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Evaluating the Performance of Channel and Fish Habitat Restoration Projects in British Columbia's Watershed Restoration Program

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In 2000 and 2001, a performance evaluation was undertaken on a subset of aquatic Watershed Restoration Program projects completed between 1995 and 2000. The objectives of the evaluation were to:

1. determine the broad-scale success of instream, off-channel and fish access rehabilitation projects,
2. identify problem areas in aquatic restoration that require follow-up training or clarification, and
3. to provide a status report on the overall performance of aquatic restoration investments.

Aquatic restoration efforts must be effective and durable to achieve aquatic sustainability. Monitoring the performance of fish habitat rehabilitation is instructive in identifying which methods are most effective. D'Aoust and Millar (1999) reviewed six studies of instream structure durability, including Higgins and Forsgren (1986), Doyle (1991), Frissell and Nawa (1992), Metzger (1997), Roper et al. (1998) and Hartman and Miles (1995). Performance "success" varied from about 40 % (Frissell and Nawa 1992) to 86 % (Metzger 1997). The most extensive study was on seven National Forests in Oregon and Washington following 50 to 100-year winter floods of 1996 (Roper et al. 1998). On average, post-flood performance was high, with only 16 % of structures leaving sites of original placement and 75% were functioning as planned. Greater operational experience with design and construction appeared to contribute to higher success rates. However, in British Columbia similar documentation is not available on the performance of projects designed to restore fish access and off-channel areas, and there is no recent examination of current stream restoration technology. Furthermore, with the recent demise of both Forest Renewal BC and the Watershed Restoration Program, the performance evaluation provides a key wrap-up of the program and documents the legacy of the work completed.

A total of 53 instream, 32 off-channel and 18 fish access rehabilitation projects were evaluated over 2000 and 2001. Projects were selected from each of the Ministry of Water Land and Air Protection regions and represented the diversity of biogeoclimatic zones that have been worked on over the life of the Watershed Restoration Program. Evaluators were a combination of headquarters staff, regional staff and consultants. To avoid bias during data collection, the evaluation team only reviewed projects with which they had no direct involvement. Project implementers often accompanied the evaluation team on site, but their role was to provide input on the project background and objectives. Data was collected on a site-by-site basis from all restoration projects, using standardized evaluation forms. Structures and sites were evaluated qualitatively using a four-point scale (allowing for half mark increments) to determine how well site-level objectives were being achieved over the short (5-year) and long (20-year) term.

Overall, the results of the performance evaluation indicate that the Watershed Restoration Program has been very successful (Figure 1) at achieving site-level restoration objectives. Fish access restoration had the highest level of success, with 94% of projects evaluated meeting or exceeding objectives as compared with instream (81%) and off-channel (92%) projects. While the success levels were high for all three components evaluated, room for improvement for each was identified.

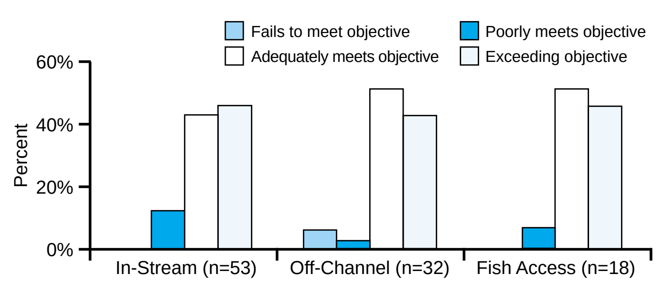

Figure 1. Overall success of in-stream, off-channel and fish-access restoration projects.

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Fish Access

Three types of fish access restoration were evaluated: bridge replacement (3), culvert replacement (4), and access modification (11). Regardless of the type of fish access work, restoration success was high (Figure 2). The only project type that showed shortcomings was fish access modification. Factors affecting restoration success of fish access modification projects included use of undersized boulder material along outlet weirs and insufficient depth in outlet pools to facilitate fish passage.

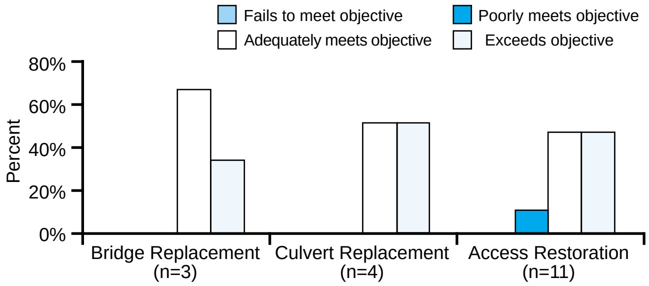

Figure 2. Overall performance of fish access modification projects broken out by type.

Because of the overall high level of success with fish access modification projects, few lessons can be learned that will improve delivery. The high level of success and extent of habitat made available for target fish species make this restoration component a very valuable tool for addressing aquatic sustainability issues. Further studies such as that of Parker (1999) examine the most appropriate method of constructing outlet weirs to aid in overcoming any potential shortfalls associated with fish access modification projects.

The off-channel performance evaluation considered both surface-fed (14) and groundwater fed (18) off-channel projects. As with fish access restoration, overall success was very high regardless of off-channel type (Figure 3). However, project failures were identified in both categories.

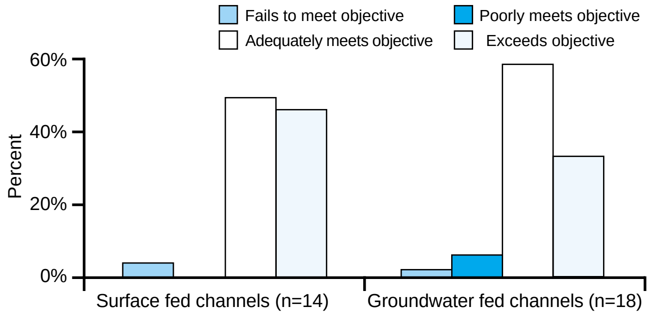

Figure 3. Overall success of side-channel projects broken out by channel type.

Failures associated with off-channel projects were either a result of intake problems (in the case of surface-fed channels), channel dewatering or channel isolation. Due to the nature of operation, surface-fed channels require routine maintenance to ensure debris does not foul intakes, and to excavate settling ponds or other sediment traps. In one occasion this routine maintenance was insufficient to prevent failure of the channel intake, leading to erosion and project failure. In other cases, large-scale flood events isolated side-channels as the mainstem river channel degraded.

Routine maintenance will continue to be an issue with side-channel projects. A lesson to be learned from this component of the performance evaluation is that long-term funding must be identified and secured to provide annual monitoring and periodic routine maintenance of these projects. Considerable investment has been made across the province to construct stable side-channel habitat, and the contribution they make to overall smolt output in salmon streams has been documented repeatedly (e.g. Cleary 2001, Decker and Foy 1998). This benefit far outweighs the cost of an annual inspection and maintenance program and must be acted on by government in combination with stakeholder groups active in watershed restoration and protection.

The division between those off-channel projects adequately meeting restoration objectives versus those exceeding objectives was due to issues of finishing quality. Some projects appeared to have been built to specification, without thorough consideration for the life history or habitat requirements of the target fish species. Projects that exceeded objectives tended to have emphasized secondary habitat features associated with juvenile rearing. This included placement of loose rip rap toes along the margins of side channels, aggressive planting and seeding of channel banks, and the placement of quality large woody debris in key habitat areas such as deep pools. The potential benefit of the secondary habitat features on smolt output was not determined but could be considerable given the low incremental cost of adding these features to side channel habitats.

As off-channel projects mature and fully revegetate, additional maintenance may be required to manage beaver colonization. While there was little evidence of colonization or damage resulting from beavers at the time of this evaluation, it may change over time. To counter these concerns, novel approaches for low maintenance beaver management such as those presented by Finnigan and Slaney (2002) will need to be employed.

Instream

When considered at the project level, instream restoration was found to be highly successful, with no projects failing to address restoration objectives and only 13% poorly addressing objectives (Figure 1). However when considered at the site level, the results indicate that across all projects, 19% of sites poorly met or failed to meet objectives over the short-term (5-year) and this increased to 32% when performance was projected over a longer (20-year) period (Figure 4).

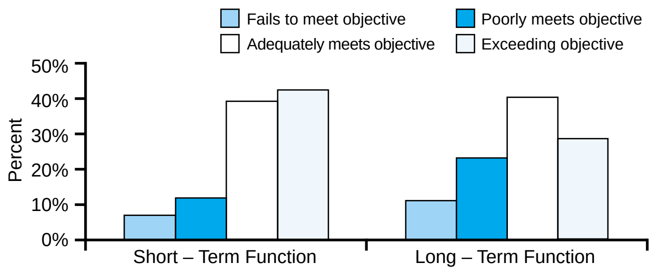

Figure 4. Function of in-stream structures over short (5-year) and long (20-year) time frames (n=552).

The decreased performance of instream restoration structures over longer time periods is a cause for concern for watershed restoration planners and practitioners. Instream restoration structures are installed with the objective that they will provide habitat or channel structure benefits for at least a 20-year period (Slaney and Martin 1997) following installation. However, this target is not being met given the results of this performance evaluation.

Several independent variables were analyzed to determine what factors might be responsible for decreasing the projected long-term performance of instream restoration structures. Previous studies (e.g. Roper et al. 1998) identified flood flows, structure location in the channel and watershed magnitude as key variables affecting the success of instream watershed restoration efforts. Findings for the Watershed Restoration Program for instream structures followed a similar pattern, although there were some differences.

Instream structure performance was found to vary by structure type. Habitat structures that tended to have a higher percentage of success included boulder clusters and lateral large woody debris jams. Structures that tended to have lower success included sill logs and pool-riffle reconstruction (Figure 5). Full channel spanning structures tended to perform less well than either laterally placed structures or structures placed in the channel as observed in the USDA Forest Service studies (Figure 6). This finding was partly due to the improper placement of full spanning structures or installation in watersheds or reaches with unfavourable geomorphic conditions (e.g. unconsolidated streambanks). Issues with riffle-pool reconstruction included in-filling of pools with bedload sediment, outflanking and displacement of riffle crests.

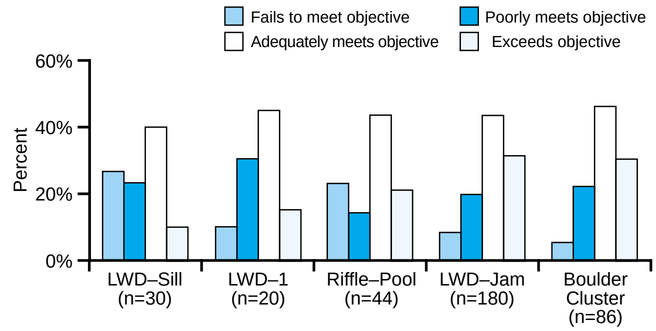

Figure 5. Long-term (20-year) function of in-stream, restoration projects broken out by structure type.

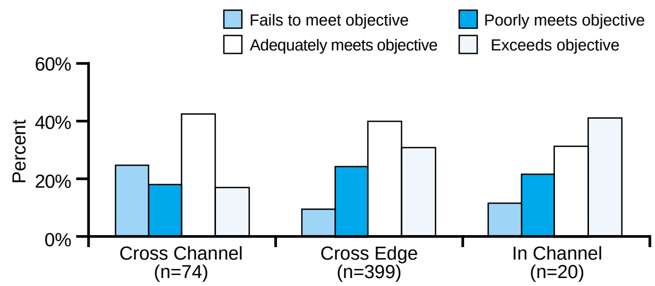

Figure 6. Long-term (20-year) function of in-stream, restoration projects broken out by channel placement.

Post-construction flood history greatly influenced structure performance. The majority of watersheds that the Watershed Restoration Program has been actively involved with have not been subjected to large-scale (e.g. greater than 20-year return period) post-construction floods. In those incidences where very large magnitude floods have occurred, structure performance was observed to be poor (Figure 7). This finding parallels that of studies conducted throughout the Pacific Northwest following regional flooding in the mid-1990s (Roper et al. 1998). While the percentage of structures failing to achieve site objectives was high for those watersheds experiencing a greater than 20 year return interval flood event, it should be cautioned that this is based largely on the results of a single project in Martin Creek. In this one instance, the 50-year flood design capacity of the project was exceeded during a 100-year return interval flood that occurred in the summer of 2001 in isolated areas throughout the north east corner of the province.

Instream structure performance varied with stream magnitude, but not in a linear fashion as has been the case with earlier investigations in the Pacific Northwest. Previous studies have determined that

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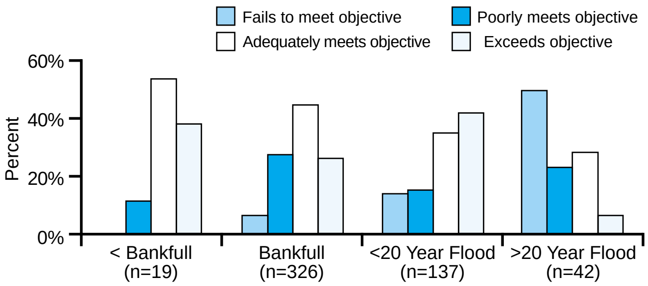

Figure 7. Long-term (20-year) function of in-stream, restoration projects broken out by post-construction flood history.

structure performance decreased with increasing stream order or magnitude (e.g. Roper et al. 1998). However, this study identified a modal or humped distribution, with a higher percentage of structures meeting or exceeding performance objectives in the medium sized watersheds (Figure 8). The lower success in small magnitude streams probably reflects the difficulty of undertaking instream restoration in steeper headwater streams or small channels located on alluvial fans.

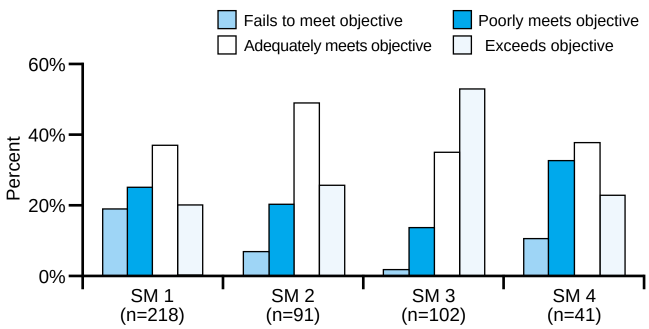

Figure 8. Long-term (20-year) function of in-stream, restoration projects broken out by stream magnitude (SM1=1-20, SM2=21-40, SM3=41-100, SM4>100).

Recommendations

The 2000 and 2001 performance evaluation of instream, off-channel and fish access restoration projects identified more than successes and failures of the Watershed Restoration Program. Examining the results and outcomes of many projects around the province allowed for the synthesis of a number of recommendations that must be considered to improve the delivery of restoration programs in the future.

1. All restoration components evaluated had high levels of success and are best used in combination with each other to best achieve resource restoration and sustainability objectives.
2. Fish access rehabilitation projects need to consider the implication of culvert water velocities when sizing rip rap to be placed in outlet weirs.
3. A formalized annual inspection and maintenance program for off-channel restoration projects must be developed to ensure that the benefit gained from these projects are not impaired.
4. Secondary habitat requirements of target species must be taken into account when constructing off-channel projects. The incremental cost of adding quality large woody debris to deep pools, aggressively planting and seeding banks and loosely placing rip rap along channel margins is likely a marginal cost relative to the sizeable benefit gained.
5. Caution must be used when selecting channel-spanning structures for instream restoration. Geomorphic and hydrologic factors in watersheds, reaches and sites must be taken into consideration when planning to use these types of restoration structures. Although these types of stream features may be prevalent in old-growth templates, they are likely transitory in nature and as such are not the best option for providing habitat over a 20-year period.
6. Avoid pursuing instream restoration in steep headwater streams and on alluvial fans. Where restoration is a requirement to achieve sustainability and restoration objectives, consider watershed processes and take into account the dynamic nature of the surroundings.
7. Continue to explore new methods and approaches to watershed restoration. Program success has been gained through a process of evolution and adaptation as more and better information on watershed processes and restoration has become available. This must continue if future restoration programs are to continually improve and achieve restoration and sustainability criteria.
8. Maintain a technical bulletin (such as Streamline) to disseminate advances in watershed restoration technology to planners and practitioners. Without publications such as this one, adaptive management and evolution are compromised.

Conclusions

The Watershed Restoration Program has invested considerable time and effort since its inception to restore and protect fish habitat and water quality adversely affected by pre-1994 forest harvesting. Although the program is coming to a close in March 2002, this study has highlighted the legacy of successful instream, off-channel and fish passage restoration projects it will leave behind all across the province. All British Columbians are the beneficiaries of this legacy, as the fishery and aquatic resource belongs to all of us. This

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study identifies issues that, once addressed, will improve future restoration, mitigation and compensation efforts. However, the most valuable output is the indication of the overall success of the Watershed Restoration Program. Thus, an integrated, watershed- and science-based restoration program or strategy is a sound approach to addressing aquatic resource sustainability issues, provided it is directed at clearly stated objectives.

The success of the Watershed Restoration Program can be largely attributed to a willingness to learn from the past while working for the future. Mentors, partners and collaborative efforts combined to deliver a program that we can all be proud of as we have worked towards the restoration of physical and biological processes in watersheds across the province. The commitment of many individuals and groups to the aquatic resources of this province has given hope that we will overcome setbacks and have abundant fish and water quality for subsequent generations to enjoy. While the Watershed Restoration Program fades, other programs, groups and individuals must continue to ensure that the aquatic resources of British Columbia are restored and protected for the benefit of future generations.

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