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Guerrilla Ecology: Toward an Effective Strategy for Monitoring Alberta's Trout Streams in a Hostile Climate

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Abstract—Alberta's Rocky Mountain East Slopes have some of the highest road densities in western North America (mean 2.7 km/km^2, maximum > 8 km/km^2) because of the province's multiple use policy for most public land, which permits concurrent logging, mining, grazing, petroleum exploration and extraction, motorized recreation, and suburban development. At the same time the region is experiencing changes in its climate and hydrology attributable to unchecked anthropogenic climate warming. The East Slopes provide most of the province's remaining trout sport fishery, and are the last refuge for two at-risk cold-stenothermic salmonids, Westslope Cutthroat Trout *Oncorhychus clarkii lewisi* and Bull Trout *Salvelinus confluentus*. The Government of Canada, by removing critical habitat protection provisions from the federal *Fisheries Act* and by reducing professional staff, is making it much more difficult to protect trout stocks. Together with chronically low funding of the responsible provincial agency, these factors have placed East Slopes trout and their habitats at high risk while hobbling the ability of remnant agency biologists to respond effectively. Drawing loosely on some principles of guerrilla warfare, I outline a strategy that makes it possible, even under these onerous conditions, to monitor a wide range of human influences on the region's trout populations and habitats. The approach relies primarily on a simple map-based watershed assessment, a modification of British Columbia's Level 1 Interior Watershed Assessment Procedure, combined with a temperature logger network to identify and prioritize at-risk streams and populations for more detailed analysis. Examples are given of simple, reliable, and inexpensive methods for the more detailed studies that would support actions protecting habitats and populations.

Introduction

The East Slopes, a 108,000-km^2 area of forests, mountains, and foothills east of the Continental Divide in Alberta, includes approximately two-thirds of the native range of trout and char in the province. Approximately 83% is under Alberta Government jurisdiction, the remainder being federally administered in three national parks. The East Slopes hold most of the remaining coldwater fish habitat supporting salmonid sport fisheries in southwestern Alberta.

This paper deals with the headwaters of the Bow and Oldman river drainages, which hold approximately 27,500 km^2 of the historical salmonid watersheds on the East Slopes outside of the national parks. The Bow and Oldman headwaters hold 24 native species, of which six are salmonids, three supporting extensive sport fisheries: Mountain Whitefish *Prosopium williamsoni,* Bull Trout *Salvelinus confluentus*, and Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*. Twelve more fish species have been introduced, of which three contribute significantly to the sport fishery. Bull Trout are a sensitive species listed under Alberta's *Wildlife Act* as a Species of Special Concern in the province. The Westslope Cutthroat Trout is listed as Threatened under the *Wildlife Act*; Alberta populations are listed as Threatened under the federal *Species At Risk Act*.

The East Slopes are under heavy use and development pressure, primarily from forestry, oil and gas exploration and production, and motorized recreation. In addition, anthropogenic global warming is changing the climate, with effects on regional hydrology. How these factors are affecting East Slopes salmonids is largely unmeasured. Their effects need to be monitored to inform fisheries management. Complicating these issues is an open hostility to environmental protection, especially by the federal government, which is responsible for protecting fisheries under the *Fisheries Act*.

Here I summarize the main evidence in these areas. I then outline how at least some issues might be addressed in a workable monitoring program. My aim is not to prescribe any particular monitoring system, but to instigate discussion toward initiating one that can be applied in the face of hostile governments and with minimal resources.

Challenges to Trout and Their Habitats

Land-use planning—The root of most environmental issues on the East Slopes has been the land-use plan. Since 1977, revised slightly in 1984, land-use on the Eastern Slopes has been governed by a policy document that, in most of the area, relegated protected lands (Prime Protection Zone) almost entirely to mountain peaks while designating the more productive valleys to multiple-use (Alberta Energy and Natural Resources 1984). Some lower-elevation lands were designated critical wildlife zones, but these were isolated patches with no special protection offered. Conservation of fish and their habitats was nominally part of the critical wildlife zones, but most critical fish habitat ended up in multiple use and general recreation zones. The effect has been that logging, petroleum exploration and development, grazing, and motorized recreation occur in the same places at the same time at the expense of ecosystem integrity. Most of the same mistakes are likely going to be repeated in a new plan, judging from advice offered to the government by its advisory committee (SSRAC no date). For example, provincially and federally listed Westslope Cutthroat Trout (Threatened) is not listed in the recommended plan. Critical spawning streams for Bull Trout and Westslope Cutthroat Trout populations, and nearly all critical populations of those fish, are placed in mixed-use forest lands. Proposed areas for conservation are again relegated mainly to mountaintops; the essential valley bottoms are turned over to every other kind of use.

Logging—Logging grew from the 1930s to the mid-1990s at an ever-increasing rate, so that by the late 1990s streams in 87 of 90 study basins were at moderate to high risk for 20-100 years (Mayhood *et al.* 2004). In the nearby 309-km^2 Carbondale River basin, more than 25% of the total basin had been logged by about the same time, and the entire basin was at high risk from the combined effects of increased peak flows and surface erosion (Sawyer and Mayhood 1998a). The Carbondale watershed has since had over 129 km^2 of its area burned (Silins *et al.* 2005: Figure 1), causing large, potentially long-lasting changes in the hydrology, sediment loading and water quality in the burned basins, effects that were exacerbated by salvage logging (Silins *et al.* 2009). Logging has continued despite the fact that the unrecovered burn area alone, not including previously existing cut blocks, is 42% of the total Carbondale basin area. The preferred scenario of the forest management plan for the C5 region (The Forestry Corp 2006), the relevant management area, suggests that overall, an additional 10% of the C5 forest will have been logged by 2026, more than double the existing proportion of equivalent clearcut area[1] in the 98 basins studied in the region. Several small watersheds will have had more than an additional 25% logged. These are large amounts, and the logging is being done in basins that are important to at-risk trout, for example, in O'Hagen and Hidden creeks. No special attempt has been made to protect these stocks; only best management practices are used. Serious sediment problems have been identified at Hidden Creek, yet further logging in the basin is planned.

Petroleum development—As of 1 August 2013, the Alberta Energy Regulator lists 1,674 existing wells that fall within the native range of trout in the Bow and Oldman river drainages (not including the main stems), of which 921 are abandoned and 430 are producing gas or oil. Most of these in forested areas required seismic lines and exploration trails to discover; all needed roads to drill and service them. Most producing crude oil wells and all gas wells require pipelines, which remain after the wells no longer produce. All add to the network of linear disturbance, which is a major source of fine sediment to stream networks.

All wells pose risks to aquatic ecosystems from leakage. Wells flowing under their own pressure (319 of the 430 currently producing oil or gas) particularly have the potential to leak hydrocarbons and brines into groundwater, where contaminants can eventually pollute streams. Most of the East Slopes has a high vulnerability rating for groundwater (SSRAC no date), so this is a serious issue in the region. Abandoned wells also commonly leak due to inadequate cementing of the borehole and casing. Well sites are sources of contamination from initial preparation and drilling,

[1] the area of forest cut, adjusted for hydrological recovery due to forest regrowth

through production and abandonment (Bertram *et al.* 1995), contributing a long list of hydrocarbon and heavy metal pollutants, among others.

Mining—Alberta's Energy Regulator has mapped at least 156 abandoned coal mines on the southern East Slopes within the range of native trout. New interest in mine development has been shown in the Crowsnest area at Grassy Mountain (Stephanson 2013). The same miner holds leases apparently in the Lynx Creek and lower Carbondale River drainages (Read 2013). A coal-related mine for magnetite is actively being pursued in the Rock Creek drainage. In addition to new roads and potential contamination issues, surface mines may require extensive drainage alteration, threatening trout habitat.

Motorized recreation—All-terrain vehicles are a major cause of watershed degradation in parts of the Castle, upper Oldman-Livingstone, Elbow, Sheep and Ghost river drainages. Roads[2] developed originally for resource extraction are taken over and used by motorized recreation vehicles. Overall road density from this cause in the 1,003-km^2 Castle Area Forest Land use Zone averages 1.5 km/km^2 (Lee and Hanneman 2011); in large parts of the Castle basin it exceeds 2.2 km/km^2; and in several small sub-basins it is up to 7.8 km/km^2 (Parkstrom 2002). The 99 small basins my colleagues and I have studied so far on the East Slopes have a mean road density of 1.5 km/km^2, and reach a maximum of 3.7 km/km^2. Overall mean road density for the all of the East Slopes is 2.7 km/km^2, reaching maxima of over 8 km/km^2 in some areas (Sawyer and Mayhood 1998b). Various measures of road extent are negatively correlated with abundance or occurrence of trout (Ripley *et al.* 2005; Valdal and Quinn 2011).

Climate change—By 2050 atmospheric temperatures on the East Slopes will be higher by 2-4 °C throughout the region, with some small differences between the Oldman and Bow basins (Sauchyn and Kulshreshtha 2008). In general, precipitation will be higher in winter, spring, and fall, but lower in summer on the East Slopes. The most likely consequences of this combination of factors are that future ice-free conditions will be longer, extend later into the fall, and begin earlier in the spring. Spring runoff will be larger with higher peak flows, and will occur earlier.

Streamflows then will tend to attenuate more rapidly through the summer, with either a small increase in fall or simply a recharge of soil moisture and groundwater drawn down over the drier summer. The higher peak flows can be expected to change stream channel morphology and the structure of the riparian zone. Temperature effects are likely to have disproportionately strong physiological and ecological effects in spring and fall, when temperatures would ordinarily be near the freezing point, and at low-temperature locations at any time of year, because physiological processes are much more sensitive to temperature change at low temperatures in poikilotherms (Winberg 1956).

Government hostility—Federal government hostility toward science, especially environmental science, is a major obstacle to protecting East Slopes aquatic ecosystems. A few examples: 16 clean lakes were designated as toxic dump sites; the *Fisheries Act* was gutted to remove protection for most fish and their habitats; there are numerous, repeated instances of preventing federal scientists from speaking to the public about their work or to speak freely at conferences; Federal scientists are highly restricted on how they can share data with other researchers; the Canadian Environmental Assessment Act was repealed; the Sustainable Water Management Division was cut; 1,000 jobs were cut at the Department of Fisheries and Oceans (DFO), and funding cuts are ongoing; Ocean Contaminants and Marine Toxicology Centre was axed; the Freshwater Institute was cut; Experimental Lakes area closure was announced; Fisheries Habitat Management Program was cut; development review was removed from the Navigable Waters Act on almost all rivers and lakes; DFO sabotaged scientists' access to the Experimental Lakes Area; and DFO libraries were closed Dupuis (2013). The federal government has also repeatedly attacked environmental groups involved in environmental hearings as radicals (Payton 2012), accused them of furthering the interests of a foreign power and laundering foreign money (CBC News 2012), has limited their ability to participate in public hearings (McCarthy 2012), has investigated them in a circus-like Senate hearing (McDiarmid 2012), and has had the Canada Revenue Agency audit their financial statements (Garossino 2012).

Gutting of the *Fisheries Act* has particularly harsh consequences for protecting fishes and their habitats

[2] includes all linear disturbances used by motorized vehicles, including seismic lines, pipelines, transmission lines, cutlines, exploration trails and others

(Taylor 2013). The changes mean that only habitat of those fish having value to commercial, recreational, or aboriginal fisheries are subject to the Act, and then only at the discretion of the Minister. Many important fish populations on the East Slopes do not support a fishery and are unprotected under the *Fisheries Act*: the fish are too small to attract anglers. Examples include designated threatened Westslope Cutthroat Trout remnant populations in small headwater creeks.

Monitoring East Slopes Trout Populations and Habitat

The number of threats to our watersheds and their inhabitants precludes any attempt to address all threats in every place: the resources are not available. Protecting East Slopes trout and their habitats is apparently an impossible task, comparable to the prospects for success in guerrilla warfare. Yet guerrilla forces do win wars on occasion. Their victorious leaders may suggest general principles revealed by their victory (Guevara 1961). In fact, there do not appear to be general principles for success in guerrilla warfare: victory depends strongly on the specific circumstances of the conflict (Dyer 2004).

There is nevertheless a uniform strategy: wear down the enemy using repeated hit-and-run tactics. In the present context, the major concern is the continued deterioration of watershed ecosystems throughout the East Slopes. The strategy involves attacking manageable problems—targets of opportunity—one by one using whatever primitive “weapons” are to hand. In this way small successes boost morale while edging closer to the overall objective. “Victory” is achieved when all critical watersheds are secured, their ecosystems functioning with all of their components present. It is the role of the guerrilla ecologist to conduct this “war” with ingenuity and whatever meager assets are available. It is the flexible, adaptable, and ingenious use of minimal assets that distinguishes the guerrilla fighter. The same qualities can inform the work of the guerrilla ecologist. The focus below is on such cheap, simple tools available for this work.

Role and meaning of monitoring—Environmental scientists tend to see monitoring as maintaining regular surveillance over some elements of the environment, starting before any impact has occurred (Green 1979) so as to recognize impacts, preferably before those impacts become a serious problem. Others seem to require that monitoring must provide proof of an impact before any further action is taken (RAMP 2010): in essence, they want to see the very thing monitoring is intended to prevent, to trigger action preventing it. Here I view monitoring as surveillance to detect evidence, not proof, that an unwanted impact is imminent. This evidence would then trigger further investigation to confirm or refute the threat, or action would be initiated to reduce the threat to acceptable levels.

Watershed assessment—Roads are a surrogate for development: almost every human development in East Slopes watersheds requires them and, in forested areas, clear-cuts of some sort. Trout occurrence and abundance is strongly related to measures of roads and (for Bull Trout) clear-cuts (Ripley *et al.* 2005, Valdal and Quinn 2011). A watershed assessment such as the Level 1 Interior Watershed Assessment Procedure (IWAP; BC Forest Service 1995) which relies on measures of clear-cut and roads obtained from existing public data sources, serves as a screening method to identify the level of existing risk to stream habitat posed by current development in a basin. Proposed development can then be added before approvals are granted to determine the extent of increased risk it poses. The system includes courses of action to follow up on any assessments that exceed certain thresholds. When combined with data on the distribution of critical trout populations, it is possible to focus even more closely on problem watersheds. The IWAP can also be used in restoration to identify how much of a road network, and what particular roads, need to be reclaimed, or how much clear-cut needs enhanced recovery.

Camera stations—A network of fixed, well-chosen camera stations used systematically with a scale such as a stadia rod is an effective and cheap way to monitor habitat features such as channel morphology, stream crossings, and changes in sediment sources. Stations should be chosen with information from the IWAP to establish effective sites. A large number of such sites can be photographed by one person in a day for the cost of tank of gas and a pack lunch. Changes in photographed features over time can be used to support management actions.

Monitoring populations—Direct monitoring of trout populations is necessary for obtaining some kinds of information to support management action.

Angling can be a solution that is minimally invasive and still provides specimens for genetic sampling (scales), external health assessment, sex determination, length, weight, and photography. With photographic identification of individuals (Gifford and Mayhood 2013), valuable data on abundance and movements can be obtained without the need for marking.

Temperature logger network—The East Slope's two most at-risk species are highly sensitive to the temperature increases that can be expected from climate change. Both will be excluded from lower main stems and restricted increasingly to cold headwaters. Westslope Cutthroat Trout headwater remnant stocks additionally will become more susceptible to hybrid invasions as more warm-tolerant Rainbow Trout *Oncorhynchus mykiss* and their hybrids with cutthroats are able to move up into the headwaters (Rasmussen *et al.* 2010). There are at least two needs for monitoring stream temperatures in a program intended to manage East Slopes trout. One is to monitor for temperatures permitting upstream Rainbow Trout allelic invasion. The other is to find unoccupied habitats, perhaps above barriers or in waters that can be reclaimed, into which remnant populations can be archived. Populations at risk from habitat contraction, and from habitat expansion favorable to Rainbow Trout, can then be identified before they are placed at more serious risk. They might then be moved to more suitable, safer habitat identified by the broader temperature monitoring. Dan Izaak's Climate-Aquatics Blog (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html) is a good source for aids in planning such a program.

Decomposition monitoring—Most East Slopes streams decompose allochthonous organic matter such as leaves and needles from the surrounding forest, producing trout food in the form of benthic invertebrates. Changes in decomposition measure changes in stream ecosystem function, and are likely to arise from any large-scale change in land use. Stream ecosystem function can be monitored from decomposition using leaf and needle packs (Reice and Wohlenberg 1993).

Whole ecosystem experiments—Every intrusion into a watershed is a whole-ecosystem experiment if properly monitored. By monitoring new and existing development with the proper study design, it is possible to detect effects of that development. Those findings then become data that can be applied to new proposals of a similar sort. One of the greatest lost opportunities of the massive development along the East Slopes has been that new developments have so seldom been monitored as they are built, and thereafter as they are operated.

Given the extent of existing development on Alberta's East Slopes and the lack of interest—even hostility—of governments toward environmental protection, we have no reason to expect an improvement in protecting its trout populations and habitats any time soon. The few ideas presented here can form part of a guerrilla-type strategy to maintain at least some pieces of the regional aquatic ecosystems intact while we await more enlightened government policies. Properly communicated, even a skeletal monitoring system can assist in bringing such policies about.

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