area and that a large portion of that value may simply be in preserving the area in a healthy condition. Whether or not residents of the Tualatin basin value their river in a similar fashion can only be determined by further investigation.

**Summary of Benefits of Riparian Restoration on Gales and Dairy Creeks**

At least four of the benefits of restoring Gales and Dairy Creeks merit further discussion and investigation; reductions in dredging sediment, especially in Lake Oswego; reductions in water treatment costs and improvements in municipal water quality; improvements in fish production and recreational fishing; and increases in non-use and other recreation values.

Reducing the cost of dredging Lake Oswego would be a substantial and identifiable benefit of riparian restoration in the Tualatin. It may also be a large enough benefit, relative to transactions costs, to warrant a compensation scheme. It may be that Lake Oswego residents would be willing to spend some of their money budgeted for dredging on upstream sediment reduction projects.

Although reductions in municipal water treatment costs may not currently be a large benefit as calculated in this study it may be quite significant. Not only is the population of Washington county expected to grow but human health concerns were not addressed in this study and they may be an important benefit.

The value of salmon and steelhead fishing is quite speculative but potentially very high. Further research is needed to clarify what level of harvest is likely if stream restoration occurred and what
other changes, such as improved access, would increase the value of the runs.

Possibly the largest benefit could be the realization of preservation, or non-use values. Unfortunately these values are difficult to measure and perhaps even more difficult to collect from people. This in no way makes this benefit of restoration any less real.

With the information currently available it is not possible to estimate a precise cost and benefit for different levels of riparian restoration to determine the optimum level of protection. It is possible to state that there are potentially significant benefits and that they could exceed the costs of restoration.
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