Adoption of conservation practices by agricultural landowners in three Oregon watersheds

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ABSTRACT: A community-based adaptive management framework is applied to the Calapooya Creek, Deer Creek, and Myrtle Creek watersheds within the Umpqua River Basin in Southwestern Oregon. The objectives are to: 1) identify agricultural landowner participation in watershed conservation projects, and 2) determine the characteristics of participating and non-participating landowners. Data are derived from a 1998 landowner mail survey with a 53% response rate. Landowners implement upland conservation practices such as off-stream livestock water developments and rotational grazing more often than riparian fencing, riparian tree planting, and installing fish screens on irrigation diversions. The key factors in adoption of conservation practices include the use of irrigation, shared management decisions with a spouse, a belief in scientific experimentation, and discussion of conservation with others. The key factors predicting adoption of best management practices depended on the kind of best management practice implemented.

Keywords: Adaptive management, adoption-diffusion, best management practices, community, Oregon, ranching, survey, watershed management

Throughout the Pacific Northwest, pressure builds to improve agricultural conservation stewardship to assist in the recovery of endangered salmon fish species. Fisheries conservation professionals advocate an adaptive management approach applied through watershed management that focuses on experimentation, modeling, monitoring, and evaluation to account for uncertainty in achieving species recovery (Lee, 1993; Gunderson et al., 1995). Additionally, interest grows in developing more voluntary, community-based approaches to watershed management that provide a range of conservation options for agricultural landowners to pursue. One key to implementing community-based adaptive watershed management is understanding the process of adoption and diffusion of conservation practices among agricultural landowners. Without implementation there can be no adaptive management (Holling, 1978; Hilborn, 1987; Bormann et al., 1999; Gunderson et al., 1995). A large research body describes the role of socioeconomic factors on the rate at which individual agricultural landowners implement conservation programs (Pampel and Van Es, 1977; Rogers, 1983; Nowak, 1987; Lockertz, 1990; Saltiel et al., 1994; Wejnert, 2002; Napier and Bridges, 2002). The stages in adoption are: a) knowledge or awareness of the innovation, b) persuasion to try the innovation, c) decision to try the innovation, d) implementation of the innovation, and e) confirmation that the innovation is successful (Rogers, 1983). The factors influencing a conceptual adoption and diffusion of innovations framework consist of the characteristics of the innovation, the characteristics of innovators, and the environmental context in which the innovation is situated (Wejnert, 2002).
Variables associated with adoption. The attributes of innovations that are positively correlated with rates of adoption include: relative advantage, compatibility, viability, and observability. There must be a clear advantage over not adopting the practice; it has to mesh with existing conditions; it has to be proven to work; and its advantages must be clearly seen (Rogers, 1983). Innovations that are complex are less likely to be adopted. The rate of adoption has been linked to demographic, agricultural, attitudinal, informational, and kinship factors.

Demographic factors show mixed success in predicting innovation adoption (Coughenour, 2003). Age has been found to be inversely related to support for environmental issues and conservation practices (Christianson and Arcury, 1992; Stoff, 1995). However, the role of innovator age has produced mixed results depending on the study observed (Rogers, 1983; M CBeth and Foster, 1994). Higher levels of education have been directly related to positive environmental attitudes (Christianson and Arcury, 1992; Wu and Babcock, 1998) and higher probabilities of adopting conservation practices (Rogers, 1983; Kraft et al., 1996), though there have been exceptions (M CBeth and Foster, 1994). Female gender has often been found to play a positive role in determining positive environmental attitudes and conservation practices (Feldman and Welsh, 1995; Aboud et al., 1996), but some question the strength of gender differences in environmental attitudes (Christianson and Arcury, 1992). Open-mindedness and nurturing are characteristics identified with women that contribute to environmental beliefs.

Positive environmental attitudes are directly related to income (M CBeth and Foster, 1994) though the relationship may be inconsistent (Christianson and Arcury, 1992). “Farmers with a negative attitude toward governmental involvement with wetland regulations were less likely to want to participate in the W Q IP (Water Quality Incentives Program)” (Kraft et al., 1996). Further, “when people are forced to change, even innovative individuals resist the innovation” (Moberg and Dyer, 1994). Greater access to information and contact with change agents will lead to greater adoption of innovations (Rogers, 1983; N owak, 1987; Kraft et al., 1996). Lastly, in the Palouse region of southeastern Washington families that farm together are more likely to adopt innovations whether the innovation is environmental or non-environmental (Carlson and Dillman, 1983). Contrarily, kinship pattern appears as non-significant in a study of Illinois farmers’ use of soil conservation practices (van Es and Tsoukalas, 1987).

Despite the wealth of studies, few conclusions exist regarding factors affecting adoption of agricultural conservation practices (Locke, 1990; N apier and Bridges, 2002). Several factors contribute to the uncertainty including variation in experimental design, statistical analysis, operationalization of conservation practices or explanatory factors; inconsistent presence or absence of possible explanatory variables; and lack of strong cause and effect relationships (Locke, 1990). While developing better studies that address the adoption-diffusion process provides one option (Locke, 1990), others have turned away from traditional adoption-diffusion theory and utilized actor-network theory (Coughenour, 2003). Actor-network theory suggests that the decision to adopt conservation or other practices occurs within a larger system than only individual actors and their immediate environments. Interaction with local and external actors over time, more strongly influences adoption of conservation practices.

Therefore, one needs to know the factors that influence farmer conservation behavior that might lead to an increased probability of improving agricultural watersheds for salmon recovery. That goal leads to development of the following research objectives: 1) identify agricultural landowner participation in watershed conservation projects and 2) determine the characteristics of participating and non-participating landowners within the context of watershed management. One would predict that adoption of conservation practices would be related to the characteristics of the innovation, the characteristics of innovators, and the environmental context in which the innovation is situated (Wejnert, 2002). Regarding the conservation practice, one would expect adoption of less complex and more profitable conservation measures. With respect to innovators, younger, more educated, information seeking farmers would be more likely to adopt conservation measures. Lastly one would expect practices that better or more visibly address the environmental issue to be adopted.

Methods and Materials

Twenty-two semi-structured interviews with agricultural landowners facilitated development of a mail survey sent to all agricultural landowners in the Calapooya Creek, Deer Creek, and Myrtle Creek watersheds within the Umpqua River Basin in Western Oregon during Spring 1998 (H abron, 2002). Calapooya Creek watershed, the largest and northernmost of the three watersheds, contains the Calapooya River flowing into the mainstem Umpqua River near the community of Umpqua. It is centered around the two communities of Oakland and Sutherlin. The Calapooya is a long, wide, flat, valley with deep soils conducive for agriculture. Deer Creek flows into the South Umpqua River at the Douglas County seat of Roseburg. Deer Creek is a shorter stream network than the Calapooya or Myrtle Creek, but its width and soils are intermediate between the other two. The Myrtle Creek watershed is southernmost and meets the South Umpqua River in the town of Myrtle Creek. Myrtle Creek consists of a very narrow, steep, and forested valley with poor agricultural soils.

The three watersheds were selected to indicate a southerly gradient toward poorer soil quality and higher geomorphic constraint resulting in declining agricultural intensity from the Calapooya to Deer Creek to Myrtle Creek. According to the Census of Agriculture, there are approximately 229 farms in the Oakland and Sutherlin region that roughly corresponds to the Calapooya watershed. In Myrtle Creek there are 154. There are no figures for Deer Creek, but 653 farms are listed for the entire Roseburg area. Most farms in the Roseburg and Myrtle Creek areas are less than 50 acres while most farms in the Oakland area are greater than 50 acres (Table 1). Roseburg has the smallest percentage of full time farmers (39%) followed by Myrtle Creek (43%) and Oakland (51%). Evidence for the gradient in agricultural intensity is indicated by the percentage of landowners owning more than 1,000 total acres, owning more than 100 acres of pasture, and owning less than 50 head of cattle in Oakland, Roseburg, and Myrtle Creek (Table 1).

Survey items included both close ended and open-ended items that encompass eleven themes. The themes reflect explanatory factors frequently identified in adoption-
diffusion research such as demographics, attitudes, problem perception, conservation practices, farm characteristics, and information sources. Interview respondents conducted the pre-test, which resulted in further editing of the survey.

The final pool of agricultural landowners was determined by selecting all landowners owning agricultural land according to the Douglas County Tax Assessor’s Office. Location within the watershed was determined through geographic information systems. Three waves of surveys were mailed preceded by a postcard notification prepared according to Salant and Dillman (1994).

Non-response bias. After three waves, 297 of 560 surveys were returned (53% response). To address non-response bias, twenty-four follow-up telephone contacts were made with survey non-respondents (Salant and Dillman, 1994). Differences with respect to farm characteristics occur among mail respondents, telephone respondents, and the 1992 Census of Agriculture respondents (Table 2). However, it appears that the populations are relatively similar except that the mail survey contains both a smaller percentage of landowners with greater than 1,000 acres and a larger percentage of landowners with greater than one-hundred acres of pasture. Comparisons of survey and telephone respondents indicate that although the two groups generally share the level of agreement regarding perceived watershed problems, phone respondents are more likely to disagree with the extent of watershed problems, and less likely to express a neutral opinion. Therefore, the mail survey is considered biased towards more moderate landowners in the three watersheds. Additionally, since a complete census was attempted, the results from the survey apply to only the three watersheds since sampling throughout the Umpqua Basin was not attempted.

Logistic regression protocol. Logistic regression allows one to determine the probability of each landowner adopting a conservation practice based on a set of explanatory variables. Further, logistic regression enables one to distinguish how the odds of adoption change given a unit change in any explanatory variable (Ramsey and Schafer, 1997). The adoption of a conservation practice is used as the response variable. Any respondent who has implemented any conservation practice is coded one (1) as an adopter. All other respondents are designated as zero (0). A subset of the items in the mail survey are then used as explanatory variables in a logistic regression model (Schuster, 1983; Kraft et al., 1996). Each of five conservation practices is modeled individually.

The forward selection method is used with a descending model option. Variables are retained in the model if there is less than a 5% probability (p=0.05) that the variable would have generated a significant effect in the sample model, when in reality it does not have an effect in the general population. All models are assessed using the Hosmer and Lemeshow Goodness-of-Fit Test (SAS Institute, 1989; Cody and Smith, 1997) as well as the percent of correctly predicted cases. With logistic regression, the use of $R^2$ to assess model fit is inappropriate. A risk of multiple regression, is to utilize a large quantity of explanatory variables in the model. With a large set of variables, models may appear to be significant when in fact they are not (Lockertz, 1990). To narrow the range of explanatory variables, the same subsets of the variables were first used to identify the most significant variables within each theme for each conservation practice. Themes addressed subsets such as demographics, farm characteristics, information seeking behavior, and attitudes. Only the significant variables within each theme were selected for final model testing for each conservation practice.

Previous studies and theory also suggest that different kinds of conservation practices possess different economic or diffusion attributes (Nowak, 1987). As a result regression models address each conservation practice separately instead of viewing all the conservation practices together. To account for lack of certainty regarding the timing of adoption within a whole farm conservation management setting, conservation practices are also used as explanatory variables. Adoption of one conservation practice may facilitate or be required for adoption of additional conservation practices (Lockertz, 1990). For example, having access to off-stream water sources facilitates rotational grazing systems.

**Results and Discussion**

**Adoption specialization models.** The list of items included in the final models appear in Table 3. There is insufficient evidence to

<table>
<thead>
<tr>
<th>Variable</th>
<th>1992 census</th>
<th>1998 mail survey</th>
<th>1998 telephone survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of farms greater than 1,000 acres</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Percentage of pastureland and rangeland greater than 100 acres</td>
<td>13</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>Percent cattle and calves inventory 1 to 49 head</td>
<td>53</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>Percent cattle and calves inventory 50 to 199 head</td>
<td>8</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Percent cattle and calves inventory &gt; 200 head</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
regress the overall model for lack of fit (Hosmer and Lemeshow, p = 0.925) for the model predicting adoption of off-stream livestock watering facilities (Table 4). Therefore, landowners who believe that experimentation is appropriate on private lands (EXP) are more than two times (e0.82) more likely to adopt off-stream livestock water developments (WATADOPT) than other landowners. Landowners who regularly tell others about their conservation practices (TELL) are also more than twice (e1.08) as likely to adopt off-stream livestock water developments.

Regarding rotational grazing (RESA-DOPT), there is insufficient evidence to reject the overall model for lack of fit (Hosmer and Lemeshow, p = 0.701). Landowners with at least 200 cattle (COW200) are almost 11 times (e2.52) more likely to adopt rotational grazing than other landowners (Table 4). Further, landowners who are very knowledgeable about the Umpqua Basin Watershed Council (KNOW) are over two times (e0.84) more likely to adopt rotational grazing than other landowners.

For the model predicting adoption of riparian exclusionary fencing (FENADOPT), there is insufficient evidence to reject the overall model for lack of fit (Hosmer and Lemeshow, p = 0.170). Landowners who irrigate (IRRIG) are almost three times (e1.43) more likely to adopt riparian exclusionary fencing than other landowners (Table 4). Landowners that seek results from the survey (R ESULTS) are twice (e0.82) as likely to adopt riparian exclusionary fencing as other landowners.

There is insufficient evidence to reject the overall model for lack of fit (Hosmer and Lemeshow, p = 0.374) for the adoption model for implementing riparian tree planting (TR EADOPT). Landowners who have successfully transferred conservation practices to other landowners (TRIED) are four times (e1.43) more likely to adopt riparian tree planting than other landowners (Table 4). Landowners who request the survey results (R ESULTS) are twice (e0.82) as likely to implement riparian tree planting than other landowners.

There is insufficient evidence to reject the overall irrigation fish screen model for lack of fit (Hosmer and Lemeshow, p = 0.737). Irrigators (IRRIG) are twelve times (e2.52) more likely to fit irrigation diversions with fish screens than other landowners (Table 4). Landowners who believe that long applications and permits are conservation barriers (APP) are three times (e1.18) more likely to adopt fish screens than other landowners.

Discussion of results. Due to the sampling strategy, the study only reflects the findings of conservation activity within three watersheds of the Umpqua basin in southwestern Oregon. However, the findings do contribute to the larger discussion of adoption-diffusion theory. Different factors play different roles depending on the type of conservation practice adopted. The most significant variables relate to irrigation use, sharing management decisions with a spouse, desiring survey results, believing in scientific experimentation, and telling other landowners about conservation practices (Table 4). The analysis describes the key factors of the characteristics of the innovation, the characteristics of innovators, and the environmental context (Nowak, 1987; W ejnert, 2002). Strong evidence indicates the importance of specifying the conservation practice implemented (Nowak, 1987; Lock e retz, 1990). More emphasis is given to explanatory variables that explain more than one conservation practice to minimizing variables that may appear as significant simply because of the volume of explanatory variables used (Locke r etz, 1990). Two of the conservation practices reflect upland agricultural practices that potentially benefit farmers as well as the environment (off-stream livestock watering and rotational grazing). While the remaining riparian ecological practices more explicitly benefit the environment but not the farm operation (exclusionary fencing, tree planting, irrigation fish screens).

Irrigation implications. Irrigation appears as a significant explanatory variable in two of

Table 3. Description of significant survey items and summary responses.

<table>
<thead>
<tr>
<th>Item</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced fish runs are a problem that needs to be addressed.</td>
<td>60.1% agree</td>
</tr>
<tr>
<td>Streambank erosion is a problem that needs to be addressed.</td>
<td>49.8% agree</td>
</tr>
<tr>
<td>How satisfied are you with the condition of natural resources in your watershed?</td>
<td>34.2% very satisfied</td>
</tr>
<tr>
<td>How informed are you regarding watershed conservation issues in your watershed?</td>
<td>27.9% very informed</td>
</tr>
<tr>
<td>How knowledgeable would you say you are about the Umpqua Basin Watershed Council?</td>
<td>8% very knowledgeable</td>
</tr>
<tr>
<td>Long or confusing applications and permits are conservation barriers.</td>
<td>59.5% agree</td>
</tr>
<tr>
<td>Streamside fencing to limit livestock access to creek.</td>
<td>26.1% adopted</td>
</tr>
<tr>
<td>Streamside tree planting.</td>
<td>26.4% adopted</td>
</tr>
<tr>
<td>Rest-rotation grazing.</td>
<td>35.8% adopted</td>
</tr>
<tr>
<td>Off-stream livestock water supply (pumps, ponds, springs).</td>
<td>41.7% adopted</td>
</tr>
<tr>
<td>Fish screens on irrigation diversions.</td>
<td>12.7% adopted</td>
</tr>
<tr>
<td>I usually tell other landowners about conservation practices I have tried.</td>
<td>45.3% agree</td>
</tr>
<tr>
<td>Voluntary scientific experimentation with watershed is appropriate on selected private lands.</td>
<td>57.4% agree</td>
</tr>
<tr>
<td>Has another landowner tried a conservation practice after talking with you.</td>
<td>9.8% yes</td>
</tr>
<tr>
<td>In the last year how many times, if any, have you sought advice from any organization or agency?</td>
<td>60% none</td>
</tr>
<tr>
<td>Do you have any irrigated property?</td>
<td>35.1% yes</td>
</tr>
<tr>
<td>Cattle</td>
<td>Median = 5</td>
</tr>
<tr>
<td>Age</td>
<td>Median = 57 years</td>
</tr>
<tr>
<td>Share management decisions with a spouse</td>
<td>64.7%</td>
</tr>
<tr>
<td>Would you like a copy of the results of this survey?</td>
<td>74.4% yes</td>
</tr>
</tbody>
</table>
the three riparian ecological practices. Although only 35% of respondents hold irrigated land, irrigators are almost three times more likely to adopt riparian exclusionary fencing even after accounting for adopting other conservation practices. Of course, it is expected that irrigators have a higher probability of using fish screens since fish screens require the presence of irrigation (characteristic of innovation) and access to streams (environmental context). However, only 30% of irrigators implement fish screens on their agricultural diversions. Irrigation appears as a significant factor along with sharing decisions with a spouse, desire to receive survey results, and telling others about conservation decisions (Table 4). These co-factors all relate to ways landowners seek and use information (characteristics of innovator). Therefore information-seeking irrigators are the most likely to adopt conservation practices.

All three watersheds fit within Douglas county, the Roseburg conservation district, and Umpqua watershed council. All three watersheds fit within one half hour drive of the Roseburg county courthouse. These factors suggest that all landowners are at least spatially accessible to similar sources of information and programs. Since irrigators are small numerically, a targeted conservation effort would be easy considering that the water master and the Oregon Water Resources Department already have lists of people with irrigation rights. The lack of fish screen use is surprising because the Oregon Department of Fisheries and Wildlife has an active cost-share program that can pay up to 100% of the cost of implementation for fish screens if the irrigation diversions occur in basins like the Umpqua with threatened and endangered fish species. This reaffirms doubts that providing information, education, technical assistance, and financial support suffice to stimulate adoption (Napier and Bridges, 2002).

Spouse implications. Sharing management decisions with a spouse (characteristics of innovator) increases the probability of adopting both upland agricultural practices such as rotational grazing and riparian ecological practices such as riparian exclusionary fencing (Table 4). Adoption of both upland and riparian practices leads to outcomes that provide both private and social benefits (characteristics of innovation). Landowners benefit from better livestock management, while society benefits from improved riparian conditions that lead to better environmental conditions. Perhaps added discussion is needed because the adoption of these two practices requires more capital outlay to install and maintain fencing benefits (characteristics of innovation). The act of fencing may also

Table 4. Significant explanatory variables for each conservation practice.

<table>
<thead>
<tr>
<th>Practice and variables</th>
<th>Parameter estimate</th>
<th>Pr &gt; Chi-square</th>
<th>Odds ratio</th>
<th>Percent correct predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-stream water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.81</td>
<td>0.000</td>
<td>2.32</td>
<td>61.8</td>
</tr>
<tr>
<td>Support voluntary scientific watershed experiments on private lands</td>
<td>0.84</td>
<td>0.020</td>
<td>2.32</td>
<td></td>
</tr>
<tr>
<td>Satisfaction with watershed condition</td>
<td>0.58</td>
<td>0.043</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td>Usually tell other landowners about own conservation practices</td>
<td>0.83</td>
<td>0.002</td>
<td>2.29</td>
<td></td>
</tr>
<tr>
<td>Younger than 50 years old</td>
<td>0.72</td>
<td>0.019</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td>Rotational grazing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.66</td>
<td>0.000</td>
<td>2.56</td>
<td>42.6</td>
</tr>
<tr>
<td>Watershed Council knowledge</td>
<td>0.94</td>
<td>0.050</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>Seek advice from agencies</td>
<td>0.67</td>
<td>0.018</td>
<td>1.95</td>
<td></td>
</tr>
<tr>
<td>Own at least 200 cattle</td>
<td>2.38</td>
<td>0.033</td>
<td>10.80</td>
<td></td>
</tr>
<tr>
<td>Share decisions with spouse</td>
<td>0.67</td>
<td>0.015</td>
<td>1.95</td>
<td></td>
</tr>
<tr>
<td>Riparian fencing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.71</td>
<td>0.000</td>
<td>2.94</td>
<td>61.5</td>
</tr>
<tr>
<td>Use irrigation</td>
<td>1.08</td>
<td>0.000</td>
<td>2.27</td>
<td></td>
</tr>
<tr>
<td>Desire survey results</td>
<td>0.82</td>
<td>0.029</td>
<td>2.27</td>
<td></td>
</tr>
<tr>
<td>Share decisions with spouse</td>
<td>0.67</td>
<td>0.030</td>
<td>1.95</td>
<td></td>
</tr>
<tr>
<td>Riparian tree planting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-3.09</td>
<td>0.000</td>
<td>2.6</td>
<td>66.2</td>
</tr>
<tr>
<td>Believe streambank erosion is a problem</td>
<td>0.70</td>
<td>0.031</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Informed of watershed conservation</td>
<td>0.76</td>
<td>0.023</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>Convinced others to try conservation</td>
<td>1.43</td>
<td>0.002</td>
<td>4.18</td>
<td></td>
</tr>
<tr>
<td>Desire survey results</td>
<td>0.83</td>
<td>0.044</td>
<td>2.29</td>
<td></td>
</tr>
<tr>
<td>Support voluntary scientific watershed experiments on private lands</td>
<td>0.74</td>
<td>0.022</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td>Irrigation fish screens</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-5.30</td>
<td>0.000</td>
<td>2.8</td>
<td>82.8</td>
</tr>
<tr>
<td>Believe fish runs are a problem</td>
<td>1.03</td>
<td>0.04</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Long applications a conservation barrier</td>
<td>1.18</td>
<td>0.014</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Usually tell other landowners about own conservation practices.</td>
<td>1.16</td>
<td>0.012</td>
<td>3.19</td>
<td></td>
</tr>
<tr>
<td>Use irrigation</td>
<td>2.52</td>
<td>0.000</td>
<td>12.43</td>
<td></td>
</tr>
<tr>
<td>Support voluntary scientific watershed experiments on private lands</td>
<td>0.74</td>
<td>0.022</td>
<td>2.10</td>
<td></td>
</tr>
</tbody>
</table>
provide a high cultural hurdle to ranchers used to open range. Both of these contribute to raising the transactions cost of these practices. Therefore management agencies and conservation groups need to develop programs that fully involve entire households and not target just the male landowner. It is important that both household decision-makers attend information gatherings and understand the issues. Research indicates that sharing decisions with family members is a mixed predictor of adoption success (Carlson and Dillman, 1983; van Es and Tsoukalas, 1987). Of course, these predictors vary with the type of adoption considered as indicated in this research as well.

Further research is needed that accounts for the fact that gender and other family relations within a household can affect farm characteristics (Feldman and Welsh, 1995). Since previous research has focused on individual farmers and not households, the effect that household dynamics may contribute to adoption of conservation practices is unknown.

Information implications. By far, various dimensions of information networking benefits (characteristics of innovator) provide the most consistent explanatory theme across all conservation practices. Landowners who desire more information regarding the landowner survey are more likely to adopt riparian ecological practices such as riparian fencing and tree planting (Table 4). Information-seeking landowners are more likely to adopt conservation practices (Rogers, 1983; Nowak, 1987; Kraft et al., 1996), however, this may not be an issue of causation (Lockezerot, 1990). Perhaps it is because landowners have implemented non-agricultural conservation practices that they now seek more information regarding the conservation behavior and experiences of other landowners. Regardless, the finding suggests that agencies can possibly expend a greater effort in providing information regarding other landowners' conservation experiences.

The implications are that instead of having agency staff lead conservation efforts, an alternative approach based on actor-network theory would be to seek to have other landowners act as the main information dissemination agents (Coughenour, 2003). Landowners trust other landowners because they can identify with their struggles and motivations. Working with other landowners also reduces landowners' fear that having agency staff on site may result in sanctions or forced conservation adoption. Yet, landowners' strong world-views toward independence and private property rights reduces their information exchange with fellow landowners (Habron, 2002). Landowners need a non-threatening forum to learn from each other. The Umbqua Basin Watershed Council is an existing forum that allows exchange of information regarding watershed principles, programs, and activities (Habron, 2003). Such an approach may require less effort in ex ante agency staff time, but require more labor expenditure in seeking out participating landowners either through public meetings, user group meetings, brochures, advertising, direct mail delivery, or television and radio campaigns.

Independence, risk, and science. The last two major factors in conservation adoption belief in scientific experimentation in private watersheds and a tendency to tell other landowners about conservation decisions (characteristics of innovation). This appears on both upland agricultural off-stream watering and riparian ecological practices (tree planting, fish screens). Both factors entail risk-taking behavior considering the strong world views landowners have regarding independence, property rights, and the government (Habron, 2002). However, it appears that landowners who are able to mitigate such concerns are more likely to adopt certain conservation practices.

Risk is also involved regarding scientific experimentation in watersheds. Landowners are skeptical of government involvement in conservation issues (Habron, 2002). It is the perceived failures regarding watershed experimentation that has led to a loss of government credibility. However, the survey data indicate that there are still landowners who believe in the experimental approach, and perhaps government agencies need to take a more overt and transparent approach toward conservation that acknowledges the uncertainty involved in the process. An adoption of adaptive management by the agencies and watershed council (Habron, 2003) provides the opportunity to incorporate landowner interest in applying and evaluating the impact of a range of conservation practices. For example, the impacts of potentially profitable upland conservation practices such as rotational grazing can be compared with potentially unprofitable riparian practices such as exclusionary fencing with respect to recovery of riparian vegetation (Habron, 2003). Such a comparison can lead to optimization of conservation practices balancing environmental and landowner benefit.

Summary and Conclusions

The logistic regression models produce a different set of significant explanatory variables for each set of conservation practice adopters (Table 4). This supports the notion that "the diffusion and economic perspectives are complementary rather than competing" (Nowak, 1987) since some factors contributed to both potentially profitable upland and potentially unprofitable riparian conservation practices. However, the factors that appear throughout the most conservation models are irrigation, sharing management decisions with a spouse, seeking results from the landowner survey, telling other landowners about conservation decisions, and believing that scientific experimentation is appropriate in private watersheds. These results are somewhat expected since it was earlier suggested that, "if the individual's degree of integration into information and assistance networks is important, and if the dichotomy between profitable and unprofitable conservation technologies is a false one, then both economic and diffusion factors should be used to predict the adoption of agricultural technologies" (Nowak, 1987). However, unlike Nowak's (1987) findings, the role of diffusion factors does not decrease with conservation practice complexity.

In order to develop conservation programs, planners should not assume homogeneity of landowners (Nowak, 1987). Uniform solutions may not apply. This heterogeneity might explain why conservation programs fail to foster higher adoption rates in target watersheds than non-target watersheds despite the concentrated provision of "information, educational learning experiences, technical assistance, and economic subsidies" (Napier and Bridges, 2002). The research findings suggest a different application of adoption-diffusion in community-based adaptive watershed management. Previously identified explanatory factors such as young age, college education, positive environmental attitudes, recent immigration, large farm size, and frequent interactions with change agents did not apply in the three study watersheds. Perhaps this indicates the lack of predictability of these factors, the lack of rigorous and consistent research design in.
the existing study and previous studies (Lockeretz, 1990) or the uniqueness of the study area; but, perhaps it reflects the limitations of traditional adoption-diffusion models suggesting that other theories and concepts such as actor-network theory (Coughenour, 2003) that focus on the context and dynamics of information flow and influence are needed as an important complement to adoption-diffusion theory as a way to better understand farmer conservation behavior.

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