Oldman Watershed Background Information for Environmental Education

Fall 2014-Spring 2015 Applied Study Resource

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Image: OWC Pintrest

1. Introduction

1.1 – Caring For Our Watersheds Contest

Caring For Our Watersheds is an international contest put on by Agrium. In each country they join forces with one local organization per watershed, Alberta's community partners are mostly local Watershed Planning and Advisory Committees. The Oldman Watershed Council is one of the Southern Alberta community partners and the organization I am doing Applied Studies with for my Bachelor's Degree in Environmental Science. The contest asks students to submit written proposals answering the question: "What can you do to improve your watershed?" Cash prizes are awarded to the top 10 finalists of each watershed before going onto a provincial round of judging. The judging process considers the originality, feasibility and the environmental impact of each entry. Agrium also covers a portion of the implementation costs for winning concepts.

To promote the contest, I will be presenting in classrooms across the Oldman Basin, at the South Western Alberta Teachers' Convention and to various youth groups including some at Helen Schuler Nature Centre in Lethbridge, Alberta. The 45 minute presentation is designed to highlight key ecological concepts and issues in the Oldman Basin so students are more familiar with their watershed prior to brainstorming ideas. The research put forth in this paper will be communicated at a level of understanding that the 12-18 year old age group can grasp. The scientific facts and data presented to students are balanced with positive, personal connections to the Albertan landscape such that the overall presentation is inspiring in spite of complex and sometimes discouraging environmental issues.

1.2 - Presentation Layout and Related Materials

Content from sections 1.3-6.2 will be delivered in classrooms and community meeting areas to high school students, 4-H clubs and various youth organizations. The presentation layout was chosen in order to maximize available materials that have been organized in a similar fashion, particularly the

2010 Oldman River State of the Watershed Report, published by the Oldman Watershed Council. The overall health of the Oldman Watershed was reported in The State of the Watershed Report by splitting the basin into five sub-basins and assessing the following indicators in each sub-basin: water quality, water quantity, terrestrial and riparian ecology. The presentation starts by discussing the Oldman Watershed as a whole, introduces more detail sub-basin by sub-basin and concludes with more general Watershed level talk. It was determined by myself and my workplace supervisor that focusing on one ecological feature per sub-basin was reasonable to keep the presentation under one hour and avoid overloading students with information.

A highlight of this project is that it uses very little paper; the presentation delivery and follow-up quiz are in digital format. The follow up quiz consists of multiple choice questions based on presentation content and is completed online. It will serve as a measure of our success because our main goal is to further the environmental awareness of students, not just get them to participate in the contest. Although the number of contest entries will certainly be useful in gauging our success, we wish to see how much the students absorb and if taking the time to deliver presentations is worth the effort in the future. A workbook that Agrium put together for developing contest ideas, which requires research as well as budgets and action plans, will be printed but only distributed to those who wish to participate to reduce paper waste. Instead of paper fact sheets to break up the spoken portion of the presentation, the use of videos allows for changes in pace and focus without wasting the time and resources associated with handing out individual sheets. The videos providing background on the contest, a brief history of the Oldman Basin and the cumulative effects of major land uses in the Oldman Watershed. These three videos efficiently explain broad topics to save time and paper while providing powerful graphics.

1.3 General Facts and Water Use

Five major streams characterize the Oldman Watershed: the Oldman, Crowsnest, Castle, Belly/Waterton and St. Mary rivers. The Alberta portion of the Oldman Watershed is 26,473.15 km^2 in area (ALCES, 2015). The Oldman Basin lies within the greater watersheds of the South Saskatchewan River and Hudson's Bay (Romanuk, 2006). To reinforce the graphics shown in the presentation that demonstrate the nested concept of the Oldman, South Saskatchewan and Hudson's Bay watersheds we have a large roll-out carpet with an image of Canada from Alberta to Hudson's Bay. The carpet shows how the Oldman and Bow rivers join to form the South Saskatchewan which then flows to Lake Winnipeg and onto Hudson's Bay from there. During the presentation I ask for a volunteer to come up and "walk the watersheds" in a scenario where we are tubing from the headwaters of the Oldman River to Hudson's Bay. Watersheds are what this contest is about so there is an emphasis on understanding what a watershed is before covering further material. The definition of a watershed, as defined by Environment Canada, provided in the presentation is: "A watershed is an area of land that water flows across or through on its way to a particular water body, such as a stream, wetland or coast."

Water use (Figure 1) and conservation in the Oldman Watershed is introduced after demonstrating the global availability of freshwater. This was done to establish two things: our limited supply of freshwater and the widespread demands on that small quantity. Means of conserving water would likely not mean much to students if the problem, limited freshwater, was not clearly emphasized prior to explaining how to use less water. I mention means of improving water use such as using newer, more efficient irrigation pivots as the majority of our water, 91% (OWC, 2010) is used for irrigation but conservation efforts embraced by students are likely to fall under municipal uses. Conservation tips include: the use of low flow showerheads and toilets, fixing leaky appliances, efficient teeth brushing and dish washing, rain barrels and practical landscaping. In the Oldman basin there are roughly 70 towns and villages within the basin including 26 urban municipalities, 11 rural municipalities and 2 First

Nations' Reserves (OWC, 2010). The ALCES video is very useful in demonstrating the trend in water quality in the Oldman Basin since European settlement that shows decreasing water quality with an increasing human population and demand for water.

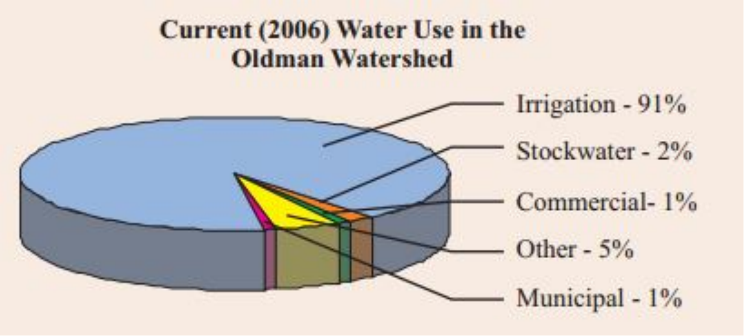


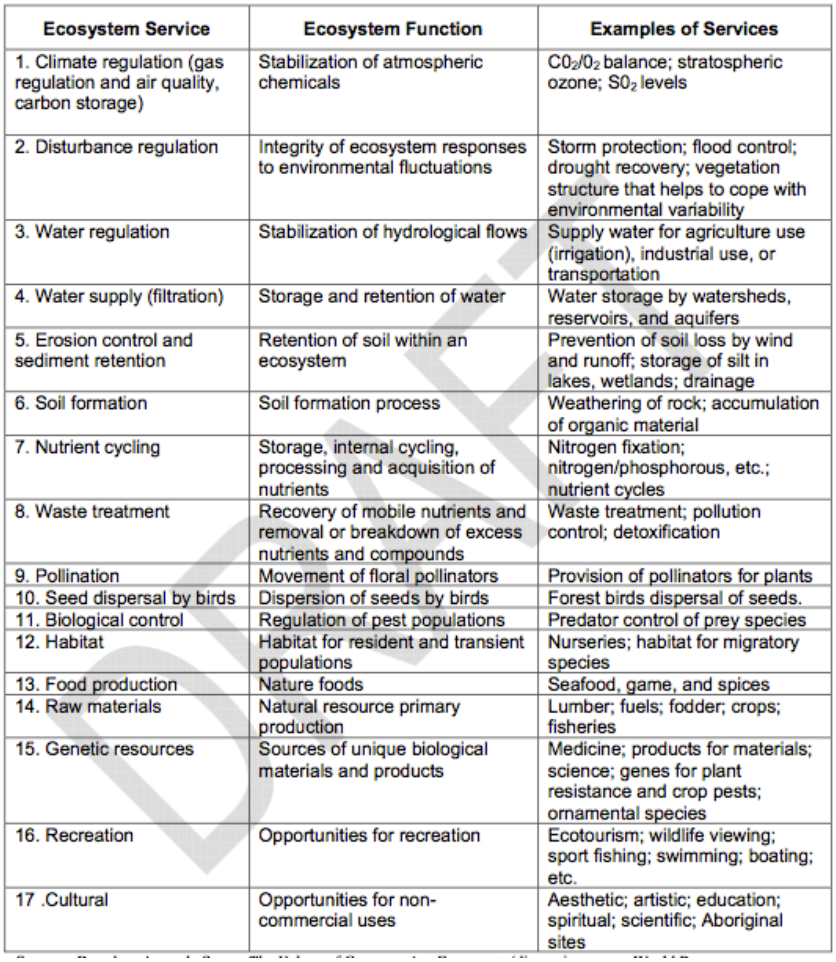
Figure 1. 2006 water use in the Oldman Watershed, State of The Watershed Report 2010.

I show that water conservation can work by showing a graph from The City of Calgary 2013 Water Report that displays decreasing per capita water use values for Calgarians over the last 11 years. In 2010 the population of the Oldman Watershed was around 210,000 people (ALCES, 2015) so it could make the impacts of basin-wide conversation seem powerful by pointing out that Calgary had close to six times the population of our entire basin last year. If a large city like Calgary can make changes like that then perhaps the students won't feel that increased water use efficiency is impossible to accomplish, even if our water uses as a basin are not identical to a large metropolitan area. There are challenges to improving watershed health but part of my goal with this presentation was to make progress seem achievable. Providing evidence of improvement instead of just talking about it should help students from feeling discouraged or that simple actions or small changes do not have large impacts.

1.3 Land Use

Cultivated cropland, confined feeding operations, cattle ranching, forestry and oil and gas are the main industrial scale land uses of the Oldman basin. These land uses are mentioned in the presentation with the sub-basin the industry is most relevant to. Simply listing the land uses without relating them to a specific sub-basin might fail to illustrate just how busy the landscape is as a whole. The concept of a busy landscape is demonstrated very well with a video that was developed by Dr. Brad Stelfox of the ALCES Group based in Calgary, Alberta. In the video he starts with a blank outline of the Oldman Watershed and uses modeling technology and reliable data to show the footprint, or area, of various human land uses: road networks, mining, oil and gas infrastructure, gravel pits, cut blocks, pasture land, cropland and human settlements from the time of European settlement to 2010. After the individual land uses are illustrated they are all shown on the watershed outline at once to powerfully demonstrate how over 50% of the land in the Oldman Watershed has been or is under direct human use(s) (ACLES, 2015).

If students are to understand and identify issues within the Oldman River Watershed, such as water quality, they should understand what has occurred on the landscape over time such that water quality has become compromised. Ecosystem services (Figure 2) are only briefly mentioned as they are mostly beyond the students' scope. Ecosystem services are useful in explaining the value of intact landscapes and provide background for why the cumulative effects of anthropogenic land use are important to be aware of. Illustrating the natural capital of the Oldman Watershed with dollar values was seen as a chance to put the value of ecosystem services provided by functional ecosystems into perspective for students. ALCES modeling has been used to calculate how in parts of Alberta, the value of some ecosystem services on a per-hectare basis is of a similar magnitude to or exceeds the Gross Domestic Product (GDP) generated from forestry, natural resource extraction, agriculture, recreation and all other sectors depending on the region's area (ASPEN Group, 2008). Grasslands, for example, provide climate regulation with a 2006 value of $766,000,000 and water supply services of $1,135,400,000 (ASPEN Group, 2008). The total 2006 GDP generated from the South Eastern Slopes Region was $3,639, 571,484 which is a value that includes all industrial sectors (ASPEN Group, 2008). The total dollar value of all ecosystem services in this region equates to a 2006 value of $2,871,700,000 meaning that the 2006 GDP, which requires a great deal of human labour and planning to generate, wasn't even one billion dollars greater than the ecosystems services provided by the South Eastern Slopes, virtually for free. It is my intention that students will at least understand the value of functional ecosystems instead of each individual service itself, as that could get quite complex and confusing.



Ecosystem Service	Ecosystem Function	Examples of Services
1. Climate regulation (gas regulation and air quality, carbon storage)	Stabilization of atmospheric chemicals	$C0_2$/0_2 balance; stratospheric ozone; $S0_2$ levels
2. Disturbance regulation	Integrity of ecosystem responses to environmental fluctuations	Storm protection; flood control; drought recovery; vegetation structure that helps to cope with environmental variability
3. Water regulation	Stabilization of hydrological flows	Supply water for agriculture use (irrigation), industrial use, or transportation
4. Water supply (filtration)	Storage and retention of water	Water storage by watersheds, reservoirs, and aquifers
5. Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of soil loss by wind and runoff; storage of silt in lakes, wetlands; drainage
6. Soil formation	Soil formation process	Weathering of rock; accumulation of organic material
7. Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation; nitrogen/phosphorous, etc.; nutrient cycles
8. Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess nutrients and compounds	Waste treatment; pollution control; detoxification
9. Pollination	Movement of floral pollinators	Provision of pollinators for plants
10. Seed dispersal by birds	Dispersion of seeds by birds	Forest birds dispersal of seeds.
11. Biological control	Regulation of pest populations	Predator control of prey species
12. Habitat	Habitat for resident and transient populations	Nurseries; habitat for migratory species
13. Food production	Nature foods	Seafood, game, and spices
14. Raw materials	Natural resource primary production	Lumber; fuels; fodder; crops; fisheries
15. Genetic resources	Sources of unique biological materials and products	Medicine; products for materials; science; genes for plant resistance and crop pests; ornamental species
16. Recreation	Opportunities for recreation	Ecotourism; wildlife viewing; sport fishing; swimming; boating; etc.
17 .Cultural	Opportunities for non-commercial uses	Aesthetic; artistic; education; spiritual; scientific; Aboriginal sites

Figure 2. Ecosystem services of the South Eastern slopes of Alberta (ASPEN Group, 2008).

Industrial, agricultural, municipal and recreational land use as well as the required infrastructure for each sector can have impacts of the landscape that vary in positive or negative magnitude depending on the practices followed. Topography generally limits most of the land use decisions in the Oldman Basin therefore the pressures in the mountain sub-basin can be quite different than other sub-basins. Recreation and natural resource extraction in the forms of mining and forestry are the major sources of environmental deterioration in the Castle River Headwaters (Jeffery, 1964). Overgrazing (Widenmaier & Strong, 2010), the loss of fire (Widenmaier & Strong, 2010), municipal wastes (Rock & Mayer, 2006) plus runoff from confined feeding operations (Rock & Mayer, 2006) and cultivated lands (Evans *et al.,* 2012) are some of other anthropogenic land uses that may diminish natural capital in other areas of the Oldman Basin.

Beyond the individual land uses that result in marketable goods comes the need to travel between sites and transport goods. Transportation networks are demonstrated in the ALCES video as an individual type of land use footprint. Roads were displayed separately from the industry/industries utilizing them to show that the effects of a single industry are not limited to where the majority of work sites occur at present. This applies particularly to logging and oil and gas, as cut blocks, well pads and access roads are usually detectable long after resource extraction occurs. The loss or alteration of intact landscapes, habitat fragmentation, introduction of invasive species, extirpation of local species, increased sediment, nutrient and contaminant loads in water are not necessarily the result of a single action or land use. This is why showing individual land uses over time followed by the cumulative footprint of all land uses was felt to be most effective in demonstrating the busy landscape of the Oldman Watershed.

It is difficult to come up with solutions unless people understand the nature of the problem(s) they are facing. A steady decline in water quality within the Oldman Watershed coincides with a growing human population since European Settlement (ALCES, 2015). It seems intuitive that as more people are present on the landscape, the greater the demand for land and water but this is clearly communicated to students to ensure they make that connection. Documented issues with water quality, both past and recent, are abundant in the primary literature. Elevated levels of Nitrogen and Mercury as well as the presence of Endocrine Disruptors in water of the Oldman Basin have been recognized multiple times over the last decade alone (Rock & Mayer, 2006; Brinkmann & Rasmussen, 2012; Evans *et al.,* 2012) which illustrates that water quality issues are not necessarily the result of a single source or action.

The presence of excess nutrients and bacteria as well as manufactured substances such as pharmaceuticals in water demonstrates the impact humans can have on ecosystem health. Ecosystem health is a concept that was introduced to the scientific community by Hutton and Clements in the early 20th century (Scrimgeour & Wicklum, 1996). Since they pioneered the concept of ecosystem health there has been a distinction between ecosystem health and integrity, terms that were at one point considered interchangeable (Scrimgeour & Wicklum, 1996). Ecosystem health refers to the normal occurrence of ecological processes and functions (Callicot, 1995), also the preferred state of ecosystems already modified by human actions. Ecosystem health differs from ecosystem integrity in that ecosystems with integrity are unimpaired by anthropogenic activities in structure or function (Scrimgeour & Wicklum, 1996).

To measure health, ecosystems with integrity could act as the baseline for a comparison with ecosystems altered by humans. The absence or alteration of ecological processes and structure in the modified ecosystem in contrast to ecosystems with integrity could be used to infer the health of the modified system. Health may also be a function of how feasible the restoration of processes and structure would be such that the modified ecosystem could function naturally once again in the absence of humans after restoration efforts were complete. These definitions are relevant because issues of integrity can be lost due to humans and health can vary with management actions. An ecosystem with poor health may not become an ecosystem with integrity again but the impaired stream could be managed to improve quality such that it starts to resemble the baseline ecosystem and regains some health.

Since human settlement in the Oldman River Basin, water quality has changed greatly. Nitrogen inputs have gone from approximately 120 kg N km^{-2} yr^{-1} to 5,180 N km^{-2} yr^{-1} (Rock & Mayer, 2006) by the turn of the century, a 43-fold increase. 5,180 km^{-2} yr^{-1} represents Nitrogen inputs from cattle manure, synthetic fertilizer, increased nitrogen fixation and human wastes (Rock & Mayer, 2006). This change in nitrogen loading is an example of the cumulative effects of land use in the basin as the human population increases, cattle populations remain high and intensive agriculture practices continue. High levels of nitrogen and other nutrients are associated with damaging algal blooms and the creation of dead zones in oceans which is mentioned to students as a demonstration of how actions here in Southern Alberta doesn't only impact local ecosystems. Mercury levels are also believed to be a result of agricultural and municipal activities (Brinkmann & Rasmussen, 2012) while Endocrine Disruptors are only associated with human effluent and pharmaceutical use in urban centers (Evans *et al.,* 2012). Both of these compounds can cause deformities in aquatic organisms (Brinkmann & Rasmussen, 2012; Evans *et al.,* 2012). Deformities in fish have been well documented and in a presentation with a major emphasis on water quality, they are a good example of multiple sources contributing to poor water quality in the Oldman Watershed.

2. Mountain Sub-basins

2.1 – Ecology and Background

Large scale projects like the 2010 State of the Watershed Report by the Oldman Watershed Council (OWC) are extremely useful sources for research and management information. This report provides a record of the Oldman Watershed's current status that can then be used to find areas in which to focus management efforts and provide a recent baseline for future studies to compare their results to. In that report, each sub-basin as well as the watershed as a whole was rated as poor, fair or good. "Good" water quality and quantity as well as terrestrial and riparian health contributed to the overall "good" rating of the Mountain sub-basins (OWC, 2010). This sub-basin had the best overall rating of the five described in the report as well as the best rating for water quality. These ratings present a chance to focus on the source of our good quality water as well as the relationship between quality and the human presence seen in our basin, one in which water quality appears to decrease as the human population increases (ALCES, 2015).

Appreciation for water resources involves understanding where we get our water from, mostly snowmelt, and that this source is not guaranteed or constant. Water quality is highest in the headwaters of the Oldman Watershed (OWC, 2010), which will be emphasized to reinforce the coincidence of declining water quality downstream with increased human activity. The topography of this area helps to limit intensive agriculture and large municipalities when compared to the degree of development observable in other sub-basins. The Oldman River headwaters occur in the glacial montane ecoregion in the Livingstone Range of the Rocky Mountains (Romanuk *et al.,* 2006). Coniferous trees are dominant in this ecoregion, which aid in the interception and accumulation of snow more than deciduous trees due to their physical structure. Over 70% of the water supply in the Oldman Basin is derived from the annual snowpack (Byrne *et al.,* 2006). Data taken in Lethbridge shows an 18.3cm decrease in snowpack from 1962-2003 (Schindler & Donahue, 2006). Variation in snowpack depth produces variation in the amount of water sourced from the mountain sub-basin to the Oldman, South Saskatchewan and Hudson's Bay watersheds.

The high flows of rivers and streams within the Oldman Watershed in late spring are observed due to the melting snowpack in the mountains and heavy rains from mid-May to mid-July (Poirier & Loe, 2011). The flow of Southern tributaries sub-basin is also supplemented by glacial melt in Waterton Lakes National Park in Alberta and Glacier National Park in Montana (Treanor *et al.,* 2013). The timing of spring runoff from snowmelt raises concerns for water supply in the Oldman Basin as summer flows have decreased over the last century (Figure 3) to just over 40% of their initial flow from 1910-2000. Water demands are highest from May-August due to irrigation, municipal uses and high instream flow needs (Byrne *et al.,* 2006). Figure 3 demonstrates peak discharge typically occurring in early June after which flows rapidly decrease. This presents an issue as supply becomes much more limited towards the latter portion of summer in July and August when demand for water is still high. In an already water stressed, semi-arid climate (Poirier & Loe, 2011), decreasing flows are particularly concerning when considering future water availability and use.

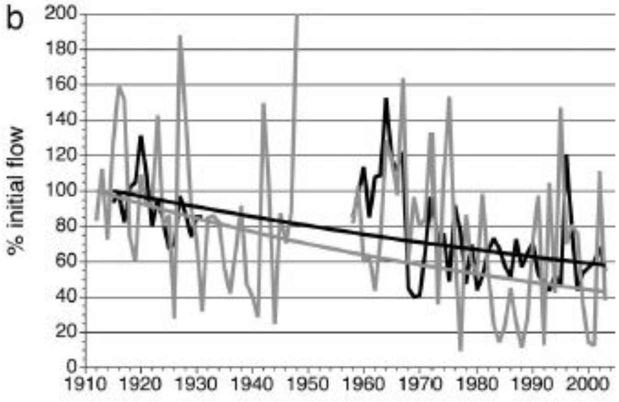


Figure 3. A historical record of the Oldman River (gray) and Peace River (black) summer flows from 1912-2003 (Schindler & Donahue, 2006).

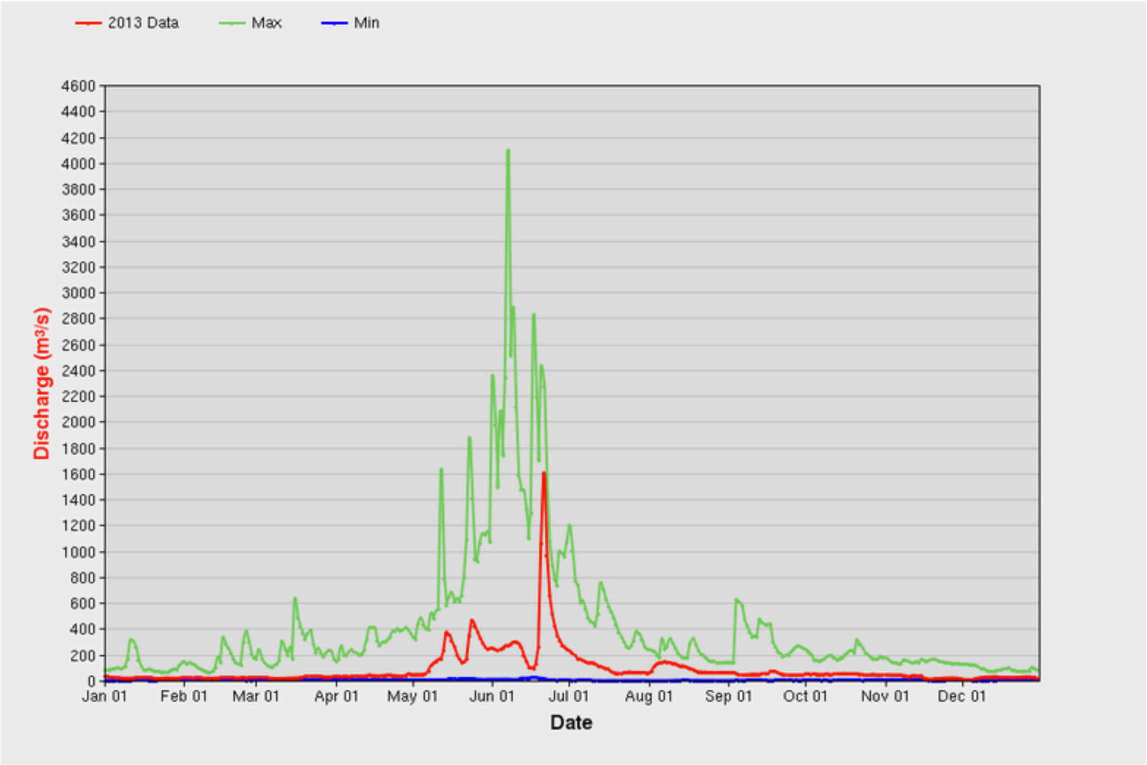


Figure 3. Annual 2013 Hydrograph for the Oldman River at Lethbridge (WSC, 2015). Red corresponds to the daily mean discharge for 2013 (m^3/s), green as maximum discharge (m^3/s) and blue for minimum discharge (m^3/s).

2.2 – Cutthroat Trout

As one of four native trout species in Alberta, Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) occupy less than 20% of their historic range. In 2006 the Alberta portion of WCT were designated as threatened (Fitch, 2013). They are now restricted to the upper drainages of the Oldman and Bow rivers as overexploitation, habitat degradation and hybridization with introduced non-native trout have reduced their pure populations (The Alberta Westslope Cutthroat Trout Recovery Team (TAWCTRT), 2013). Recent research has shown that cold temperatures less than 7.3 degrees (Rasmussen, Robinson & Heath, 2010) and shallow waters are strongly selected for however the need for extensive research to confirm specific habitat requirements has been outlined in the 2012-2017 Species Recovery Plan.

I took this section as an opportunity to explain the idea of using an indicator species, which Westslope Cutthroat Trout are an example of, to infer general ecosystem health as well as water quality (TAWCTRT, 2013). Westslope Cutthroat Trout have evolved under specific habitat requirements therefore the remaining isolated populations of the Oldman headwaters help to make inferences about possible changes in alpine water and habitat quality (Wenger et al., 2011). Measuring concentrations of nutrients, sediment and pollutants may seem too complicated or boring to students so indicator species are mentioned as another way of learning about water quality.

A common ancestor with rainbow trout (*Oncorhynchus mykiss*) allows hybridization with WCT in spite of different life history characteristics (Rasmussen *et al.,* 2010). WCT are very temperature sensitive and in the Oldman Basin headwaters are typically found in areas where the average summer water temperature does not exceed 7.3 degrees (Rasmussen *et al.,* 2010). Introduced rainbow trout are able to outcompete WCT at lower elevations as they have been selectively bred to do well in warmer water. Compared to WCT, rainbow trout have lower survivorship, grow faster and have higher food requirements that are unlikely to be met by high elevation streams of lower productivity compared to streams of lesser elevation where rainbow trout are more abundant (Rasmussen *et al.,* 2010).

Records for rainbow trout stocking began in 1950. Since this time over 1.5 million rainbow trout have been introduced into the Oldman Drainage in Dutch and Racehorse creeks as well as the Livingstone, Oldman and Crowsnest rivers. A gradient is observable in the basin with pure WCT in the headwaters, pure RT in lower elevations and a zone of hybridization between (Rasmussen *et al.,* 2010). The increased frequency of rainbow trout alleles at higher elevations over time may be used in the future as an indicator of water quality and overall ecosystem health in the Oldman Watershed.

Hybridization is a major issue for trout populations and a well backed, scientific example of the effects of anthropogenic actions on an ecosystem scale. It is also easier to find literature that will directly relate a cause (hybridization) and effect (declining pure WCT) to human actions (RT stocking) whereas documents that explicitly state declining populations due to anthropogenic actions as a cause of decline is not as easy to come by in recent primary literature, unlike other threatened species in other sub-basins.

3. Foothills Sub-basin

3.1 – Ecology and background

Foothills rough fescue (*Festuca campestris* Rydb.) is the dominant climax species (Willms, 1991) of the Foothills sub-basin, which is rated as “Fair” in terms of overall health (OWC, 2010). Mean annual precipitation of this region is 550mm giving it a sub humid classification (Naeth *et al.,* 1991). Orthic black chernozemic soil coupled with above average precipitation for the basin allow for highly productive grasslands (Willms & Chanasyk, 2006). This grassland ecozone is a biodiversity sink that is vital to the foraging of both wildlife and livestock in Southwestern Alberta (Thrift, Mosley & Mosley, 2013) hence extensive research has been carried out regarding the effects of grazing on foothills fescue grasslands.

Considering that the topography of the Foothills makes this sub-basin more accessible than the mountains, which was also rated good for terrestrial and riparian habitat, I saw this as an opportunity to discuss sustainable grazing as a land use that rely on healthy ecosystems annually. A deficiency in a specific nutrient on the grasslands is not mediated by a round of chemical fertilizer as is practiced in cultivated agriculture. Forestry for example does not utilize the exact same pieces of land year to year because a cut block cannot be harvested again until decades of regrowth have occurred. The grasslands of the Foothills sub-basin are managed primarily by annual grazing and if mismanaged, create the potential for economic losses during subsequent years until the land is capable of providing sufficient grass cover for cattle to forage on.

3.2 - Grazing

Grazing by cattle can have varying impacts on rangelands depending on the intensity as well as the timing and duration of grazing (Naeth *et al.,* 1991). Rough fescue is the most productive grass species for foraging among the native species of the Foothills Region, provided it occurs on range in good condition (Wilms, 1991). It is important for land managers to understand the interactions between grasslands and grazing in order to manage for desirable grass species such as rough fescue and the range condition that allows for abundant and productive fescue pastures. Many ranchers prefer rough fescue for grazing to timothy, june grass, brome and other non-native/invasive species (Ryan, Gordon and John Cartwright 1990s-2000s; personal communication). Part of this preference is because rough fescue's relatively good nutritional content during winter dormancy. It is high enough that it can act as forage along with baled hay that is also fed on the range during winter unlike other grasses in Alberta. Rough fescue's ability to act as a supplement to baled hay makes winter feeding easier by reducing costs of feed, equipment maintenance and labour.

Vegetative cover and water holding capacity are characteristics of grasslands directly impacted by grazing intensity. Low vegetative cover is often observed as a result of early season grazing under moderate-heavy regimes (1.6-2.4 AUM ha^{-1}) whereas light grazing (1.2 AUM ha^{-1}) typically results in the highest level of cover (Naeth *et al.,* 1991). Cover is important because bare ground translates to evaporative losses (Naeth & Chanasyk, 1995) as well as the potential for invasion by weeds and non-native grasses (Naeth *et al.*, 1991) and water erosion. Cover also allows for the retention of litter, which can increase decomposition rates and nutrient cycling as cattle help to fragment above ground biomass while adding nutrients through excretion.

The water holding capacity (WHC) of foothills rough fescue decreases with grazing intensity; moderately grazed plots had an intermediate WHC whereas heavy and very heavy treatments showed both showed a reduced WHC (Naeth *et al.,* 1991). The ability to retain water is a function of soil aggregation and root systems (Figure 4). Unlike cultivated crops, most grassland pastures in Southern Alberta do not undergo irrigation to stay moist. Water held below ground by root systems can be redistributed to other plants through hydraulic lift thus improving overall range condition. The study by Naeth *et al*. (1991) also looked at mixed prairie and parkland fescue, two types of grasslands that did not have water holding capacities outside of the range: 35-84%. Foothills rough fescue had a WHC that of 124% even under very heavy grazing. WHC values for moderate and heavy grazing were 130% and 133% respectively. These results demonstrate that foothills rough fescue outperforms other grass species in Alberta when it comes to services such as water regulation and retention.

Figure 4. A demonstration of rough fescue's root systems with varying degrees of removal of plant material above ground, Canadian Journal of Plant Science.

The flexibility of foothills rough fescue due to its resilient nature of foothills rough fescue makes it a desirable grassland type for cattle ranching. Naeth also found that of parkland fescue, mixed prairie and foothills rough fescue, light-moderate season-long grazing is ecologically ideal only for foothills rough fescue and none of the other grassland types. Occasionally issues such as damaged fences and undesirable range conditions like excess moisture force ranchers to leave cattle in a pasture longer than desired. Discretion on a situation-by-situation basis is required but it is typically better for the pasture to leave cattle on for a longer time period than move them to a soggy field that would be more prone to compaction. Rotational and/or deferred grazing is a common technique employed by ranchers to rest fields that cannot withstand long periods of grazing.

In the Foothills of Southern Alberta many ranches are extremely large compared to others in the province. The time and effort required to move hundreds of pairs of cattle across thousands of acres of varying terrain on horseback, to decrease surface disturbance by motorized vehicles, as frequent as most rotational grazing programs suggest is not always feasible on ranches of this size. Weather conditions in this region often interrupt what may seem like the best plans on paper providing yet another reason why this grassland type is well suited for cattle ranching, hence reliance upon conservation efforts as opposed to relocating to less desirable types of grassland to maintain high quality ranchland.

4. Prairie Sub-basin

4.1 – Ecology and Background

The prairies of the Oldman Basin are considered semi-arid as the mean annual precipitation is 30-45cm (Poirier & Loe, 2011). When the area was first surveyed prior to settlement John Palliser deemed the area unfit for agriculture (Fitch 2014, Personal communication; Schindler and Donahue, 2006). 76% of this sub-basin’s area is cultivated land (OWC, 2010), which is made possible, in light of

Palliser's predictions, by managed rivers. Many people make the connection between the prairies and food production without realizing the effects the agricultural industry has on the terrestrial landscape as well as the water resources at multiple spatial scales.

The overall rating of this sub-basin is fair to poor (OWC, 2010) making it the lowest ranked basin in the Oldman Watershed. The prairies sub-basin also has the lowest rating for the terrestrial and riparian indicator. Keeping these ratings in mind I chose to discuss riparian areas and wetlands in connection with a different sub-basin in the presentation to avoid overly negative coverage of the prairies sub-basin. With that said, the reality of human land use in the prairies which contributes to degraded ecosystems were sufficiently covered as to not understate the consequences of our actions.

Grasslands currently cover 21% of the Prairie sub-basin (OWC, 2010) with a total area of 6,007.49 km^2 (ALCES, 2015). Native grasslands are typically associated with high biodiversity among plant, invertebrate and vertebrate communities. In 1910 approximately 16, 829 km^2 of native grassland existed here, translating to a loss of 36% in area (ALCES, 2015). The loss of natural habitat in the Prairie sub-basin has resulted in shifts in the abundance of previously common grassland specialist species such as burrowing owls (*Athene cunicularia)*. At-risk species such as the burrowing owl generally avoid croplands and grazed pasture in favour of grass-forb areas that support the insects owls prefer to forage on (Alberta Environment and Sustainable Resource Development, 2012). The specific habitat requirements of burrowing owls among other specialist species demonstrate the need to maintain what is left of native grasslands in the Oldman Basin if conservation goals set forth for at-risk species by the provincial government are to be achieved.

4.2 – Cultivated Agriculture

Agricultural intensification has had a domino effect in degrading the terrestrial landscape in the prairie sub-basin. The previously mentioned 36% loss in grassland area is due to human footprints such as road networks, oil and gas infrastructure, human settlements and cultivated agriculture (ALCES, 2015). As grasslands are torn up to be replaced with cropland the result is a plant community that is very simple. Crops typically contain a single plant species. Farmers don't typically plant more than one crop type in a field in a given year whereas healthy grasslands consist of multiple plant species. The burrowing owl is an example of a species from the grasslands that would aide in controlling insect populations. With the loss of predators comes an increase in pests. To control pests and maintain profitable crop yields, pesticides are applied to crops in the absence of the pests' natural predators (Meehan *et al*., 2011). While crop yield has economic and social significance, pesticide use and intensive farming is associated with declining pollinator populations (Brittain *et al.*, 2010). There overall loss of biodiversity is reflected in the poor health of terrestrial and riparian habitat indicator as well as the water quality of the prairie sub-basin (OWC, 2010).

Agriculture is the main water use in the Oldman Watershed, which has an overall water quality rating of good-fair (OWC, 2010). Pesticides, bacteria and nutrient concentrations in water increase as a function of the land area subject to intensive agriculture (Palliser Environmental Services Ltd. and Alberta Agriculture and Rural Development, 2008) and water quality is poorest in the prairie sub-basin where agriculture is the dominant land use (OWC, 2010). A diverse agricultural landscape consisting of both feedlots and croplands allows for many non-point sources of pollutants to enter water ways that include: fields under pesticide and fertilizer application, feedlot effluent and municipal wastewater outputs (Evan *et al.*, 2012). Extensive modern agriculture is likely the largest contributing factor to the degraded water of this sub-basin as 28 organic compounds have been found in these waters during past research (OWC, 2010).

The prairie sub-basin has the greatest West-East length of all sub basins in the Oldman Watershed, which allows for greater accumulation of contaminants from multiple non-point sources. In a watershed where flows are decreasing (Schindler & Donahue, 2006) during the summer period of high agricultural activity, less water is available in streams to dilute added pollutants as they travel downstream (Palliser Environmental Services Ltd. and Alberta Agriculture and Rural Development, 2008). Elevated levels of contaminants have a variety of ecological implications but I chose to focus on one in my presentation, an example involving aquatic species affected by both agricultural and municipal effluent. Work focused on the effects of endocrine disruptors on longnose dace found that those exhibiting feminization, altered growth and deformed gonads have high levels of endocrine disruptors in their gonads (Evans, *et al.*, 2012). Endocrine disruptors are occur in pharmaceuticals that humans take as well as in veterinary chemicals for livestock. The City of Lethbridge has taken action to reduce the high concentrations of contaminants such as endocrine disruptors leaving the waste water treatment plant (OWC, 2005) however not all municipalities can afford to do the same and livestock effluent remains an issue.

My reasoning for only choosing one example of the ecological effects of contaminants in water ways of the Oldman Basin was for the sake of time and to avoid negative focus on the prairies. The Oldman Watershed Council has had difficulty getting citizens from that basin involved in the watershed and I was told to be realistic but not overly negative as to not dissuade anyone from this sub-basin in the audience from further participation with the OWC. Given that water quality is mentioned throughout the presentation with multiple references to the effects of agriculture on water quality I am confident that the message of how agriculture is related to water quality was made very clear. Another reason the issue of agricultural chemicals was not extensively researched is that I would be identifying a problem that students cannot fix. It is unrealistic to think that Agrium would fund a project for the mass shut-down of intensive agriculture in Southern Alberta or that students would attempt such a thing. With that said, it is important for students to be aware of real issues which is why this topic receives at least as much attention as the other problems put forth in this paper such as a declining snowpack, the degradation of various habitat types, fragmentation by industry and municipalities, as well as water use, conservation and treatment.

4.3 – Dams and Irrigation

Over 70% of the water that originates within the Oldman Watershed is used agricultural purposes (OWC, 2010). Dams and irrigation networks are fundamental in providing the water that enables a high degree of intensive agriculture in the Oldman Watershed. Twenty percent of the Oldman Watershed's agricultural land is irrigated (OWC, 2010), most of it occurring in the prairie sub-basin. Three major on-stream storage reservoirs help to make the irrigation industry viable: the Oldman, Waterton and St Mary's (Alberta Water Portal, 2013). Across all districts, July is the month where peak irrigation typically occurs (RID, 2014) which coincides with peak temperatures and for many crops, the time at which water requirements are at or nearing their highest demands. The timing of high temperatures and high water demands corresponds to declining summer flows in Western Canada (Schindler and Donahue, 2006). It is difficult to say how sustainable irrigation may be into the future in the face of climate change if decreasing summer flows persist. While this is yet to become a widely acknowledged public concern, some irrigation districts are still expanding and converting pasture into irrigated cropland (SMIRD, 2011).

Irrigation doesn't only affect the surfaces of the fields to which water is applied. Dams and irrigation canals allow for alteration in water quantity and distribution but they have also received special interest for their effects on the upstream movement of fish and groundwater recharge (Nilsson & Berggren, 2000). Groundwater use by all sectors has increased over the last decade (ALCES, 2015) so it is important to consider how this unseen source of water is affected by above-ground activities. Riparian areas, given the vegetation's dependence on below-ground sources of water, are particularly responsive to the effects of upstream dams on flow regimes (Rood *et al.,* 2013). Aquatic and terrestrial communities may be affected by groundwater availability so the effect of altered species composition is a potential issue to consider in the future. Improving water quality in the Oldman Basin is likely a goal many residents can agree after learning more about their watershed and the environment therefore the future expansion of cultivated and/or irrigated agriculture should be carefully considered given current agricultural practices and declining river flows among many other watershed wide issues.

5. Southern Tributaries

5.1 – Ecology and Background

Three of the five major rivers running through the Oldman Watershed originate in this sub-basin: the Belly, St. Mary's and Waterton (OWC, 2010). Unlike the headwaters of the Oldman and Crowsnest rivers, those originating in the Southern Tributaries are protected from development, extensive agriculture and natural resource extraction, as they are included in the 44,000 km^2 Crown of the Continent Ecosystem. This creates the potential for immense biodiversity as is seen by the 45 habitat types (OWC, 2010) that occur in Waterton Lakes National Park. Similar to the prairie sub-basin, the Southern Tributaries' main land use is cultivated land at 45% of the area. Grassland coverage by fescue species and other grasses takes up a relatively large portion of the Southern Tributaries sub-basin at 38% compared to 21% grassland in the prairie sub-basin (OWC, 2010). Topography and protected status likely have a lot to do with the higher occurrence of native grassland in parts of the Southern Tributaries.

5.2 – Riparian areas and wetlands

Riparian areas of the Oldman Basin overall and the Southern Tributaries are rated "Fair" (OWC, 2010). Water quantity in the Southern Tributaries was rated as "Poor" (OWC, 2010), which may play a role in the Fair Riparian indicator rating. Riparian vegetation thrives under wet conditions therefore health can be inferred by a lush green appearance as a result of water occurring on or near the surface

(Fitch, Adams and O'Shaughnessy, 2003). Riparian health can also be compromised by agriculture or human recreation as is seen in the Prairie and Mainstem sub-basins.

In my presentation I borrow the term "Green Zone" from Cows and Fish for describing riparian areas and wetlands. The Green Zone later serves as a comparison between nature's mechanisms of water treatment and human methods. Healthy riparian areas are more likely to efficiently perform functions such as water purification, flood control and nutrient recycling than degraded riparian systems. After introducing riparian areas to students I ask: "Does it make more sense to you that we improve and maintain natural landscapes that do these things for us, or leave them as they are and focus on building newer and/or better waste water treatment facilities?" I do not provide a definite answer to this question, it is more so asked to get them thinking about how riparian restoration in areas lacking health may result in better water quality. Riparian areas as "nature's waste water treatment facilities" are mentioned again in the Mainstem section when the Lethbridge Waste Water Treatment Plant is focused on. Another benefit of healthy riparian areas is aesthetics that puts forth another question for students: "Which method of water treatment would you rather see in your yard, a riparian area or a small waste water treatment plant?"

Riparian areas are focused on because of the unique opportunity to discuss those that occur in rural areas as well as the river valley in Lethbridge. The cottonwood forests in the coulees are relatively well known but that area may not register with people as being riparian because it occurs so close to a municipality. Besides recycling nutrients and purifying water, riparian areas provide forage and valuable fish and wildlife habitat. Much of Alberta's wildlife use riparian areas for all of or part of their life cycle (Fitch, Adams & O'Shaughnessy, 2003), which can explain why city dwellers claim to enjoy bird and animal watching in the coulees.

Wildlife's dependence on riparian areas can seem like just another fact and at this point I will be far along in my presentation, which is why I utilize a personal story to regain attention. My most recent moose (three animals) and cougar (a mom and her two kits) encounters also occurred near wetlands or riparian areas. I speak of seeing my first cougar following a well-known game trail along a lake when I was seven years old, riding horseback with my Mother a few hours from home before the time of cell phones. I will ensure students make the connection between predators using riparian areas to find prey and prey animals foraging on productive plants near abundant water, as they will likely be more thrown off by the thought of not having a smartphone handy than the animals. The overall point here is that wildlife are reliant on riparian areas and they should be maintained for their provision of habitat as well as ecosystem services. Ecosystem services, again, are only briefly mentioned as to avoid too much detail. I feel that this section of the presentation may result in some contest ideas which would require them to do further research or utilize me as a resource for helping to shape their proposals, so further learning may occur during the writing process.

Topography of the Southern Tributaries also allows for many types of standing water bodies, such as the multiple lakes that are protected in Waterton Lakes National Park. Wetlands are also abundant in this sub-basin and are considered to be more efficient in removing nutrients than riparian buffers zones on a unit area basis (Mitsch & Gosselink, 1999). The Southern Tributaries has higher rated riparian and terrestrial habitat as well as better water quality than the prairies (OWC, 2010) yet cultivated agriculture occurs in both sub-basins. More wetlands and less extensive agriculture in the Southern Tributaries may be associated with the higher ratings.

In 1910, 625.055 km^2 of wetlands existed in the Oldman basin. A century later in 2010 only about 22% of wetlands remained after 488 km^2 were lost (ALCES, 2015). The substantial loss of wetlands in an extremely agriculturally active watershed is concerning. Increased downstream concentrations of phosphorus, nitrogen and sediment loads are associated with the loss of wetlands (Yang et al., 2008).

Ecosystem health becomes an exacerbated issue in a system greatly modified by anthropogenic activity with decreased wetland area to efficiently remove nutrients and improve water quality. Wetlands were also saved as the last ecological concept to highlight as the work the OWC does with landowners through the Watershed Legacy Program, which is emphasized near the end of my presentation as a "feel-good" story to hopefully restore any low spirits. This example shows that maintaining and enhancing aquatic habitat is valued by many different stakeholders in the Oldman Watershed and gives evidence through pictures of people making improvements to our remaining wetlands and riparian areas.

Best management practices have been employed in the Oldman Basin by the OWC and Cows and Fish to enhance the health of riparian areas and wetlands while raising awareness for the need to do so. The efficacy of wetlands in providing habitat and stream integrity is negatively correlated with the extent of agriculture in a region (Roth, Allan & Erickson, 1996). It is unreasonable to expect agricultural activity in the Oldman Basin to halt or decrease to activity levels similar to pre-settlement or early homesteading, therefore efforts to improve agricultural practices are a means of improving water quality.

The installation of off-stream watering systems, establishment of riparian buffers, construction of riffle crossings in streams and rotational grazing regimes are common management tools (Alberta Agriculture & Food and the OWC, 2007) promoted to improve riparian and wetland health in Southern Alberta. These practices are designed to draw livestock away from riparian areas to reduce issues of soil compaction among other negative impacts livestock can have. Compaction decreases water infiltration and root penetration in soil that results in nutrients and bacteria from animal wastes running off into water. Overgrazing of riparian vegetation is also an issue. Healthy vegetation allows for nutrient cycling, bank stability and reduces erosion potential while also providing habitat for many species of wildlife (Fitch, Adams and O'Shaughnessy, 2003). Past winning contest ideas have included riparian tree planting, riffle crossings and bank stability projects which I will also mention after some basic riparian facts so students realize that it doesn't just take ranchers and scientists to make positive changes.

6. Mainstem

6.1 – Ecology and Background

Half of Lethbridge's population occurs along the Mainstem of the Oldman River (Poirier & Loe, 2011). The city is divided by the coulee through which the Oldman River flows, referred to as knaapi by the Blackfoot (Fitch, personal communication 2014). Unique features of the river valley include expansive cottonwood forests and coulees. Riparian poplar forests have an ecological importance in providing habitat for species such as migratory songbirds, but also offer value for recreation and culture in the Lethbridge area (Bradley, Reintjes and Mahoney, 1991). Much work has been conducted in this area to examine the relationships between natural and managed flows on cottonwood forests. Recently research has been focused on climate change, Pacific Decal Oscillations and flooding as the longevity of these trees allows for snapshots of past environmental conditions through tree ring analysis (Rood *et al.*, 2013). I emphasize the riparian nature of the Lethbridge river valley and how the features that attract people to this area: water, trees, birds and animals, are the product of a functional local ecosystem in spite of its occurrence between two parts of a city.

6.2 – Water Treatment

In the presentation I discuss municipal effluent treatment and untreated storm drain runoff to bring the focus back to humans and our impacts on the landscape. After discussing how riparian areas and wetlands can serve to improve water quality we move into the city where water treatment costs money. It is also mentioned that as water quality decreases, costs of treatment increase. A 1998 synoptic survey determined that outflow from Waste Water Treatment Plant in Lethbridge to be the largest point source of nutrients and bacteria inputs to the Oldman River, which prompted an upgrade in

1999. Prior to the upgrade, 82.7% of bacteria in the Oldman River were derived from outflow of the Waste Water Treatment Plant; this value was reduced to 0.1% in 2000 after the installation of UV disinfection equipment (OWC, 2005). Phosphorus and nitrogen inputs were also significantly cut from 87.5% to 23.6% and 59.1% to 10.8% from 1998 to 2000 respectively (OWC, 2005). I could not find a reliable source to speak to the cost of this upgrade.

Nutrient and bacteria levels are not the only concern when examining water quality within the Oldman Basin. At this point I remind students of Endocrine Disruptors (Evans *et al.*, 2012) and other pollutants that enter the river before it flows through Lethbridge. We did not want to appear to be blaming agriculture for all issues with water quality and this is a good chance to bring all sources of contaminants into context. There seems to be a knowledge gap with the general public as to how and why water is treated hence the need for awareness of storm drains. To demonstrate storm drain function I show a cartoon with pollutants derived from people's yards: gardening chemicals, garbage, vehicle leaks and pet feces, running into a storm drain and straight into a river. A recent Caring For Our Watersheds winner from the Oldman Watershed won with her idea of "Storm Drain Survival Kits" and this is mentioned as means of wrapping up issues within the watershed and refocusing back on the contest. This section was kept relatively light and short, as students will be nearing 40 minutes of listening by this point in the presentation.

7.0 – Conclusion

I did my best while designing this presentation to identify where knowledge gaps tend to occur between the scientific community and general public about certain ecological concepts within the Oldman Watershed, water quality and use as well as the role of human play in their watersheds. The source of our water, impacts of various land uses, managing water for human use, comparing how nature and humans improve water quality as well as what people are currently doing to improve watershed health were identified as key points to cover. It was extremely difficult to limit this list of concepts so the presentation would not exceed an hour or become too confusing.

To reinforce the sub-basin concept and how many different land uses make our watershed a busy place, I conclude the presentation with a “photo quiz”. They include shots of different industries (forestry, oil and gas, farming, ranching, feedlots) and then photos in which I am snowboarding, riding horses/moving cattle or hiking along with the wildlife (snakes, deer, bears) I’ve encountered while doing so. I then ask the students which sub-basin each photo may have been taken in. I did this also to emphasize that multiple ecosystems occur within a single watershed, which is why land use and water quality can vary. After the photo “quiz”, I show some photos of projects I was involved in during my time as member of the Cochrane High School Sustainable Development Committee. By showing them photos of my own actions and mentioning previous winners’ ideas they will hopefully begin their own brainstorming without feeling discouraged or like kids can’t make a difference. The last slide of the presentation simply states the contest question: “What can you do to improve your watershed?” alongside an empowering quote by Wendell Berry: “What I stand for is what I stand on”. I make my availability as a mentor very clear and it is then up to students to ask questions and choose whether they will participate in the 2015 Caring For Our Watersheds Contest.

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