Reservoir operation impacts on survival of Yellow Warblers in the Revelstoke Reach Wetlands, BC

2007/8 SUMMARY REPORT

Active yellow warbler nest built in a willow shrub

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EXECUTIVE SUMMARY

Songbirds breeding in riparian habitat within valleys where hydroelectric power generation regulates water levels may suffer increased nest mortality or reduced survival if rising water levels flood active nests or reduce food availability. We have studied yellow warblers (*Dendroica petechia*) breeding in three types of riparian habitat adjacent to the Upper Arrow Reservoir near Revelstoke, BC since 2004. Previous work showed that variation in dam operations in 2005 and 2006 did not have a significant on the breeding success of yellow warblers. In this study we assessed whether differences in the timing of inundation and maximum water level at full pool in 2005 and 2006 influenced the return of breeding adults in the following year. We found that despite large differences in dam operations in the two years adult return rates in 2006 and 2007 did not differ. Return rates combine both a measure of survival and breeding dispersal but no birds were observed to move between the three study sites within Revelstoke Reach. This study therefore suggests that differences in dam operations in 2005 and 2006, (years with low and high water levels at maximum pool, respectively), did not have a significant impact on adult survival. Differences in how nestlings were banded in 2005 and 2006 made it impossible to evaluate whether dam operations influenced juvenile survival. However, our failure to detect any returning juveniles from the 2006 cohort warrant further work on the impact of dam operations on juvenile survival. We also found that the return rates of male and female yellow warblers did not differ significantly (overall rate of return was 44%). Return rates were however approximately three times higher at Machete Island, the site containing continuous willow habitat bordering mature cottonwoods, than either Drimmie Creek a site with fragmented willow habitat, or Illacillawaet, a restored riparian site. This supports previous work that concluded continuous willow habitat bordering mature cottonwoods constitutes high quality habitat for this riparian dependent songbird.

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INTRODUCTION

Human activities have resulted in dramatic declines in the amount of riparian habitat in North America. On the Columbia River, for example, 250 dams have been constructed over the last 100 years which have played a significant role in the estimated loss of 87 % of riparian habitat within the Columbia River Basin (Moody et al. 2006). Parallel to the loss of riparian habitat in North America have been widespread population declines of bird species that use this habitat (DeSante and George 1994, Sauer et al. 2001). These population declines could result from habitat loss or the lower productivity and higher mortality associated with using remnant habitat impacted by dam operations.

Revelstoke Reach, BC, remains one of largest relatively intact floodplain/wetlands in the Columbia Basin, despite hydroelectric development that regulates water flow, and provides critical habitat for a diversity of bird species (Jarvis 2001, Boulanger et al. 2002). Birds in riparian habitat within Revelstoke Reach are likely, however, to be influenced by water use decisions that result in fluctuating water levels in Arrow Lakes Reservoir that can lead to the flooding of active nests (Jarvis 2006) and/or reductions in the amount of foraging habitat available during the breeding season. Previous work comparing the breeding performance of yellow warblers in two years that varied in the timing and elevation of full pool in the Arrow Reservoir suggested that current water use decisions did not have a major impact on nest mortality and the breeding success of yellow warblers (Green and Quinlan 2007). However, broods raised on territories that were partially flooded tended to be lighter than those on territories that were not impacted by rising water levels suggesting that water use decisions may have indirect effects on survival (Green and Quinlan 2007). In this study we therefore evaluate how water use decisions impact the survival of adult yellow warblers that breed in Revelstoke Reach by comparing their return rates following years that differ dramatically in the timing of inundation and the maximum eater level at full pool. We also provide preliminary data on the return rates of juvenile yellow warblers banded as nestlings in Revelstoke Reach in the same two years.

METHODS

Study species

Western populations of the yellow warbler are common among deciduous riparian habitats where they are associated with willow thickets, other stream-side shrubs and

large deciduous trees, such as black cottonwood (Cilimburg et al. 2002). Yellow warblers have consequently been identified as a riparian focal species by Partners in Flight. In British Columbia, males typically arrive first to the breeding grounds in May to establish permanent territories with females arriving about a week later (Campbell et al. 2001). Females construct open-cup nests about 1.5 to 4m high in shrubs and less often in the canopy of larger cottonwood trees. Females are the sole incubators of 4-5 eggs, while both sexes feed nestlings and fledglings.

Study site

Revelstoke Reach is situated at the northern end of the Arrow Lakes Reservoir, a 230-km long reservoir system in the Columbia River valley separating the Monashee and Selkirk mountain ranges, in the West Kootenay region of British Columbia (N50.58'56"/W-118.20'00", Fig. 1). The study area is characterized by a patchy network of willow-cottonwood habitats associated with the higher elevations within the drawdown zone of the reservoir (435m to 442m). We worked at three sites that are representative of the three major riparian habitat types found in Revelstoke Reach. The site at Machete Island covers 30 ha, much of it slightly above the highest allowable flood elevation of 440m. This site includes a large stand of mature black cottonwoods with a diverse understorey and an adjacent area of dense, mixed-woody plant species bordered almost entirely by a strip of willow shrubs. The second site centred at the mouth of Drimmie Creek is more representative of much of the riparian habitat within the drawdown zone of Revelstoke Reach. This 37.5 ha site comprises a thin strip of mature cottonwood forest, grading into a contiguous area of willow followed by more isolated patches of willow at lower elevations (<438 m) that are imbedded in grassland (mainly reed canary grass and to a lesser extent, planted fall rye grass). The third site located at the mouth of the Illecillewaet River is a 39 ha area where restoration efforts have been conducted by part by the Illecillewaet Greenbelt Society and BC Hydro. Restoration projects between 1999 and 2006 have included dredging to create wetland pools and the planting of various riparian shrubs and trees (F. Maltby, pers. comm). Riparian habitat at this site varies from areas of short willow shrub to small stands of mature cottonwood.

Monitoring, banding and determining rates of return to breeding sites

We monitored all three sites at 2-3 day intervals from early April until the end of June in both 2005 and 2006. We attempted to catch all breeding birds that established territories within the three study sites using 12-m mist nests combined with playbacks of yellow warbler songs. Birds were then fitted with a Canadian Wildlife Service-issued aluminium band and a unique combination of three-colour bands. We monitored a total of twenty-four breeding pairs in 2005 and 36 breeding pairs in 2006. A small number of birds remained unbanded as they were not captured over the course of the breeding season. We banded 67 nestlings that fledged in 2005 (62 were colour-banded) and 50 nestlings that fledged in 2006 (0 were colour-banded).

We determined the return rate of banded adults, the level of breeding dispersal between sites, and the recruitment of local juveniles by searching the three study sites and

all areas of willow habitat along the Arrows Lake Reservoir between Revelstoke and Drimmie Creek (Fig 1) in 2006 and 2007. In both years, searches were conducted during the first three weeks in May (the period when territory establishment and nest-building occurs), and a 2 week period in mid-June (when pairs are typically provisioning young). We recorded the band combination and location of any yellow warbler observed. Attempts were made to catch any birds whose identity was uncertain (eg birds banded with a single metal band). We also evaluated whether any additional banded birds were observed during routine monitoring of the breeding population in 2006.

Statistical analyses

We used generalized linear models to examine whether differences in the timing of reservoir fill and the maximum water level in the Upper Arrows Reservoir in 2005 and 2006 influenced the likelihood that breeding birds returned in the following years. We explored both differences in return rates between years (2005 low water, 2006 high water) and between territories that were or were not inundated by water, while controlling for any difference due to site, sex or reproductive success. In both analyses we initially fitted a full model and sequentially removed all non-significant interaction terms and then non-significant main effects until only significant factors remained. We report the change in deviance, which approximates a chi-square statistic, when the term of interest is dropped from the final model.

RESULTS

Return rates of banded yellow warblers

We monitored the breeding of 46 banded yellow warblers in 2005 and 64 banded yellow warblers in 2006. The increased sample size in 2006 was due to an increase in the number of second-year birds (i.e first time breeders) that settled in Illecillawaet in that year. Despite dramatic difference in the timing of reservoir fill and the maximum water level in 2005 and 2006 there were no detectable differences in the return rates of adult warblers to breeding sites in Revelstoke Reach in 2006 and 2007 (Table 1). Adult return rates also did not differ depending on whether they had bred on a territory that became inundated by water or not (χ^2= 0.7 df=1 p=0.40). Return rates, however, were 2-3 times higher at Machete Island than either Drimmie Creek or Illecillawaet (Table 1). Males and females were equally likely to return to Revelstoke Reach (males 47%, n=60; females 41%, n=51; sex differences after controlling for site χ^2 =0.9, df=1 p=0.34). Since songbirds are known to be more likely to disperse following reproductive failure and reproductive success is higher at Machete Island site differences in return rate may reflect differences in local philopatry as well as differences in survival. However, significant site differences remained after controlling for any effect of reproductive success (success/fail in previous year χ^2= 4.2, df=1 p=0.04, site effect χ^2= 26.5 df=2 p<0.001).

We banded 67 nestlings that fledged in 2005 (62 were colour-banded) and 50 nestlings that fledged in 2006 (0 were colour-banded). Approximately ten per cent of the 2005 fledglings (N=6) were known to have returned to breed in Revelstoke Reach. Four were resighted and/or captured in mist-nest in 2006 and a further two were resighted in 2007. To date, none of the 2006 fledglings are known to have returned despite attempts to locate and capture metal-banded birds. However, since juveniles were only color-banded in 2005 we were unable to examine inter-annual variation in juvenile return rates.

DISCUSSION

Songbirds breeding in riparian habitat within valleys where hydroelectric power generation regulates water levels may suffer increased nest mortality or reduced survival if rising water levels flood active nests or reduce food availability. However, previous work in Revelstoke Reach suggested that water use decisions for the Arrow Lakes Reservoir in 2005 and 2006, two years that differed dramatically in water level at full pool, did not have a major impact on the breeding success of yellow warblers (Green and Quinlan 2007). This study suggests that these water use decisions also did not have a significant impact on the return rate, and by extension the survival, of adult yellow warblers. This should not be taken to mean that water use decisions will not impact yellow warbler populations since minor changes to the timing of reservoir fill would significantly increase nest mortality (Green and Quinlan 2007), and could alter conclusions about the impact of water use decisions on adult survival. This study was also unable to determine whether high water levels in 2006 that tended to lower nestling mass prior to fledgling influenced juvenile survival since nestlings were only colour-banded in 2005. The data available however suggests that further work on the relationship between water levels, nestling growth rates and juvenile survival is warranted as no fledglings banded with metal bands in 2006 were known to have returned to Revelstoke Reach despite attempts to relocate and capture any metal-banded birds in 2007. The overall impact of water use decisions on populations of riparian dependant songbirds in Revelstoke Reach will also require additional detailed studies on other species since dam operations are likely to have a greater impact on ground nesting species or species that breed later in the year.

Riparian habitat in Revelstoke Reach varies considerably, but includes one large stand of mature cottonwoods with a diverse understorey bordered by willow (Machete Island), remnant patches of willow that grade into thin strips of deciduous woodland at higher elevations, and restored areas with plantings riparian shrubs and trees. Previous work on settlement patterns and age structure of yellow warblers in riparian habitat suggests that they prefer continuous willow habitat that borders mature cottonwood stands. This preference appears to confer a reproductive benefit since breeding success was significantly higher in this habitat type (Green and Quinlan 2007). This study which

shows that adults are three times as likely to return to Machete Island as sites representative of fragmented or restored riparian habitat suggests that any preference for this habitat type would also confer a survival benefit to individuals. Research to date on settlement patterns, breeding success and philopatry of yellow warblers therefore all suggest that willow habitat bordering mature cottonwoods constitutes high quality habitat for this riparian dependent songbird.

Recommendations for management

We use the results of this study with the results of previous work (Quinlan and Green 2006, Green and Quinlan 2007) to make the following recommendations for managers working to restore riparian habitat for songbirds in the Columbia Basin.

1. Research on yellow warblers suggests that restoration efforts seeking to improve or create new riparian habitat for nesting songbirds should focus on increasing the amount of willow habitat linked to stands of mature cottonwoods and reducing the number of isolated willow patches. Willow plantings that create territories with high shrub stem densities by joining existing willow patches to mature deciduous forest at higher elevations are likely to both attract nesting songbirds dependent of riparian habitat and enhance their nesting success.

2. Monitoring should be conducted to evaluate whether restoration efforts are effective at providing suitable habitat for wildlife. Effectiveness should be evaluated using a suite of species selected to represent the range of spatial and functional requirements of wildlife in a restored ecological system.

3. We advocate using measures of productivity and survival, rather than measures of abundance, to assess efficacy of restoration efforts given that they are directly related to population viability. Productivity measures may need to consider both the quantity and quality of offspring produced if offspring quality influences juvenile survival and recruitment. Where abundance measures are used data should be collected in multiple years and attention should be given to variance in abundance. High quality reference and restored sites are likely to have both higher densities and less variance in density than low quality sites.

4. Within Revelstoke Reach, the timing of full pool in Arrow Lakes Reservoir determines the proportion of bird nests lost to flooding. For yellow warblers, a shrub nesting species that initiates nests between late May and early June, delaying full pool until July 12 ensures that >90% of nests have a chance to fledge. Species that nest in patchier riparian habitat, closer to the ground and later in the year will be impacted more. Restoration activities that increase the amount of riparian at low elevations will increase the importance of regulating the timing of reservoir fill in relation to the breeding schedules of riparian birds to minimise nest mortality.

Recommendations for future research

1. The ability to assess how dam operations impact Yellow warblers would be improved by long-term data on adult and juvenile survival in relation to annual and spatial variation in water levels within individual territories. Multi-year data would allow the use of more sophisticated mark-recapture models in estimating adult and juvenile survival. These data combined with similar long-term data on productivity would allow estimation of population growth in relation to variation in water level and assessment of whether populations in riparian habitat function as a source or sink.

2. Conclusions about the extent to which dam operations impact other songbirds dependant on riparian habitat in Revelstoke Reach will require additional research on other focal species that may have different ecological requirements and/or may be more vulnerable to fluctuations in water levels within Upper Arrows Lake Reservoir. Savannah sparrows, that nest on the ground, and willow flycatchers, that use more isolated willow patches and have an extended breeding season, may be suitable candidates since they are common breeding birds in riparian habitat within Revelstoke Reach.

3. Decisions regarding how best to restore riparian habitat for songbirds would be improved by integrating research on the habitat selection decisions and the relationship between habitat characteristics and demography of yellow warblers with similar data on other focal species that may have different ecological requirements. This will require further data on how vegetation and habitat characteristics at multiple scales influence settlement patterns, nest site selection decisions, productivity and survival of other riparian dependent songbirds.

4. Conclusions about the utility of abundance as a rapid and more cost effective method to evaluate the success of ecological restoration projects would be strengthened by a) having replicates for the three different types of riparian habitat monitored in this study and b) obtaining similar data on the relationship between abundance, nest success and productivity for other riparian dependent songbird.

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Table 1. Inter-annual variation in the return rate of Yellow warblers breeding at three sites in Revelstoke Reach

Parameter		2006	(N)	2007	(N)	Year Stats (P)	Site Stats (P)	Year *Site Stats (P)
Area monitored (ha)	Machete	30		30				
	Drimmie	37.5		37.5				
	Illacillewaet	39		39				
Return rate (%)	Machete	78	(23)	68	(25)	0.01	32.0	0.2
	Drimmie	17	(11)	33	(12)	(0.92)	(<0.001)	(0.91)
	Illacillewaet	18	(12)	19	(27)			
	Combined	48	(46)	44	(64)			

Figure 1: Locations of the three study sites selected from the available floodplain area above the 435m water level in the Revelstoke Reach section of the Arrow Lakes Reservoir / Columbia River