# Aquatic Ecosystem Services Survey:

## Round Two Results

**Prepared May 2022 by:**

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# 1. Introduction

Wetlands, streams, and floodplains (hereafter called aquatic systems) are an important resource for social and ecological wellbeing. Since the early 1990s, Federal policy has required a no overall net loss (NNL) of wetland area (i.e., aquatic systems), functions, and values in the United States (US). Past efforts to build assessment tools have focused primarily on wetland structure and function, and less on inherent services provided by aquatic ecosystems that are valued by people (hereafter referred to as ecosystem services (ES)). Moreover, there has been little effort to develop assessment tools that measure wetland services in a rapid and repeatable manner. Our intent with this research is to develop a framework and generalized methodology for the rapid assessment of ES provided by wetlands, streams, and their riparian buffers for use in permitting, compensatory mitigation, and preservation decisions. Moreover, we seek to understand aquatic systems decision-makers' perceptions of planning and land use surrounding wetland protection and mitigation.

This document reports the results (n=59) of Round 2 of a Delphi survey that includes the following topics:

- Ranked lists of cultural, provisioning, and regulating ES according to respondents selection of the most important ecosystem services to how land management decisions are made
- Respondents' perceptions of the importance of the public in protecting wetlands and streams
- Respondents' perceptions of the importance of different types of information for their work (scientist generated knowledge, personal observations, volunteer collected information, etc.)
- Respondents' perceptions of local and state government aquatic systems protection efforts and the effects of land use planning on aquatic systems

## 2. Data collection and analysis

We conducted a survey of wetland experts in the U.S. Mountain West using a Delphi method approach. The Delphi method is a technique used to arrive at a group consensus through expert judgement. The process entails systematically and iteratively asking an expert panel to rank statements/issues until a group consensus as achieved, producing quantitative metrics along with participants' rationale for their selection (Powell 2003, Taylor and Ryder 2003a, Cole et al. 2013). This document reports on Round 2 of this survey (see Gilbert et al. 2021 for Round 1 results). The primary purpose of the Round 2 survey was to determine a subset of services and benefits to include in a rapid wetland services assessment tool module. We asked respondents to choose what they considered to be the five most important aquatic ES to how land management decisions are made. Respondents selected their top 5 ES from a list of 34 aquatic ES that received the highest overall ratings in the Round 1 survey (ES with means of 3.8 and above where 1=strongly disagree and 5=strongly agree), along with two additional ES that were strongly suggested in the Round 1 results (general habitat protection and recreational fishing). The original list of ES we inquired about in the Round 1 survey was generated from relevant theory and case study papers found in the literature as well as guidance documents provided by USEPA (Landers and Nahlik 2013, US EPA 2020). In addition to questions related to ranking ES, we asked respondents to provide us more information about planning and management decision-making, as well as thoughts about requirements surrounding wetland mitigation.

Prior to administering the survey, we piloted the survey with five wetlands experts to ensure the survey's efficacy; feedback from the survey resulted in chases to the wording of several questions. We distributed the survey through online Qualtrics survey software to the same aquatic systems professionals that had participated in the Round 1 survey for whom we had names and email addresses (N= 83). These professionals are Federal, State, Local, and Tribal wetland decision-makers as well as employees of non-governmental organizations and University staff. We administered the survey in December 2021 and January 2022. We sent initial survey invitations through email and sent respondents up to three reminders. This document reports descriptive statistics from the first survey round of the Delphi method. We analyzed the quantitative data using IBM SPSS Statistics Version 26.

There are several questions in this report where respondents were given the opportunity to type in responses using their own words or sentences. For some of these questions, we list the respondents' answers in their entirety while others were coded into themes using NVivo 1.6.1 qualitative analysis software. The theme, definition of the theme, and number of times each theme was coded are shown where applicable. We indicate which write-in responses are shown in their entirety and which are coded into themes throughout the report.

The survey is covered under MSU's Institutional Review Board approval (SC100820-EX).

# 3. Results

Overall, we received 59 survey responses. We count all surveys where participants completed at least one survey question as a response. We sent the survey to 83 individual email addresses which gives us a response rate of 71% for the Round 2 survey.

**TABLE 1 ECOSYSTEM SERVICES RANK**

**Round 2 participants were shown the n and mean for each ES from the Round 1 survey as well as how they previously ranked each service. The survey question asked: "Using your professional opinion and best judgment, please select five aquatic ES you think are the most important to how land management decisions are made."**

**The following ES are ranked by number of respondents who selected each ecosystem service during the second round of the survey.**

NA indicates that the ecosystem service was not offered to the participants during the corresponding survey round, n=59

| Rank | Ecosystem service | Round 2 n | Round 1 Mean | Round 1 Rank | Round 1 n |
|---|---|---|---|---|---|
| 1 | Baseflow support | 38 | 4.54 | 2 | 113 |
| 2 | Flood control | 33 | 4.51 | 4 | 113 |
| 3 | Drinking water | 28 | 4.61 | 1 | 112 |
| 4 | General habitat protection | 23 | NA | NA | NA |
| 5 | Nutrient/toxin recycling and retention | 22 | 4.22 | 9 | 113 |
| 6 | Groundwater exchange | 20 | 4.35 | 7 | 113 |
| 7 | Landscape integrity | 18 | 4.22 | 11 | 113 |
| 8 | Sediment capture | 14 | 4.38 | 6 | 114 |
| 9 | Reduction of erosion | 13 | 4.52 | 3 | 113 |
| 10 | Removal of contaminants | 11 | 4.38 | 5 | 114 |
| 11 | Irrigation | 10 | 4.13 | 16 | 112 |
| 12 | Intrinsic value | 7 | 4.14 | 15 | R115 |
| 13 | Carbon sequestration | 6 | 3.94 | 29 | 113 |
| 14 | Recreational fishing | 6 | NA | NA | NA |
| 15 | Stock grazing | 5 | 3.82 | 33 | 111 |
| 16 | Crop production | 4 | 3.98 | 27 | 112 |
| 17 | Disaster control | 4 | 4.21 | 12 | 113 |
| 18 | Soil moisture | 4 | 4.19 | 13 | 113 |
| 19 | Support of beneficial invertebrates (e.g., pollinators) | 4 | 4.22 | 10 | 112 |
| 20 | Connectedness to nature | 3 | 4.18 | 14 | 115 |
| 21 | Hunting | 3 | 4.05 | 23 | 112 |
| 22 | Recreational boating/floating | 3 | 4.08 | 22 | 115 |
| 23 | Restorative experience | 3 | 3.90 | 30 | 115 |
| 24 | Support of beneficial amphibians and reptiles to help manage pests | 3 | 3.89 | 31 | 112 |
| 25 | Education | 2 | 4.23 | 8 | 115 |
| 26 | Historical/archaeological/heritage | 2 | 4.09 | 21 | 115 |
| 27 | Microclimate | 2 | 3.87 | 32 | 113 |
| 28 | Naturalist activities | 1 | 4.01 | 24 | 114 |
| 29 | Nutrient production | 1 | 3.99 | 25 | 113 |
| 30 | Research | 1 | 4.11 | 17 | 115 |
| 31 | Support of beneficial bird populations to help manage pests | 1 | 3.99 | 26 | 112 |
| 32 | Recreational bird watching | 0 | 4.10 | 18 | 115 |
| 33 | Viewscapes | 0 | 4.09 | 19 | 115 |
| 34 | Recreational wildlife watching | 0 | 4.09 | 20 | 115 |
| 35 | Support of beneficial mammals to help manage pests | 0 | 3.95 | 28 | 112 |
| 36 | Energy generation | NA | 3.73 | 34 | 111 |
| 37 | Subsistence fishing | NA | 3.71 | 35 | 112 |
| 38 | Spiritual/ceremonial | NA | 3.67 | 36 | 115 |

| Rank | Ecosystem service | Round 2 n | Round 1 Mean | Round 1 Rank | Round 1 n |
|---|---|---|---|---|---|
| 39 | Commercial fishing | NA | 3.64 | 37 | 112 |
| **Rank** | **Ecosystem service** | **Round 2 n** | **Round 1 Mean** | **Round 1 Rank** | **Round 1 n** |
| 40 | Commercial food production | NA | 3.63 | 38 | 112 |
| 41 | Recreational swimming | NA | 3.61 | 39 | 114 |
| 42 | Gathering | NA | 3.60 | 40 | 111 |
| 43 | Other sensory experiences (not related to art/media inspiration) | NA | 3.46 | 41 | 114 |
| 44 | Timber production | NA | 3.45 | 42 | 112 |
| 45 | Sensory experiences that inspire art and media | NA | 3.45 | 43 | 115 |
| 46 | Aquaculture | NA | 3.39 | 44 | 112 |
| 47 | Industrial water use (cooling water) | NA | 3.34 | 45 | 110 |
| 48 | Transportation of goods and/or people | NA | 3.31 | 46 | 114 |
| 49 | Fiber production | NA | 3.29 | 47 | 111 |
| 50 | Food processing | NA | 3.26 | 48 | 109 |
| 51 | Pharmaceuticals | NA | 2.99 | 48 | 110 |
| 52 | Fur/feather/ornamental production | NA | 2.79 | 50 | 112 |
| 53 | Military use | NA | 2.42 | 51 | 114 |

**TABLE 2 ECOSYSTEM SERICES BY CATEOGRY**

**The following table shows the category of each ecosystem service: regulating, provisioning, or cultural for each ecosystem service selected in the Round Two survey – See Table 1**

**The following ES are listed in order of the number of respondents who selected each ecosystem service in the Round 2 survey**

n=59

| Rank | Ecosystem service | Category |
|---|---|---|
| 1 | Baseflow support | Regulating |
| 2 | Flood control | Regulating |
| 3 | Drinking water | Provisioning |
| 4 | General habitat protection | Regulating |
| 5 | Nutrient/toxin recycling and retention | Regulating |
| 6 | Groundwater exchange | Regulating |
| 7 | Landscape integrity | Regulating |
| 8 | Sediment capture | Regulating |
| 9 | Reduction of erosion | Regulating |
| 10 | Removal of contaminants | Regulating |
| 11 | Irrigation | Provisioning |
| 12 | Intrinsic value | Cultural |
| 13 | Carbon sequestration | Regulating |
| 14 | Recreational fishing | Cultural |
| 15 | Stock grazing | Provisioning |
| 16 | Crop production | Provisioning |
| 17 | Disaster control | Regulating |
| 18 | Soil moisture | Regulating |
| 19 | Support of beneficial invertebrates (e.g., pollinators) | Provisioning |
| 20 | Connectedness to nature | Cultural |
| 21 | Hunting | Cultural |
| 22 | Recreational boating/floating | Cultural |
| 23 | Restorative experience | Cultural |
| 24 | Support of beneficial amphibians and reptiles to help manage pests | Provisioning |
| 25 | Education | Cultural |
| 26 | Historical/archaeological/heritage | Cultural |
| 27 | Microclimate | Regulating |
| 28 | Naturalist activities | Cultural |
| 29 | Nutrient production | Regulating |
| 30 | Research | Cultural |
| 31 | Support of beneficial bird populations to help manage pests | Provisioning |

**TABLE 3 ECOSYSTEM SERVICES BY ORGANIZATION AND AGENCY TYPE**

**This table shows how participants ranked the ecosystem services from the Round 2 survey categorized by the type of organization or agency for which they work**

| Rank | Ecosystem service | Consulting n=9 | Engineering n=2 | Federal government n=7 | State government n=17 | Local government n=4 | Tribal organization or agency n=2 | NGO n=7 | University n=2 | Other* n=9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Baseflow support | 6 | 1 | 4 | 11 | 3 | 1 | 6 | 1 | 6 |
| 2 | Flood control | 5 | 0 | 4 | 9 | 3 | 1 | 3 | 2 | 5 |
| 3 | Drinking water | 2 | 1 | 4 | 8 | 3 | 0 | 4 | 1 | 5 |
| 4 | General habitat protection | 3 | 1 | 2 | 6 | 0 | 1 | 3 | 1 | 6 |
| 5 | Nutrient/toxin recycling and retention | 5 | 1 | 3 | 9 | 1 | 0 | 1 | 1 | 1 |
| 6 | Groundwater exchange | 1 | 2 | 3 | 5 | 0 | 0 | 3 | 0 | 6 |
| 7 | Landscape integrity | 3 | 0 | 2 | 4 | 1 | 2 | 4 | 0 | 2 |
| 8 | Sediment capture | 1 | 1 | 1 | 8 | 1 | 0 | 1 | 0 | 1 |
| 9 | Reduction of erosion | 2 | 0 | 1 | 5 | 0 | 0 | 2 | 1 | 2 |
| 10 | Removal of contaminants | 1 | 0 | 1 | 3 | 2 | 0 | 1 | 1 | 2 |
| 11 | Irrigation | 2 | 1 | 2 | 2 | 1 | 0 | 1 | 1 | 0 |
| 12 | Intrinsic value | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 1 |
| 13 | Carbon sequestration | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| 14 | Recreational fishing | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 |
| 15 | Stock grazing | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 16 | Crop production | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 17 | Disaster control | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 |
| 18 | Soil moisture | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 19 | Support of beneficial invertebrates (e.g., pollinators) | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 20 | Connectedness to nature | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 21 | Hunting | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 22 | Recreational boating/floating | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| 23 | Restorative experience | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 24 | Support of beneficial amphibians and reptiles to help manage pests | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 25 | Education | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 26 | Historical/archaeological/heritage | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 27 | Microclimate | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | Naturalist activities | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 29 | Nutrient production | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | Research | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 31 | Support of beneficial bird populations to help manage pests | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | 45 | 10 | 35 | 85 | 20 | 10 | 35 | 10 | 45 |

*The "other" category contains participants who did not indicate where they work as wells those who work multiple jobs or are retired.

**TABLE 4 ECOSYSTEM SERVICES BY STATE AFFILIATION**

| This table shows how participants ranked the ecosystem services from the Round 2 survey categorized by state that for which they work | | | | | | |
|---|---|---|---|---|---|---|
| **Rank** | **Ecosystem service** | **Colorado** n=9 | **Montana** n=27 | **Washington** n=10 | **Wyoming** n=4 | **Other*** n=9 |
| 1 | Baseflow support | 5 | 19 | 6 | 3 | 6 |
| 2 | Flood control | 6 | 13 | 6 | 1 | 6 |
| 3 | Drinking water | 5 | 16 | 3 | 3 | 1 |
| 4 | General habitat protection | 4 | 11 | 3 | 0 | 5 |
| 5 | Nutrient/toxin recycling and retention | 2 | 8 | 7 | 3 | 2 |
| 6 | Groundwater exchange | 2 | 12 | 3 | 0 | 3 |
| 7 | Landscape integrity | 2 | 6 | 4 | 2 | 4 |
| 8 | Sediment capture | 4 | 2 | 5 | 2 | 1 |
| 9 | Reduction of erosion | 2 | 7 | 1 | 0 | 3 |
| 10 | Removal of contaminants | 2 | 5 | 2 | 0 | 2 |
| 11 | Irrigation | 0 | 7 | 1 | 2 | 0 |
| 12 | Intrinsic value | 3 | 2 | 2 | 0 | 0 |
| 13 | Carbon sequestration | 1 | 2 | 1 | 1 | 1 |
| 14 | Recreational fishing | 1 | 2 | 0 | 2 | 1 |
| 15 | Stock grazing | 0 | 3 | 2 | 0 | 0 |
| 16 | Crop production | 2 | 1 | 1 | 0 | 0 |
| 17 | Disaster control | 2 | 2 | 0 | 0 | 0 |
| 18 | Soil moisture | 0 | 4 | 0 | 0 | 0 |
| 19 | Support of beneficial invertebrates (e.g., pollinators) | 0 | 1 | 1 | 1 | 1 |
| 20 | Connectedness to nature | 0 | 1 | 0 | 0 | 2 |
| 21 | Hunting | 0 | 2 | 0 | 0 | 1 |
| 22 | Recreational boating/floating | 0 | 2 | 0 | 0 | 1 |
| 23 | Restorative experience | 1 | 2 | 0 | 0 | 0 |
| 24 | Support of beneficial amphibians and reptiles to help manage pests | 0 | 1 | 1 | 0 | 1 |
| 25 | Education | 1 | 1 | 0 | 0 | 0 |
| 26 | Historical/archaeological/heritage | 0 | | 0 | 0 | 2 |
| 27 | Microclimate | 0 | 1 | 1 | 0 | 0 |
| 28 | Naturalist activities | 0 | 1 | 0 | 0 | 0 |
| 29 | Nutrient production | 0 | 0 | 0 | 0 | 1 |
| 30 | Research | 0 | 0 | 0 | 0 | 1 |
| 31 | Support of beneficial bird populations to help manage pests | 0 | 1 | 0 | 0 | 0 |
| **Total** | | 45 | 135 | 50 | 20 | 45 |

*The "other" category contains participants who work in states with a low number of respondents.

**TABLE 5 TOP 5 ECOSYSTEM SERVICES**

**Top 5 Ecosystem Services**

After selecting their choices for the five most important ecosystem services, participants were asked to describe why they think each ecosystem service they chose is important. Themes from these responses and an example quote from the top 5 ecosystem services are shown below. To see the full responses each participant wrote for each ecosystem service, see Appendix A.

| Service | Round 2 n | Round 1 Mean | Themes | Example quote |
|---|---|---|---|---|
| Baseflow support | 38 | 4.54 | Critical for overall ecosystem health, important in arid regions and low flow periods, important to maintain flow for both humans and wildlife | "Aquatic ecosystems rely on sufficient flow during times of shortage. Without groundwater fed baseflow during late summer and winter, aquatic ecosystems begin to fail." |
| Flood control | 33 | 4.51 | Cheaper and more appropriate than engineered flood control, promotes human safety and well-being, promotes ecosystem integrity, protects wildlife | "Aquatic systems provide natural flood control and are important factor when considering these systems and how much they provide for human protection rather than creating levees or other manmade flood protection." |
| Drinking water | 28 | 4.61 | Necessary for life, promotes water quality, even more necessary in the face of climate change | "Clean drinking water is the baseline for human survival and is, without question, the most important function of a watershed." |
| General habitat protection | 23 | NA | Wildlife protection, biodiversity protection, endangered species protection, entire ecosystem preservation | "Habitat benefits are broad, encompassing human, plant, bird and animals which are each a reflection of ecosystem health. The creatures each drive human economic and ecological benefits from food production to recreational hunting, floating, fishing." |
| Nutrient/toxin recycling and retention | 22 | 4.22 | Natural water purification, reduced reliance on water treatment plants, diminishes excess nutrient concerns, preserves ecosystems | "Excessive nutrient loading throws ecosystems out of balance and can be very hard to fix, especially for lakes. Toxins can be hugely detrimental to aquatic life diversity and abundance. Toxins in fish consumed by humans also threaten human health." |

**TABLE 6 ROLE OF THE PUBLIC IN PROTECTION**

**"What role, if any, do you think the general public plays in helping to protect wetlands and streams in the geographic area where you work? (Please enter your response below)"**

For this open-ended question, responses were coded into themes. Some respondents' open-ended responses included more than one theme, n= 57

| Code | Definition | n | Example quote |
|---|---|---|---|
| General public support | Public support influences policy decisions or funding allocation for aquatic resource protection and restoration. | 18 | "Public buy-in is essential to successful protection of streams and wetlands, especially with prevention or mitigation of nonpoint source pollution that is not regulated under the Clean Water Act." |
| Individual actions | The actions of individuals (landowners, water users, etc.) has implications for resource stewardship or degradation. | 16 | "The general public can help protect wetlands and streams through voluntary efforts, which are often stimulated and supported by education and outreach. They also protect wetlands as member of the regulated public by adhering to requirements to protect wetlands on their properties." |
| Policy process engagement | The public informs the government agenda and what gets addressed by policy by offering input, electing public officials, exerting political pressure, and more. | 12 | "The public is capable of advocating aquatic habitats through engaging with local development processes, commenting on proposals that impact such habitats (development, regulatory rule making, etc.) and by voting in support of candidates or measures that align with their personal values." |
| Ecological understanding | The general public's ecological understanding and awareness of the importance of aquatic resources does or can aid stewardship and protection. | 10 | "People in general need to be aware of the benefits of wetlands and streams so that they can ensure that we have sufficient water for human consumption and to support the wildlife species that we depend upon." |
| Limited role | Public input, actions, or decisions are ultimately limited in the effect they have on aquatic resource protection. | 9 | "In my experience, the public plays a limited role in helping to protect wetlands and streams in my area. It occurs primarily through interest groups and organizations that advocate for conservation, object to impactful projects, or provide funding for specific restoration/enhancement efforts. The public tends to prioritize use over protection." |
| Lack of ecological understanding | The public is largely unaware or unconcerned with their impacts or general impacts to aquatic resources. | 7 | "The general public has some role in that some people work on or encourage reduced pollutants. In general however, the wide variety of services provided by wetland and streams are often not understood in the geographic area I work." |
| Issue identification | Public plays a role in identifying issues and bringing them to the attention of managers or policy makers in order to produce changes in management or stewardship. | 6 | "They are the collective voice of the watershed. Holistically, what happens upstream impacts what happens downstream. The general public can act as an alarm system when something doesn't seem right. The people of the watershed can identify local problems faster than monitoring can, by being the eyes and ears of the land." |
| Formal comment | Public comment or comment at public hearing influences aquatic resource decisions. | 3 | "The public is capable of advocating aquatic habitats through engaging with local development processes, commenting on proposals that impact such habitats (development, regulatory rule making, etc.) and by voting in support of candidates or measures that align with their personal values." |
| Interest group agenda setting | Groups with an interest in resource management and stewardship (NGOs, agencies, etc.) and particularly vocal individuals set the government agenda for how aquatic resources are managed or stewarded. | 3 | "It occurs primarily through interest groups and organizations that advocate for conservation, object to impactful projects, or provide funding for specific restoration/enhancement efforts." |
| Systematic or systemic influence | Greater influences beyond public input and involvement influence the management and decisions made around aquatic resources. | 3 | "There is a risk in holding public too responsible - I know that there has been push back on littering campaigns that say that litter we see is an individual's direct responsibility as opposed to a broader system that supports production of excess future litter." |
| Ecological knowledge dispersal | Public plays a role in dispersing ecological knowledge and awareness throughout their communities and/or social networks. | 1 | "Raising awareness with family and friends about the importance of these features." |
| NGO Funding and education | Non-governmental organizations play a role in sourcing funding for projects and educating the general public. | 1 | "Organizations such as Trout Unlimited secure grant money to sponsor stream/river habitat improvement projects. They also provide educational programs to the broader general public on stream/river ecology and what they can do to protect streams." |
| Resource destruction | General public mostly destroys resources rather than playing a protective role. | 1 | "They work to destroy resources more than protect them." |

**TABLE 7 FREQUENT STRATEGIES**

| "Please consider how frequently the strategies listed in the table below are used in your current aquatic systems work" | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **Never (1)** | **Seldom (2)** | **Occasionally (3)** | **To a considerable degree (4)** | **Almost always (5)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | | |
| Collaborating with permitting agencies on projects or initiatives | 46 | 2.2% | 2.2% | 13% | 39.1% | 43.5% | 4.20 | 0.91 |
| Collaborating with non-governmental organizations on projects or initiatives | 46 | 0 | 13% | 13% | 37% | 37% | 3.98 | 1.02 |
| Collaborating with agencies on projects or initiatives (not including permitting agencies) | 46 | 0 | 13% | 19.6% | 32.6% | 34.8% | 3.89 | 1.03 |
| Using an adaptive approach to aquatic systems management | 46 | 4.3% | 6.5% | 37% | 34.8% | 17.4% | 3.54 | 1.00 |
| Diverse stakeholder inclusion in aquatic systems planning processes (e.g., Indigenous communities, ranchers, farmers, landowners, etc.) | 46 | 0 | 23.9% | 23.9% | 32.6% | 19.6% | 3.48 | 1.07 |
| Ongoing assessment of outcomes from aquatic systems management decisions | 46 | 4.3% | 8.7% | 47.8% | 26.1% | 13% | 3.35 | 0.97 |

**TABLE 8 IMPORTANCE OF STRATEGIES**

| "Now, please consider how important the same items are for successful aquatic systems management in the geographic area where you work" | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **n** | **Not important (1)** | **Somewhat important (2)** | **Moderately important (3)** | **Very important (4)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | |
| Using an adaptive approach to aquatic systems management | 45 | 0 | 4.4% | 15.6% | 80% | 3.76 | 0.52 |
| Collaborating with permitting agencies on projects or initiatives | 44 | 0 | 2.3% | 20.5% | 77.3% | 3.75 | 0.48 |
| Ongoing assessment of outcomes from aquatic systems management decisions | 45 | 2.2% | 6.7% | 17.8% | 73.3% | 3.62 | 0.71 |
| Diverse stakeholder inclusion in aquatic systems planning processes (e.g., Indigenous communities, ranchers, farmers, landowners, etc.) | 45 | 0 | 4.4% | 31.1% | 64.4% | 3.60 | 0.58 |
| Collaborating with agencies on projects or initiatives (not including permitting agencies) | 44 | 0 | 11.4% | 38.6% | 50% | 3.39 | 0.68 |
| Collaborating with non-governmental organizations on projects or initiatives | 45 | 0 | 15.6% | 33.3% | 51.1% | 3.36 | 0.74 |

**TABLE 9 ENVIRONMENTAL DECISION-MAKER**

| **"Do you consider yourself an environmental decision-maker or manager?"** | | |
|---|---|---|
| | Frequency | Percent |
| Yes | 36 | 61% |
| No | 18 | 31.6% |
| Unsure/Don't know | 3 | 5.3% |

**TABLE 10 TYPES OF INFORMATION AND DECISION-MAKING**

| **Please rate the following sources of information for their importance to how you make aquatic systems-related decisions for the geographic area where you work:*** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **n** | **Not applicable (1)** | **Not important (2)** | **Moderately important (3)** | **Very important (4)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | |
| Scientist collected quantitative data (e.g., monitoring data) | 36 | 0 | 0 | 22.2% | 77.8% | 3.78 | 0.42 |
| Personal observations and experiences | 36 | 0 | 5.6% | 27.8% | 66.7% | 3.61 | 0.59 |
| State government agency reports | 36 | 0 | 8.3% | 47.2% | 44.4% | 3.36 | 0.63 |
| Peer-reviewed journal article research | 36 | 0 | 11.1% | 50% | 38.9% | 3.28 | 0.65 |
| Federal government agency reports | 36 | 0 | 16.7% | 50% | 33.3% | 3.17 | 0.69 |
| Non-expert observations or experiences (e.g., community members, partners, or other stakeholders) | 34 | 0 | 26.5% | 52.9% | 20.6% | 2.94 | 0.69 |
| Volunteer collected quantitative data (e.g., monitoring data) | 35 | 0 | 31.4% | 48.6% | 20% | 2.89 | 0.71 |

* Participants were asked this question only if they answered "yes" to the question shown in Table 9. Participants were offered an option to write in another source of information and rank its importance, see the results in Table 11.

**TABLE 11 TYPES OF INFORMATION - WRITE-IN**

| **"Please rate the following sources of information for their importance to how you make aquatic systems-related decisions for the geographic area where you work:"** | | |
|---|---|---|
| This table contains participant write-in answers to the same question shown in Table 10 | | |
| **Write-in answer** | **Frequency** | **Importance** |
| Anecdotal information | 1 | Very important |
| Balancing the need for additional information with the potential benefits, experience of the practitioner, and project costs. | 1 | No rating |
| Consultant reports | 1 | Very important |
| Law, regulation, policy, guidance | 1 | No rating |
| Networking with others in the profession | 1 | Very important |
| Organization-generated observations and data | 1 | No rating |
| Public comment | 1 | Moderately important |

**TABLE 12 UNHOUSED IN AQUATIC SENSITIVE AREAS**

| **"In the geographic area where you work, are there unhoused (i.e., homeless) people living in or immediately adjacent to aquatic sensitive areas (i.e., wetlands, streams, or shorelines)?"*** | | |
|---|---|---|
| | Frequency | Percent |
| Yes | 33 | 57.9% |
| No | 12 | 21.1% |
| Unsure/Don't know | 12 | 21.1% |

*If participants answered "yes" to this question, they were shown the follow-up question shown in Table 13.

**TABLE 13 UNHOUSED AND AQUATIC IMPACTS**

| **"In the geographic area where you work, how much of an impact do unhoused (i.e., homeless) people living in or immediately adjacent to aquatic sensitive areas have on the ecological functions and services of the sensitive areas?"** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| n | **Unsure/ Don't know (0)** | **Negative impact (1)** | **Somewhat negative impact (2)** | **No impact (3)** | **Somewhat positive impact (4)** | **Positive impact (5)** | **Mean** | **Standard deviation** |
| | Frequency % | | | | | | | |
| 33* | 0 | 51.5% | 36.4% | 9.1% | 3.0% | 0 | 1.64 | 0.78 |

*Participants were asked this question only if they answered "yes" to the question shown in Table 12.

**TABLE 14 LARGE PERMITTEE PROJECTS AND WETLANDS**

| **"Please indicate your level of agreement with the following statement:**<br>**In general, current compensatory mitigation projects through large permittee driven projects (like those by state transportation agencies) are effective for:"** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **Strongly Disagree (1)** | **Disagree (2)** | **Neither agree nor disagree (3)** | **Agree (4)** | **Strongly Agree (5)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | | |
| The replacement of wetland area | 56 | 1.8% | 12.5% | 12.5% | 55.4% | 17.9% | 3.75 | 0.95 |
| The replacement of wetland functions | 56 | 7.1% | 33.9% | 17.9% | 35.7% | 5.4% | 2.98 | 1.10 |
| The replacement of wetland services | 56 | 8.9% | 30.4% | 21.4% | 37.5% | 1.8% | 2.93 | 1.05 |

**TABLE 15 PURCHASING CREDITS AND WETLANDS**

| **"Please indicate your level of agreement with the following statement: In general, current compensatory mitigation projects through purchasing credits in wetland banks are effective for:"** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **Strongly Disagree (1)** | **Disagree (2)** | **Neither agree nor disagree (3)** | **Agree (4)** | **Strongly Agree (5)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | | |
| The replacement of wetland area | 45 | 6.7% | 4.4% | 24.4% | 44.4% | 20% | 3.67 | 1.06 |
| The replacement of wetland functions | 45 | 11.1% | 22.2% | 28.9% | 26.7% | 11.1% | 3.04 | 1.18 |
| The replacement of wetland services | 45 | 8.9% | 24.4% | 37.8% | 22.2% | 6.7% | 2.93 | 1.05 |

**TABLE 16 IN-LIEU FEE AND WETLANDS**

| **"Please indicate your level of agreement with the following statement: In general, current compensatory mitigation projects through funding and implementing in-lieu fee wetland mitigation projects are effective for:"** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **Strongly Disagree (1)** | **Disagree (2)** | **Neither agree nor disagree (3)** | **Agree (4)** | **Strongly Agree (5)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | | |
| The replacement of wetland area | 46 | 6.5% | 10.9% | 30.4% | 39.1% | 13% | 3.41 | 1.06 |
| The replacement of wetland functions | 46 | 8.7% | 15.2% | 39.1% | 28.3% | 8.7% | 3.13 | 1.06 |
| The replacement of wetland services | 46 | 6.5% | 21.7% | 41.3% | 26.1% | 4.3% | 3 | 0.96 |

**TABLE 17 ECOSYSTEM SERVICES AND ASSESSMENT TOOLS**

| "Using your professional opinion and best judgment, please indicate your level of agreement about whether assessment tools should have increased capability to consider the following ecosystem service categories:" | n | Strongly Disagree (1) | Disagree (2) | Neither agree nor disagree (3) | Agree (4) | Strongly Agree (5) | Mean | Standard deviation |
|---|---|---|---|---|---|---|---|---|
| | | Frequency % | | | | | | |
| Regulating ecosystem services (e.g., regulation of climate, water quality, and stormwater control) | 57 | 0 | 3.5% | 8.8% | 50.9% | 36.8% | 4.21 | 0.75 |
| Cultural ecosystem services (e.g., spiritual enrichment, cognitive development, reflection, recreation, aesthetic experience, etc.) | 57 | 5.3% | 14% | 36.8% | 33.3% | 10.5% | 3.30 | 1.01 |
| Provisioning ecosystem services (e.g., genetic resources, food and fiber, and irrigation water) | 57 | 3.5% | 14% | 38.6% | 36.8% | 7% | 3.30 | 0.92 |

**TABLE 18 LOCAL GOVERNMENT REGULATIONS AND INCENTIVES**

| "Please indicate your level of agreement with the following statements regarding local government (e.g., city, county) regulation and incentives in the geographic area where you work." | n | Strongly Disagree (1) | Disagree (2) | Neither agree nor disagree (3) | Agree (4) | Strongly Agree (5) | Mean | Standard deviation |
|---|---|---|---|---|---|---|---|---|
| | | Frequency % | | | | | | |
| Local government (e.g., city, county) has adequate regulations to effectively protect wetlands and streams | 56 | 17.9% | 35.7% | 12.5% | 26.8% | 7.1% | 2.70 | 1.24 |
| Local government (e.g., city, county) provides enough economic incentives to landowners, to effectively protect wetlands and streams | 46 | 30.4% | 50% | 6.5% | 13% | 0 | 2.02 | 0.95 |

**TABLE 19 LOCAL GOVERNMENT REGULATIONS BY STATE AFFILIATION**

**"Please indicate your level of agreement with the following statements regarding local government (e.g., city, county) regulation and incentives in the geographic area where you work."**

The following table shows the data from the same question shown in Table 18 categorized by the state that the participant works in. The mean is on a scale of 1=Strongly disagree to 5=Strongly agree.

| | Colorado | | Montana | | Washington | | Wyoming | | Other* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) |
| Local government (e.g., city, county) has adequate regulations to effectively protect wetlands and streams | 9 | 2.0 (1.0) | 25 | 2.56 (1.12) | 10 | 3.40 (1.50) | 4 | 2.0 (.00) | 8 | 3.38 (1.30) |
| Local government (e.g., city, county) provides enough economic incentives to landowners, to effectively protect wetlands and streams | 8 | 1.75 (0.70) | 20 | 1.85 (0.81) | 9 | 2.11 (1.16) | 4 | 2.0 (.00) | 5 | 3.0 (1.41) |

*The "other" category contains participants who work in states with a low number of respondents.

**TABLE 20 STATE GOVERNMENT REGULATIONS AND INCENTIVES**

| **"Please indicate your level of agreement with the following statements regarding state government regulation and partnerships in the geographic area where you work."** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **Strongly Disagree (1)** | **Disagree (2)** | **Neither agree nor disagree (3)** | **Agree (4)** | **Strongly Agree (5)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | | |
| State government should leverage existing water quality, groundwater, or surface water regulations (e.g., beneficial use of waters of the state, public trust doctrine) to more effectively protect wetlands and streams | 46 | 2.2% | 2.2% | 15.2% | 43.5% | 37% | 4.11 | 0.90 |
| State government should leverage existing partnerships with Federal agencies (e.g., Clean Water Act 401 certification, Migratory Bird Treaty act) to more effectively protect wetlands and streams | 46 | 0 | 2.2% | 6.5% | 56.5% | 34.8% | 4.24 | 0.67 |
| State government should develop new partnerships with Federal agencies (e.g., Clean Water Act 401 certification, Migratory Bird Treaty act) to more effectively protect wetlands and streams | 46 | 2.2% | 4.3% | 21.7% | 43.5% | 28.3% | 3.91 | 0.93 |
| State government has adequate regulations to effectively protect wetlands and streams | 46 | 17.4% | 39.1% | 10.9% | 30.4% | 2.2% | 2.61 | 1.16 |
| State government provides enough economic incentives to landowners, to effectively protect wetlands and streams | 46 | 28.3% | 45.7% | 17.4% | 8.7% | 0 | 2.07 | 0.90 |

**TABLE 21 STATE GOVERNMENT REGULATIONS AND INCENTIVES BY STATE AFFILIATION**

**"Please indicate your level of agreement with the following statements regarding state government regulation and partnerships in the geographic area where you work."**

The following table shows the data from the same question shown in Table 20 categorized by the state that the participant works in. The mean is on a scale of 1=Strongly disagree to 5=Strongly agree.

| | Colorado | | Montana | | Washington | | Wyoming | | Other* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) |
| State government should leverage existing water quality, groundwater, or surface water regulations (e.g., beneficial use of waters of the state, public trust doctrine) to more effectively protect wetlands and streams | 8 | 4.25 (0.70) | 20 | 4.10 (0.96) | 9 | 3.67 (1.0) | 4 | 4.75 (0.50) | 5 | 4.20 (0.83) |
| State government should leverage existing partnerships with Federal agencies (e.g., Clean Water Act 401 certification, Migratory Bird Treaty act) to more effectively protect wetlands and streams | 8 | 4.25 (0.46) | 20 | 4.35 (0.48) | 9 | 3.89 (1.05) | 4 | 4.50 (0.57) | 5 | 4.20 (0.83) |
| State government should develop new partnerships with Federal agencies (e.g., Clean Water Act 401 certification, Migratory Bird Treaty act) to more effectively protect wetlands and streams | 8 | 4.38 (0.51) | 20 | 3.75 (1.02) | 9 | 3.78 (1.09) | 4 | 3.75 (0.95) | 5 | 4.20 (0.83) |
| State government has adequate regulations to effectively protect wetlands and streams | 8 | 2.0 (0.75) | 20 | 2.40 (0.99) | 9 | 3.56 (1.23) | 4 | 2.50 (1.0) | 5 | 2.80 (1.64) |
| State government provides enough economic incentives to landowners, to effectively protect wetlands and streams | 8 | 1.75 (0.70) | 20 | 1.85 (0.81) | 9 | 2.22 (0.97) | 4 | 3.0 (0.81) | 5 | 2.40 (1.14) |

*The "other" category contains participants who work in states with a low number of respondents.

**TABLE 22 LAND USE AND WATER PLANNING**

| **"Please indicate your level of agreement with the following statements regarding land use and water planning in the geographic area where you work."** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **Strongly Disagree (1)** | **Disagree (2)** | **Neither agree nor disagree (3)** | **Agree (4)** | **Strongly Agree (5)** | **Mean** | **Standard deviation** |
| | | Frequency % | | | | | | |
| There is a need for better coordination between planning for land use and planning for water resources | 46 | 2.2% | 0 | 6.5% | 39.1% | 52.2% | 4.39 | 0.80 |
| Local land use planners often make decisions that negatively impact water resources | 46 | 2.2% | 8.7% | 15.2% | 32.6% | 41.3% | 4.02 | 1.06 |

**TABLE 23 LAND USE BY STATE AFFILIATION**

**"Please indicate your level of agreement with the following statements regarding land use and water planning in the geographic area where you work."**

The following table shows the data from the same question shown in Table 22 categorized by the state that the participant works in. The mean is on a scale of 1=Strongly disagree to 5=Strongly agree.

| | **Colorado** | | **Montana** | | **Washington** | | **Wyoming** | | **Other*** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) | n | Mean (sd) |
| There is a need for better coordination between planning for land use and planning for water resources | 8 | 4.50 (0.75) | 20 | 4.25 (0.91) | 9 | 4.33 (0.86) | 4 | 4.75 (0.50) | 5 | 4.60 (0.54) |
| Local land use planners often make decisions that negatively impact water resources | 8 | 4.25 (1.03) | 20 | 3.95 (1.23) | 9 | 3.78 (0.97) | 4 | 4.0 (0.81) | 5 | 4.40 (0.89) |

*The "other" category contains participants who work in states with a low number of respondents.

**TABLE 24 EMPLOYMENT CATEGORIES**

| "For which organization do you currently work?" Responses were categorized into employer types by the research team. | |
|---|---|
| **Employer Type** | **Frequency** |
| State | 18 |
| Consulting | 10 |
| Federal Government | 8 |
| NGO | 7 |
| Local Government | 4 |
| Retired | 3 |
| University Staff | 2 |
| Engineering | 2 |
| Multiple | 2 |
| Tribal | 2 |
| No response | 1 |
| Total | 59 |

**TABLE 25 PRIMARY EMPLOYMENT STATE**

| "In which state do you primarily work?" | | |
|---|---|---|
| **State** | **Frequency** | **Percent** |
| Montana | 26 | 44.1% |
| Other | 13 | 22.0% |
| Washington | 10 | 16.9% |
| Wyoming | 4 | 6.8% |
| Idaho | 2 | 3.4% |
| Colorado | 2 | 3.4% |
| North Dakota | 1 | 1.7% |
| Total | 59 | 100% |

**TABLE 26 LEVEL OF FORMAL EDUCATION**

| "What is your highest level of formal education?" | | |
|---|---|---|
| | **Frequency** | **Percent** |
| Some formal schooling | 0 | 0% |
| High school diploma/GED | 0 | 0% |
| Some college | 0 | 0% |
| 2-year college degree | 0 | 0% |
| 4-year college degree | 26 | 44.1% |
| Post-graduate degree | 11 | 18.6% |
| No response | 22 | 37.3% |
| Total | 59 | 100% |

**TABLE 27 GENDER**

| "Which best describes your gender?" | | |
|---|---|---|
| | **Frequency** | **Percent** |
| Female | 41 | 38.8% |
| Male | 62 | 67.8% |
| No response | 2 | 3.4% |
| Prefer not to say | 0 | 0% |
| Prefer to self-describe | 0 | 0% |
| Total | 109 | 100% |

# 4. Appendix A

## Importance of Ecosystem Services

After respondents selected the five ecosystem services they thought were most important, they were shown the five ecosystem services they chose and asked: "In 1-2 sentences, please describe why each ecosystem service you chose is important?" The following shows the responses the participants provided for each ecosystem service. Information that could be used to identify the participant is redacted.

### Baseflow support

- Important for overall system function.
- This addresses multiple issues; aquatic life support during late summer/fall low-flow, soil moisture, riparian size and condition, irrigation.
- contributes to salmonid conservation
- Important for sustaining fisheries and other aquatic life
- Riverine and riparian wetlands are/can be maintained by baseflow
- Water is scarce, and global warming is likely to adversely affect availability. Baseflows are critical for the support of aquatic life.
- Wetland loss has impacted stream flows
- Retention of water in wetlands, especially riparian wetlands is essential to providing baseflow to streams during low water. This provides water for animals and humans for a longer duration during the year.
- Focus on making "deposits" of precipitation into surficial and deeper water sources, so that water sources are available for all in times of scarcity.
- Water quantity, especially out west, is going to be an emerging issue with climate change.
- Critical to habitat, wildlife and operations especially in leaner years
- critical for aquatic and riparian habitat
- In support of aquatic life maintenance and overall habitat protection, especially in arid regions where these areas are important for all wildlife support
- essential to maintaining habitat and water quality
- Rivers are the veins and arteries of the planet and we need to be sure human activities don't dry them up.
- We suffer from lower summer streamflows every year. Baseflow support is a key feature of landscape resilience.
- Adequate water is critical to most other aquatic ecosystem services
- Reliable in-stream base flows support a wide range of other services such as recreation, diversions for agriculture, etc.
- Aquatic organisms need water to live. Also, Colorado has potent water rights issues. If my agency cut off water to downstream users, it would be caustic.
- We need to make sure that there is enough support for the water sources we have now.
- This addresses both drinking water resources and surface water sources vital to support streams and associated riparian ecosystems.
- Surface and groundwater availability are foundational to several functions and services. Baseflow support is extremely important in the face of climate change.
- Aquatic ecosystems rely on sufficient flow during times of shortage. Without groundwater fed baseflow during late summer and winter, aquatic ecosystems begin to fail.
- Without it, streams will be dry in late summer and winter
- Lower base flow facilitates higher rates of warming
- Needed for wildlife and fisheries habitat
- consistent flow levels
- Without water in the river for every other service mentioned in this list, then a discussion of other services is pointless.
- Baseflows important to support our aquatic species. It also helps support these species that make up a large portion of our restoration economy.
- Baseflow maintenance a multitude of aquatic species and support recreational activities which are tied to local economy.
- ensures a minimum flow for organisms dependent on clean and abundant water resources
- Baseflows are managed for navigation and fisheries.
- quality and quantity baseflow to support ecosystem and function
- If wetlands are numerous enough to support an adequate baseflow in the area streams, then the aquatic species that inhabit the streams are more likely to survive droughts and thus the important fisheries are hopefully in turn protected.
- Riffles must remain wetted for maximum stream productivity and health.

## Flood Control

- Provides benefits for humans and animals. Important to consider with climate change.
- reduce risk, preserve floodplains
- Systems in our state are incredibly flashy, which leaves infrastructure vulnerable. Consideration of flood control is becoming more important.
- Most expensive type of disaster in the US every year
- By focusing on natural flood control ES, we can avoid many other ills, such as introducing pollutants to the riparian area.
- Aquatic areas and wetlands are important for flood control
- Focus on thinking about flood control more in terms of water sinks, again with the idea that in times of scarcity water is available.
- The impact flooding has on infrastructure and human habitations and economy in Montana (agriculture)
- Surface water that may otherwise cause flooding is stored to a greater degree in wetlands than typically occurs in terrestrial environments (Adamus et al. 1991). The release of water from these wetlands is staggered and gradual, resulting in more persistent flows but much lower peak flows.
- Aquatic systems provide natural flood control and are important factor when considering these systems and how much they provide for human protection rather than creating levees or other manmade flood protection.
- engineered solutions are expensive, unreliable, and create false security. Natural solutions are more cost effective
- As global warming increases the risk of floods, this becomes a very important function in reducing the peak flood flows. The more wetlands and riparian areas we can restore will decrease the intensity of flood events.
- Floodplain restoration can provide substantial improvements for flood control issues. Flood control is an economic issue that aquatic resource managers should coordinate with engineers to find multi-resource benefits.
- protect human life and well-being while protecting the critical habitat that is the floodplain
- Liminal (wetland/riparian) habitats provide volumetric capacity for peak flows, reducing scour from main channel at areas.
- Natural floodplains provide flood control benefits that can't be replicated using traditional grey infrastructure.
- With the increase variability of flows and large flood events, floodplains and their effective flood control processes become even more important. effective food water distribution helps stabilize the stream systems downstream as well.
- I work in an urban area and the aquatic systems are critical to safely conveying flood flows away from high risk areas
- Storage of flood water in depressions protects infrastructure and natural resources from damage.
- Probably more land is preserved by flood control actions than other considerations.
- My agency manages roadsides. Flood control is important to protect infrastructure.
- Flood control has always been an important ecosystem service that drives both urban and rural decision making. It has been primarily addressed through artificial means - dam construction, but is becoming recognized as natural, less costly, benefit of undeveloped, well vegetated, unconfined floodplain ecosystems.
- This service is protective of both human infrastructure and ecological integrity.
- Natural infrastructure is far superior and cheaper than human-made.
- Flood control is essential because many humans live in a floodplain and will be impacted by future flooding.
- Flooding is a huge problem and natural infrastructure to protect and reduce flood impacts is very important.
- ensures communities, properties and resources will remain safe and viable
- Managers seek to prevent impacts to private and public infrastructure.
- Extreme floods are damaging to people, structures, wildlife, crops, etc. However, Had we as a species made better prior decisions, we would not have placed structures, towns, and crops in the path of danger from flooding. Before demonstration of our ignorance, floods were natural along most streams, had less negative impacts to the natural environment and built environment, and were actually beneficial and necessary for riparian habitat rejuvenation and native seed dispersal.

## Drinking Water

- Vital to maintain society.
- humans die without water
- Many MT communities rely on surface water drinking supplies.
- Basis of life
- With the effects of climate change on the form, quantity, and distribution of precipitation, access to clean water for all living things will become more important.
- Drinking water is becoming more vital to protect, and wetlands are important in supplying clean drinking water.
- When thinking about ES that benefit humans this seems like the biggest no brainer. We can't survive without clean water.
- Essential to people.
- essential to human life and health
- Essential life function.
- Healthy drinking water is critical for human populations, and many communities/households depend on natural aquatic systems for this ES
- I get thirsty! Also, surface supplies of drinking water (including shallow alluvial groundwater) reduce the need to deplete non-renewable aquifers.
- We need to make sure that we have water that is drinkable.
- If we protect groundwater and surface water for drinking purposes, then most other ecosystem services are also protected.
- Drinking water is a catch all term for water quality. Some rural communities still utilize streams/surface waters as a source of drinking water but surface water is also a source of drinking water for wildlife and domestic livestock. It's the first essential value of aquatic systems for humans and drives many management decisions. It is integrally related to other functions and services such as groundwater exchange.
- Clean water is the basis for human and wildlife health
- We have to have it.
- People need clean water. Polluted water is very difficult to purify.
- Fresh drinking water is essential for the survival of humans
- health
- Clean drinking water is the baseline for human survival and is, without question, the most important function of a watershed.
- I think this is pretty clear. Communities need clean water and having good water reduces treatment costs and has other benefits
- Direct tie to human well-being.
- supports healthy communities/humans
- Our resource managers work to maintain enough clean water for drinking and industry.
- We all depend of clean drinking water. We can do without it for a shorter period than we can go without food.

## General habitat protection

- Aquatic ecosystems are amongst the most imperiled systems in the world and are relied upon by a myriad of species
- Areas must function in combination with each other for wildlife, fisheries and wetland values to occur.
- Biodiversity is critical on so many levels and once it's gone, it's gone.
- By protecting the habitat, you ultimately benefit all the other ecosystem services on the list.
- Climate change coupled with a wide diversity of habitats in Montana.
- General habitat covers a lot of bases for why communities preserve/restore wetlands, including bird watching, hunting, food chain support, etc.
- Habitat benefits are broad, encompassing human, plant, bird and animals which are each a reflection of ecosystem health. The creatures each drive human economic and ecological benefits from food production to recreational hunting, floating, fishing.
- habitat protection often means increased biodiversity which is essential for human survival
- If we can protect more of the general habitat associated with aquatic systems, we can protect many of the ecosystem services associated with this survey. If we can protect riparian areas, we can reduce contaminants and sediment, increase water quality and provide some flood protection.
- Important recognition of nonhumans - we just don't have the right to not consider this. You break it you buy/fix it
- management that protects existing habitat
- Rather than specifics one needs to look at the whole system.
- Structures and processes found within wetlands that make them an important habitat feature of the landscape.
- The allows for an assessment of overall wildlife habitat, without a single species group (e.g. fish) focus or direct connection to a narrow function (controlling pests).
- This concept captures many other important categories without singling out particular flora/fauna and their perceived anthropogenically beneficial functions.
- This is inclusive of several other fish and wildlife-related services, including habitat for rare and endangered species.
- Vegetation and different hydroperiods provide niches for water-dependent species.
- Watersheds function best as a complete system with habitat intact. Streams benefit exponentially from healthy riparian areas and forests that mitigate sedimentation, improve cover, reduce water temperature, etc... This is critical to aquatic resources.
- We have to preserve the earths biodiversity and extinction
- Whole system health

## Nutrient/toxic recycling and retention

- An overabundance of nutrients to water is leading to HCBs, so nutrient retention is becoming more important.
- Clean water helps humans and animals
- Clean water supports many of the other services
- critical for biodiversity support as well as providing clean water for human use
- Critical function in many landscapes: urban and agricultural landscapes discharge pollutants.
- Downstream habitats are protected when vegetation absorbs nutrients and pollutant within runoff.
- Excess N and P are among the top impairments of MT streams & rivers. Sources are agriculture and domestic discharges.
- Excessive nutrient loading throws ecosystems out of balance and can be very hard to fix, especially for lakes. Toxins can be hugely detrimental to aquatic life diversity and abundance. Toxins in fish consumed by humans also threaten human health
- Exposure to soil/groundwater allows for geochemical processes to attenuate pollutants.
- Helps improve water quality leaving urban areas by reducing excess nutrients and toxins
- Natural nutrient/toxin recycling is much cheaper than building a water treatment plant.
- Natural toxin removal retention and nutrient holding are superior and cheaper than human-made efforts.
- Retention and treatment is another important benefit
- Same as above
- Several options on sediment and nutrient reduction but this seemed to be the most comprehensive for addressing biogeochemical cycling role that aquatic ecosystems play.
- The high profile cases of nutrient and mining toxins in Montana dominate some big land management decisions across the state.
- This addresses both pollutant removal and bicycling timed releases.
- This is an important service provided by wetlands, both riparian and isolated.
- Understanding nutrient/toxin recycling retention is critical to addressing many areas of contamination in the world and developing innovative ways to restore aquatic systems that deal with negative impacts from excess nutrients and toxins.
- Water treatment through natural processes supports clean water which a multitude of aquatic species and support recreational activities which are tied to local economy.
- Wetlands naturally catch, filter, and retain toxins and excess nutrients from downstream waters/users. This means less processing for water treatment plants and a healthier ecosystem.
- Wetlands with clay soils can remove toxic contaminants because of the chemical properties of this type of soil. Wetlands with organic soils such as peat bogs and fens have the necessary soil conditions by definition (high content of organic matter) to react with and adsorb toxic contaminants.

## Groundwater exchange

- Consistent water retention
- Critical in understanding water cycles and dynamics. Correlated to flood control and stream base flows, local aquifers.
- Drinking water/irrigation supply maintenance
- Floodplains, wetlands, riparian filter and absorb water in times of abundance, and release clean, cooler water to surface waters. Exchange between surface and groundwater drives ecosystems and the related habitat benefits for terrestrial and aquatic life.
- Groundwater exchange is necessary for ecosystems especially along river systems.
- Groundwater recharge and maintaining surface water baseflow are critical to meeting human and environmental water needs.
- Groundwater recharge is critical for maintaining or hydrologic systems and base stream flows. Additionally many communities/households depend on groundwater for multiple uses.
- GW exchange will become increasingly important as ecosystem change due to agricultural, residential, and industrial development continues unabated.
- Having natural areas of recharge and discharge supports health aquatic systems. These areas also have many other benefits as these are areas that help nutrient attenuation.
- Often ignored in my opinion yet critical in decision making and policy.
- Periods of low streamflow may depend on groundwater for instream flow.
- Preserving the recharge and discharge cycles of groundwater is critical especially as we increase our demand on groundwater and experience extreme weather events.
- Recharging groundwater through soil percolation and discharge of groundwater in seeps are important functions.
- Retention of water in wetlands allows for infiltration into the ground, raising local water tables and aiding in filtration.
- Similar to baseflow support above.
- supports connectedness between ground and surface water (impacts many resources)
- Supports healthy streams.
- With climate change - we are running out of surface water in areas like the Colorado River Basin - it is important to protect and restore groundwater exchange for future generations.

## Landscape integrity

- All the pieces are necessary for full expression of the local ecosystem.
- Aquatic habitats retained amid a matrix of developed and undeveloped uplands provides habitat and other ecosystem services.
- Connection of habitats are crucial to supporting wildlife populations.
- Connectivity is key, especially in floodplain habitats.
- Continuation of life
- creating robust resilient ecosystems
- Defined in many ways so can be very ambiguous but seems essential to everything we do.
- Highly fragmented landscapes have impaired ecological processes, and more limited potential to provide food, water, shelter, etc. for biological communities. Interruption ecology: Wildlife can be interrupted to death in highly fragmented landscapes because they can't do what they need to do to survive and reproduce.
- I think of this the same as intertwined ecosystems support.
- Landscape integrity and intrinsic value are vague, but get at the reasons for habitat protection.
- Landscape integrity is another catchall term for the intrinsic values, functions and services of aquatic ecosystems that capture the interest of most land managers. Aquatic resources are the circulatory system that connects the living elements of our environment.
- landscapes encompass ecosystems, landscape integrity is critical to the full ecosystem
- Our agency tries to focus on identifying priority areas in our state for acquisitio**n** or management, and one of those things is related to what the surrounding landscape looks like.
- They provide important corridors for all walks of life. They provide important movement and refuge for migratory and sedentary species.
- This covers almost all of it sort of like an umbrella.

## Sediment capture

- Excessive amounts of sediment is a ginormous problem in MT for aquatic life in streams
- Excessive sediment in ecological systems can be problematic for humans and fish/wildlife (e.g., cold-water fisheries and sight-feeding wildlife such as eagles) making use of local resources.
- In my urban area, aquatic systems (particularly toward headwaters) are sinks for sediment generated by development. These areas reduce excess sediment in lower reaches.
- Low energy (off-channel, pond, pool, outer floodplain) habitats provide space for sediments to drop out and avoid adverse effects elsewhere.
- pollution
- Provides value and information on many levels. Well correlated to flood control, pollutant sequestration and habitat benefits to fish and other aquatics.
- Sediments deposited in wetlands are removed from surface flows, thereby improving water quality down-gradient.
- Similar to reduction of erosion, excessive unnatural discharges affects aquatic systems. Detaining and removing sediments before they entire systems is important, such as winter traction sands.
- Streams and wetlands that are capturing sediment are stable, probably support diverse aquatic habitat, clean drinking water, recreational fishing and other aquatic species
- Vegetation can slow velocities and depressions can capture sediment so they don't harm downstream areas.
- Wetlands are one of the best features at collecting sediment, which is one of the top pollutants of water.
- When being limited to five choices, sediment capture rises to the top as it is integral for flood mitigation, erosion control, habitat development for plants and animals, carbon sequestration, turbidity, etc.

## Reduction of erosion

- Soil is a valuable resource. Some erosion is good and natural, but excessive erosion can harm aquatic life and reduce the productivity of the land.
- The capacity of a wetland to store surface water affects its ability to reduce peak flows. Reducing peak flows helps to decrease downstream erosion.
- The reduction in erosion supports several other ecosystem services such as reduction in contaminants entering waterways and increasing functions and preservation of land (including agricultural lands).
- Erosion from land activities has negative impacts to the watershed, from natural riparian buffers to aquatic habitat for fish. There is a large impact to the ecosystem as a whole by reducing erosion that could benefit many layers of wildlife and aquatic species.
- essential to health of land and water
- Erosion reduction is important for maintaining sediment balance (degradation/aggradation) in fish-bearing streams.
- Many activities by my agency can lead to excessive erosion discharge. Reducing the input is really important for aquatic health.
- Prevents transport of sediment and, potentially, sediment bound contaminants to downstream waters
- Erosion reduces ability of areas to function properly
- Wetlands, if numerous enough, should be able to prevent erosion of soils, capture sediments, and thus improve the quality and clarity of water that makes it to streams.
- Erosion should be at natural levels for a particular stream as local native biota has adapted to exist with such levels.

## Removal of contaminants

- Aquatic systems naturally filter out contaminants and therefore provide an important function to our waterways.
- As more and more contaminants are put on the landscape, developed, and discharged, this will be a never ending issue.
- clean water is essential for not only humans but also for all living beings. Contaminated water = reduced biodiversity
- Contaminants continue to accrue in the ecological system, many of which have a long residence time. Processing/removal of contaminants increases water quality and benefits several other related functions/services, both human and ecological.
- contributes to overall ecosystem health
- essential to health of all life forms
- improves overall environmental health, and can affect human health
- Natural pollutant removal is much cheaper than building a treatment plant.
- nutrient pollution/non-point source pollution one of the greatest threats to water quality
- We need to make sure to keep the water clean for our consumption.

## Irrigation

- A mix of pivot and flood irrigation and the legacy of agricultural water rights in Montana.
- Agriculture, including irrigated agriculture, remains one of MT's top economic drivers.
- As the primary consumer of surface water, irrigation plays a keystone role in the economic benefits and ecological costs of aquatic ecosystem benefits.
- humans die without food and irrigation is required for food production
- Illegal irrigation and over pumping have altered hydrology of system with many negative consequences
- In the western U.S. water rights reign supreme, most of which are linked directly to crop and livestock production.
- Irrigation is a dominant use of surface waters and driver of land management decisions, either in support of or response to this use.
- Let's face it, irrigation is a very important service in the arid west.
- Needed to grow food for people.
- Sustaining food supply for life

## Intrinsic value

- Ecosystems are not solely for human use. We need to manage land and water resources for all the plants and animal's benefit.
- I see a value in acknowledging the plethora of services and functions underway in wetlands of which we are currently ignorant.
- Intact and healthy aquatic systems are critical in many aspects of the earth's function and the function of humans
- Landscape integrity and intrinsic value are vague, but get at the reasons for habitat protection.
- there is intrinsic value from a rights of nature perspective
- This has to be part of the equation otherwise we get a human use centered protection framework. Example: the hook and bullet management scheme for fish and game.
- Wetland and aquatic systems provide so many function and values, wildlife habitat, and are such an important ecosystem that should be protected

## Carbon sequestration

- C02 = 412 ppm currently. Mangroves/sea grass/marshlands/perma-frost are some of the best natural sequestration options
- Climate change is the largest threat to ecosystem services we face. We can't let ecosystems flip from carbon sink to source.
- Possibly one of the greatest goods, as learning how to most effectively trap carbon in plants might truly save our lives.
- Sequestration of carbon is important for managing CO2 and ultimately protecting humans and nature.
- Vital to consider as our climate changes.
- We should take every opportunity to sequester the carbon we've put into the atmosphere.

## Recreational fishing

- A favorite year-round activity.
- Also one of MT's top economic drivers, and a deeply-engrained part of MT outdoor culture.
- Clean Water Act priority
- Recreational fishing is an ecosystem service that may not be as universally applicable to the public but it represents strong values held for healthy habitats, fish populations, and recreational access.
- Recreational fishing provides the economic driver and social relevance for aquatic ecological protection and restoration.

## Stock grazing

- Exploitive uses also include all sorts of transportation and development activities, which are not included in your question.
- humans die without food and water is required for stock grazing
- Indiscriminate and cheap grazing of BLM and forest service land continues to damage soil and vegetation and pollute water.
- Stock grazing is an important part of our state's economy. In order to use grazing as a management tool to benefit wildlife, we need to be able to provide consistent and quality water sources for the ranching community in arid parts of our state.
- Sustaining food supply for life

## Crop production

- humans die without food and water is required for crop production
- humans need food to survive
- If I could have selected a crop and livestock production category I would have as, next to drinking water, food is the most important provision of a watershed to humanity.
- Land use decisions are driven mostly by exploitive uses of the land.

## Disaster control

- I'm a bit leery on this one - and note that I gave it a 3 before - because I don't want to support unnatural disaster control (e.g. levees or channelization. There is a major role that aquatic ecosystems play in mitigating disasters by restoring functions (e.g., promoting access to floodplain and flooding to mitigate DS impacts to urbanized areas; storing late season flows).
- Unfortunately, transportation infrastructure often follows streams. Disaster events (fire, flood, landslides) can't be controlled, but the resiliency of the roads and streams can be improved.
- Wetlands provide a buffer for flood water, retaining water for slower release and slowing the velocity of the water, reducing damage

## Soil moisture

- Building block of life
- humans die without food and soil moisture is required for food production
- Necessary for crop and other vegetation growth.
- We cannot let human activities deplete the moisture from the soils.

## Support of beneficial invertebrates (e.g., pollinators)

- contributes to overall ecosystem health
- Support of biodiversity writ large is key because wetlands are hotspots of biodiversity on the landscape. This biodiversity provides numerous services in terms of pollination and forage to higher predators.

## Connectedness to nature

- I know more about nature from the time I spend on water than any other activity.
- part of a whole ecosystem
- Watersheds are part of the last remaining wild lands of North America. They are the connecting piece of all ecosystems.

## Hunting

- Hunting is a key social and ecological value in Montana
- Our agencies primary responsibility is related to hunting and fishing in our state. Any of our land management decisions are based on what services we could provide to our constituents.
- Watersheds are the connecting corridors from the Rocky Mountains to the Ocean. They provide important movement refuge for animals. This allows hunters to hunt in a controlled, isolated habitat. In a historical context watershed were highly important to the <<Name of tribe>> people. They were a source of cleanliness, drinking, hunting and camping.

## Recreational boating/floating

- A favorite summer past time.
- Clean Water Act priority
- The size of the recreational economy in Montana, and it's relationship to water based activities.

## Restorative experience

- This one covers recreation for me - fishing, birding, hiking, hunting - since they are ways to restore ourselves. Many men go fishing all of their lives without knowing that it is not fish they are after.

## Support of beneficial amphibians and reptiles to help manage pests

- an important indicator of water quality and supports ecosystem habitat and wildlife cycle
- We need to make sure there are sources of water to support beneficial species that start with amphibians and reptiles that rely on water for survival.

## Education

- This is the crux of change
- Without convincing the hearts and minds of citizens on the value of ecosystem services, we cannot hope to preserve ecosystem services into the future.

## Historical/archaeological/heritage

- I work for the <<Name of tribe>> people....aquatic environments have cultural significance.
- The watersheds are very important to First Nations people from a historical and contemporary perspective. They provide a connection to our past through the historical sites that are associated with watersheds. They are important sites for cultural resources..

## Microclimate

- It should be a priority to keep moist, cool microclimates from becoming hot and dry.
- Microclimate is inextricably connected with macro-climate, and these wet systems absorb heat and buffer heat exchange.

## Naturalist activities

- Education, research, and recreation all are covered by this topic.

## Nutrient production

- A productive system to support life cycle

## Research

- Watershed allow research to be conducted in a multifaceted approach. We can conduct historical, riparian health, watershed health, ecological restoration, wildlife surveys, bird surveys, invasive species distribution.

## Support of beneficial bird populations to help manage pests

- Biodiversity in general is huge to maintaining balance; birds are my particular favorite!

# 5. Appendix B

## Survey Comments

The final question on the survey allowed the participants to comment on any part of the survey, they were asked to "Please use the space below for any additional comments you may have about the survey, ecosystem services, and/or aquatic systems." Their comments are shown here. Information that could be used to identify the participant is redacted.

### Survey comments

- Federal and state agencies should work together to update the NWI and to develop a flexible GIS to identify restoration opportunities that could be made available to local agencies for their own configuration.
- Hope your research goes well, and that a useful end report or product will come from your efforts.
- I wish you the best of luck on this important endeavor.
- Thanks for this survey, interesting perspectives so far!
- My personal observation has been that protection of aquatic resources needs to start at a local level (city and county) and progress to a state level. In North Dakota, the U.S. Army Corps of Engineers Regulatory Program is the ONLY protection against loss of aquatic resources and there is very little support at a local or state level for protection. I have worked in numerous states (11) and have seen the whole range of local protection (King County, Washington, Wisconsin, California) to no protection in North Dakota. I think education is key to establishing some sort of grassroots movement to protect aquatic resources and may be most beneficial with grade school children. Outreach to landowners may also be beneficial but may meet with some resistance in rural areas.
- My answers on this survey reflect my feeling that ecosystems should be managed holistically for all the native plants and animals. If done properly, then humans too will benefit from those intact systems. I like to look at the big picture of ecosystem health; limiting your consideration of ecosystem health to human benefits will result in poor management of the resource in my opinion.
- The regulatory environment differs widely by state and region; for context my environment is one where state-level protections exist for wetlands and other waters. I am glad for state-level regulations as a check against changes in Federal protections of waters, but also see redundancy in state and federal programs that create inefficiency. If I had greater trust in state-level staff, I would support local assumption of federal clean water (401) program. I must admit to having more critique and questions than solid answers. Thank you, <<Name of participant>>
- Thanks! Good stuff :) Feel free to contact me with any follow up. <<Name of participant>>
- I think your first question is misworded, and asks a different question than what you intended. Yo**u** asked; "what factors ARE most important in land use decisions", but from the possible responses, it looked to me that you really meant to ask; "what factors SHOULD BE" most important in land use decisions.
- Please email results of surveys and findings. Thank you.
- We need property tax credits that make it more profitable for farmers and ranchers to grow stream and wetland buffers than to grow crops or livestock in riparian areas. Could somehow tie this to compensatory mitigation and credits, i.e. money from this goes into a property tax credit fund used to pay landowners.
- There were many questions where the underlying assumptions were not delineated and one would answer the question differently based on what those might be. This indicates poor survey design, and I fear the results will be suspect. There seemed to be an inherent bias to foster the integration of social sciences into decision making, and to de-emphasize the science of fish and wildlife management and ecological science in general.
- Thanks for letting me participate!
- Thanks for doing this survey. I look forward to learning the results!
- We should be keeping our ecosystem services within our own local watershed, which should be the practice everywhere. There should be more emphasis on keeping wetlands in situ.
- Best of luck