Castle Management Plan
Ecological Working Group – Summary of Science

Preamble

The Castle Management Plan - Ecological Working Group (EWG) in the Castle Management Plan process was convened in August 2016 by Environment and Parks to provide the best available science input to support the primary **nature conservation intent** for the proposed Castle Provincial Wildland Park and Castle Provincial Park. The EWG focus is to provide input into management planning approaches and decisions that pertain to the preservation and restoration of ecological health in the proposed Castle parks.

Summary of Ecological Science

The EWG has selected the following key indicators of ecological health and provided an overview of each indicator, selected annotations/abstracts where possible, and some suggestions for consideration in the completion of the management plans of the two proposed Castle parks. The Summary is not an exhaustive list of research, but does provide evidence for addressing several management concerns in the proposed Castle parks, including the type, extent and intensity of human recreation activities.

- Intact Landscapes and Connectivity
- Linear Feature Density
- Soil Erosion Risk
- Species at Risk:
  - Grizzly Bears
  - Westslope Cutthroat Trout
  - Bull Trout
  - Five needled Pines
- Elk
- Amphibians
- Meso-carnivores (ie: wolverine, lynx, fisher)
- Environmental Impacts of Off Highway Vehicles (OHVs)

Key Considerations for Castle Management Planning:

Thresholds

The concept of a ***threshold*** is that human disturbance can develop to a certain point without demonstrable and negative impacts on hydrologic response, fish and wildlife populations response or biodiversity response. Past the threshold noticeable declines in ecological integrity and biodiversity occur. The reality is that a response occurs starting with the first human footprint, ever so slight, at a landscape or watershed level. For native trout (i.e. bull trout and westslope cutthroat trout) Fish

Sustainability Indices show even low levels of linear features can have negative impacts, shifting population viability from low risk to moderate risk at a linear density less than 0.2 km/km². The risk shifts from moderate to high at densities of about 0.6 km/km². For trout populations that are in a "threatened" category, recovery strategies mean that linear densities should be reduced to shift populations from a high risk to a low risk. In the Castle this means a substantial reduction of linear density especially OHV trails, given that many roads will remain in use.

(Submitted by Lorne Fitch)

The importance of establishing the best benchmark for monitoring ecological health

A ***benchmark*** is a place in time and space where we have made a point of noticing and noting as many parameters as exactly as possible so we can say in the future, that is how things were then. It is a measure of landscape health, biodiversity and productivity and a mark against which we measure change. Many of our landscapes have been disturbed and subject to change for so long it appears to the uninitiated as if this is the norm. Our benchmarks of landscape health have shifted to one of disturbance, without realizing the impacts on aesthetics and ecosystem services, attributes and benefits. Often there is not vision of health left to provide a reference point to assess disturbed sites.

As an example, streams run muddy now, every time it rains. This was not always so, but the proliferation of roads, trails and crossings plus our extensive landscape footprint bleeds sediment into streams with every rain shower. Watersheds not so impacted continue to run clear, but we have so few pristine watersheds now to act as benchmarks we take it as a given that rain equals muddy water. Historical benchmarks provide a vision of past landscape integrity and rich biodiversity that we can use as a guide to help define what we want of today's landscapes and on, into the future. Restoration of past fish and wildlife populations, a metric of landscape health, may not be completely possible, or feasible, but past populations and the landscape mosaic do provide a sense of what is in the realm of the possible. If we pick today as the measure of health we miss the opportunity for landscape and biodiversity restoration, especially for species at risk.

(Submitted by Lorne Fitch)

Intact Landscapes and Connectivity

Benz RA, Boyce MS, Thurfjell H, Paton DG, Musiani M, Dormann CF, et al. (2016) Dispersal Ecology Informs Design of Large-Scale Wildlife Corridors. PLoS ONE 11(9): e0162989. doi:10.1371/journal.pone.0162989

https://www.docphin.com/research/article-detail/18843395/PubMedID-27657496/Dispersal-Ecology-Informs-Design-of-Large-Scale-Wildlife-Corridors

p. 2. 'Conservation efforts for large mammals by wildlife managers and conservationists typically focus on identifying and maintaining wildlife corridors to facilitate movement through human modified landscapes. Poorly designed corridors can result in population sinks, wasted financial resources, or a loss of stakeholder support'

p. 2. 'Dispersal across landscapes, or the movement of individuals or genes among resource patches, is essential for functional connectivity.'

p. 2. 'Our novel approach incorporates elk dispersal ecology into connectivity modelling science. Our method is based on the knowledge that animals obviously do not move from wintering areas directly to new ones in one step. Instead, elk move through the landscape and disperse to new areas through a sequence of concatenated steps undertaken from early spring, to late autumn, when young males leave the natal home range.'
p. 15, '...it is important to map multiple potential core areas across the landscape that act as nodes, and to create a network of corridors between them.'

Crown Managers Partnership – Strategic Conservation Framework 2016-2020

http://static1.1.sqspcdn.com/static/f/808688/26910881/1457818310387/CMP2016-webfinal.pdf?token=18%2F4%2BsbaFvqoDxwDGqAwzs5lIvM%3D

Key focus: Connectivity of Large Landscapes

The Crown Managers Partnership has identified five areas that have the greatest risk to fragmentation and a reduction in landscape connectivity for the Crown. Two areas that interact with the proposed Castle parks are emphasized below (bold face):

1. **Highway 3 corridor within the Alberta and British Columbia portions of the Crown**;
2. Highway 2 corridor within the Montana portion of the Crown;
3. The trans-boundary Flathead watershed, including the Flathead River in British Columbia and the north fork of the Flathead in Montana;
4. The continental divide area between Alberta and British Columbia, both north and south of the Highway 3 corridor; and
5. **The southwest Alberta headwaters.**

Continued research and steps forward by the Miistakis Institute of the Rockies, conservation NGOs, Alberta Transportation, Alberta Environment and Parks and the MD of Crowsnest Pass will be an important undertaking to ensure wildlife corridors in/out of the Castle (north/south and east/west) are integrated into the Castle Management Plan.

Crown of the Continent - A Backgrounder on Connectivity and Ecological Health. Miistakis Institute of the Rockies, 2007.

http://www.rockies.ca/files/reports/Crown%20of%20the%20Continent_A%20Backgrounder%20on%20Connectivity%20and%20Ecological%20Health.pdf

Global Forest Watch – Bulletin 1: Anthropogenic Disturbance and Intactness in the Castle

http://www.globalforestwatch.ca/node/260

'This first bulletin examines the human disturbance footprint, Intact Forest Landscape Fragments (IFLFs), and changes occurring between 2000 and 2015. GFWC applied its established method to analyse Landsat satellite imagery and examined a higher resolution human-footprint dataset derived from SPOT imagery.

The key findings in this Bulletin are:

- Landsat imagery showed an increase in buffered human-caused disturbance from 401.5 km ^{2} in 2000 to 441.4 km^2 in 2015.

- Higher resolution data indicates there was a total human footprint of 146 km^2 by 2012, which is 14% of the Castle area. When buffered at 500 m, the total human footprint was almost 673 km^2.
- Based on analysis of Landsat imagery, there were 535 km^2 IFLFs in the Castle *circa* 2000 but these were reduced to 482 km^2 by 2015, which covers 46% of the Castle. Thus, there was a total decline of 10% (53 km^2) of the original 2000 IFLFs by 2015.
- Almost all of the remaining IFLFs (470 km^2) are in the Wildland Provincial Park, while there are only 11.5 km^2 in the Provincial Park (4% of the area of the park).
- Almost 76% of the *circa* 2000 IFLFs in the Provincial Park were lost by 2015. The higher resolution data for 2012 showed only 333 km^2 of IFLFs in 2012. This amount is 150 km^2, or 31%, less IFLF area than identified through the Landsat mapping.
- The analyses in this bulletin reveal that access to data based on high-resolution imagery shows a substantially fragmented picture of the Castle.
- The human disturbance footprint in the Castle indicates that there is considerable restoration work required to ensure this area retains its important role for biodiversity and other ecosystem values.

Weaver, John L., Protecting and Connecting Headwater Havens – Vital Landscapes for Vulnerable Fish and Wildlife – Southern Canadian Rockies of Alberta. 2013. Wildlife Conservation Society Canada.

https://newsroom.wcs.org/News-Releases/articleType/ArticleView/articleId/5537/Protecting-and-Connecting-Headwater-Havens.aspx

'This report from the Wildlife Conservation Society Canada (WCS Canada) calls for the designation of new Wildland Provincial Parks in the Southern Canadian Rockies (Alberta) to protect vulnerable wildlife and provide for their safe passage in an increasingly fragmented landscape. The report focused on determining important, secure habitats ("safe havens") and landscape connections ("safe passages") for six species -- bull trout, westslope cutthroat trout, grizzly bears, wolverines, mountain goats and bighorn sheep. These species are vulnerable to loss of secure habitat from industrial land uses and/or climate change

Weaver assessed 6,452 square kilometres of land to determine its conservation value for the vulnerable species and the cumulative challenges of expanding industrial resource extraction and mechanized recreation facing each of them. For example, about 20 percent of the land is prime habitat for the threatened grizzly bear but may serve as 'attractive traps' due to the high density of roads. As climate changes, warmer winters will reduce mountain snow cover and suitable habitat for the rare wolverine, a species highly adapted to persistent snow pack. Reduced stream flow and warmer stream temperatures will diminish habitat for westslope cutthroat trout and bull trout, native fish adapted well to cold waters -- while favouring introduced rainbow trout and brook trout.

Weaver recommends designating 257,065 ha of Crown land as Wildland Provincial Parks because it would be a smart investment that would conserve 66 percent of important habitats on 40 percent of the land. Vital places with particular concentration of present and future habitat include Castle Special

Place, lands on the north and south of the Crowsnest Pass, the headwaters of the Oldman River, and the headwater basins of the Highwood River. The new direction would recognize the value of wildlife diversity and headwater sources of clean water but require improved management of other land uses.'

Wildlife, highways, local knowledge: Identifying where large mammals cross Highway 3. Miistakis Institute of the Rockies. http://www.rockies.ca/roadwatch/files/movementzones.pdf

Linear feature density

Forman, T.T. and Alexander, L.E. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231.

This is a lengthy review of studies conducted throughout the world. It covers roads of various sizes, from trails to busy highways.

Disturbance and Avoidance

Pg. 214-15: "Songbirds appear to be sensitive to remarkably low noise levels, similar to those in a library reading room (100, 102, 103). The noise level at which population densities of all woodland birds began to decline averaged 42 decibels (dB), compared with an average of 48 dB for grassland species. The most sensitive woodland species (cuckoo) showed a decline in density at 35 dB, and the most sensitive grassland bird (black-tailed godwit, *Limosa limosa*) responded at 43 dB. Field studies and experiments will help clarify the significance of these important results for traffic noise and birds."

Pg. 215: "Various large mammals tend to have lower population densities within 100–200 m of roads (72, 93, 108). Other animals that seem to avoid roads include arthropods, small mammals, forest birds, and grassland birds (37, 47, 73, 123). Such road-effect zones, extending outward tens or hundreds of meters from a road, generally exhibit lower breeding densities and reduced species richness compared with control sites (32,101). Considering the density of roads plus the total area of avoidance zones, the ecological impact of road avoidance must well exceed the impact of either road-kills or habitat loss in road corridors."

Barrier Effects and Habitat Fragmentation

Pg. 215: "All roads serve as barriers or filters to some animal movement. Experiments show that carabid beetles and wolf spiders (*Lycosa*) are blocked by roads as narrow as 2.5 m wide (73), and wider roads are significant barriers to crossing for many mammals (11, 54, 90, 113). The probability of small mammals crossing lightly traveled roads 6–15 m wide may be <10% of that for movements within adjacent habitats (78, 119). Similarly, wetland species, including amphibians and turtles, commonly show a reduced tendency to cross roads (34, 67)."

Pg. 216: "The barrier effect tends to create meta-populations, e.g. where roads divide a large continuous population into smaller, partially isolated local populations (subpopulations) (6, 54, 128). Small populations fluctuate more widely over time and have a higher probability of extinction than do large populations (1, 88, 115, 122, 123). Furthermore, the re-colonization process is also blocked by road barriers, often accentuated by road widening or increases in traffic."

Pg. 216: "The genetics of a population is also altered by a barrier that persists over many generations (73, 115). For instance, road barriers altered the genetic structure of small local populations of the common frog (*Rana temporaria*) in Germany by lowering genetic heterozygosity and polymorphism (97, 98). Other than the barrier effect on this amphibian and roadkill effects on two southern Florida mammals (20, 54), little is known of the genetic effects of roads."

Road Density

Pg. 223: "A road density of approx. 0.6 km/$^{km\ 2}$ (1.0 mi/mi2) appears to be the maximum for a naturally functioning landscape containing sustained populations of large predators, such as wolves and mountain lions (*Felis concolor*) (43, 76, 124). Moose (*Alces*), bear (*Ursus*) (brown, black, and grizzly), and certain other populations also decrease with increasing road density (11, 43, 72). These species are differentially sensitive to the roadkill, road-avoidance, and human-access dimensions of road density. Species that move along, rather than across, roads presumably are benefitted by higher road density (12, 39)."

Findlay, C.S. and Houlahan, J. 1997. Anthropogenic correlates of species richness in southeastern Ontario wetlands. Conservation Biology 11(4):1000-1009.

This paper reports on how species richness of four taxonomic groups (plants, herptiles, birds, mammals) relates to road density and forest cover. Species richness correlated strongly with the area of wetlands, a pattern long recognized in ecology. When wetland area was controlled for, further relationships were evident – those of local road density (within a radius ranging from 500m-2000m) and local forest cover (radius of 2000m) – species richness declined as road densities increased.

Global Forest Watch – Bulletin 2

http://www.globalforestwatch.ca/node/264

'This second bulletin examines the human footprint in the Castle proposed protected areas (the Castle) through a high resolution analysis of linear disturbance. Using a refined dataset derived from official road and trails datasets, extracted features from an Alberta dataset, and digitized features from high resolution (0.5 m) aerial photographs, Global Forest Watch Canada (GFWC) provides a series of maps showcasing the extent of linear disturbances across the newly proposed protected areas.
The key findings in this Bulletin are:

- There were 1,822.6 km of linear features (roads, trails, seismic lines, transmission line corridors, and pipeline right of ways) in the Castle proposed protected areas as of 2012.
- The high resolution (0.5 m) aerial photography provided a linear disturbance footprint much higher than GFWC mapped in 2010; aerial photographs yielded an additional 703 km of linear features.
- Although there are only 130 km of official roads, GFWC has identified at least 301 km of features in the Castle that may function as roads. The density of linear disturbances for the entire Castle proposed protected areas is 1.76 km/km^2.
- The proposed Provincial Park is much more fragmented with a density over 3.5 km/km^2, while the Wildland Provincial Park is just over 1 km/km^2.
- The widespread existence and use of many of the linear disturbances beyond the official roads and designated trails underlines the importance of addressing off-highway vehicle use in the Castle.
- Further fieldwork to assess linear feature type and volume of use would enrich the dataset and make it more useful for management planning and monitoring purposes.
- As part of our commitment to open data, GFWC is making its linear disturbances dataset available via our website for others to use.'

Ladle, A., T. Avgar, M. Wheatley, and M. S. Boyce. 2016. Predictive modeling of ecological patterns along linear-feature networks. Meth. Ecol. Evol. (doi: 10.1111/2041-210X.12660).
http://onlinelibrary.wiley.com/doi/10.1111/2041-210X.12660/full

Oldman Watershed Council (OWC) – Integrated Watershed Management Plan (IWMP) Headwaters Indicator Project (2014)
https://static1.squarespace.com/static/55775efbe4b02c5614691727/t/55ba6084e4b08db54f561f24/1438277764498/HeadwatersIndicatorsProject.pdf
The **Oldman Headwaters Indicator Project** found the Castle region sub-watersheds (fourth Strahler order) ranged from high risk/pressure to low risk/pressure from density of all linear features. Highest risk/pressure (greater than 3.0 km/km^2) and moderate risk/pressure (1.2 – 3.0 km/km^2) extended across sub-watersheds in the upper regions of the proposed Castle Parks. The lowest pressure/risk (less than 0.6) was found in sub-watersheds the southwest extent of the proposed parks.

OWC – IWMP: Headwaters Action Plan (2013-14)
https://static1.squarespace.com/static/55775efbe4b02c5614691727/t/559cab54e4b08185b1947a75/1436330836141/HAPsummary.pdf
As an important element of the Oldman Integrated Watershed Management Plan, a multi-stakeholder process resulted in the Headwaters Action Plan that provided advice to the Government of Alberta to reduce of the density of linear features in sub-watersheds rated at high to moderate risk/pressure, and to maintain (no increase) low to negligible risk/pressure ratings in the remaining sub-watersheds.

Steenhof, K., Brown, J.L. and Kochert, M.N. 2014. Temporal and spatial changes in golden eagle reproduction in relation to increased off highway vehicle activity. Wildlife Society Bulletin 38(4): 682-688.

Research study implications for resource managers: "Land managers should develop plans to manage OHV use throughout the golden eagle's range to minimize adverse effects of disturbance. They should consider limiting effects of recreation by appropriately locating and designing facilities and establishing refuges where activities are prohibited or regulated. At a minimum, management should include seasonal trail closures, buffer zones around nests, and suitable location of staging areas to minimize OHV effects on golden eagles."

Castle Management Plan implications:

The existence of roads and trails themselves, and the motorized activities on them clearly have measurable negative impacts on a variety of terrestrial and aquatic animals. Abundant evidence indicates that negative ecological impacts increase with linear density of trails. Thus, decommissioning and recovering trails can cease the negative impacts and provide opportunities for ecological restoration. Where trails must be retained, temporary or permanent traffic control through the use of gates and enforcement may help reduce impacts.

Soil Erosion Risk

Oldman Watershed Council – Integrated Watershed Management Plan (IWMP) Headwaters Indicator Project (2014)

https://static1.squarespace.com/static/55775efbe4b02c5614691727/t/55ba6084e4b08db54f561f24/1438277764498/HeadwatersIndicatorsProject.pdf

An assessment of the density of all linear features in habitat with high erosion risk was found to be pervasive across the Oldman Headwaters region. In the Castle parks area, only approximately 32 sub-watersheds (4th Strahler) order, were able to be assessed due to lack of LiDar wet area mapping datasets. The assessment area covered the north and northwest extent of the Castle parks area and shows **moderate risk/pressure (0.6 – 1.5 km/km^2) to high risk/pressure (greater than 1.5 km/km^2) on 30 of the 32 sub-watersheds assessed for soil erosion risk/pressure.**

Castle Management Plan implications: The Castle parks area with moderate to high soil erosion risk overlaps critical habitat for westslope cutthroat trout and bull trout. Sedimentation in streams remains a concern for spawning and core habitat viability for WSCT and BTR.

Species At Risk – an overview of 4 species

- **Grizzly Bears**
- **Westslope Cutthroat Trout**
- **Bull Trout**
- **Five Needled Pines**

CAP (Crown Adaptation Partnership). 2014. Workshop report -- Taking Action on Climate Change Adaptation: Piloting Adaptation Strategies to Reduce Vulnerability and Increase Resilience for Native Salmonids in the Crown of the Continent Ecosystem. Crown Managers Partnership, The Wilderness Society, Crown Conservation Initiative, US Department of Agriculture, US Forest Service. Available for download at:
http://crownmanagers.org/adaptativemanagement/

Crown Managers Partnership – Strategic Conservation Framework 2016-2020
Crown Managers Partnership research and focus - Five Needled Pines
http://static1.1.sqspcdn.com/static/f/808688/26910881/1457818310387/CMP2016-webfinal.pdf?token=18%2F4%2BsbaFvqoDxwDGqAwzs5lIvM%3D
(p. 11) 'Five Needle Pine Forests - Whitebark pine forests anchor high mountain ecosystems. It acts as a keystone species by providing important food sources for a wide variety of animals. It is also a foundation species that stabilizes ecosystem function by shading snowpack and reducing erosion, which helps to regulate downstream flows. Less is known about the ecology of limber pine forests, whose range overlaps with whitebark pine. It is well documented, however, that the Crown's whitebark pine and limber pine forests have declined significantly due to a combination of stressors, including an exotic pathogen, native pine beetle epidemics and the exclusion of fire from these forests. Climate changes further threatens these forests by exacerbating the present stressors and acting as a new stressor. The Crown Managers Partnership, working in full collaboration with non-governmental organization partners, will focus on the implementation of several shared priorities related to restoring whitebark and limber pine forests in the Crown:

- In close collaboration with whitebark and limber pine specialists, identify existing distribution and status of whitebark and limber pine forests, and identify the climate-smart restoration strategies that can most effectively recover these species in an era of rapid climate change;
- Advance solutions that overcome barriers to restoration, including issues related to limited supplies of five needle pine seedlings for planting, human development impacts in five needle pine forests, limited public awareness and support for the level of restoration required; and
- Increase the pace and scale of restoration by identifying high priority areas for restoration in the Crown, by leveraging individual agencies and Tribes/First Nations contributions, and by working with community and NGO partners to seek new sources of funding and capacity. The Crown Managers Partnership will explore the possibility of organizing a formal Crown of the Continent

Five Needle Pine Working Group comprised of all willing agency, Tribal/First Nation, community, NGO and industry partners committed to advancing these shared priorities.'

Crown Managers Partnership – Strategic Conservation Framework 2016-2020
http://static1.1.sqspcdn.com/static/f/808688/26910881/1457818310387/CMP2016-webfinal.pdf?token=18%2F4%2BsbaFvqoDxwDGqAwzs5lIvM%3D

Crown Managers Partnership research and focus – Native Salmonids

(p. 10) 'While the Crown is a stronghold for both bull trout and westslope cutthroat trout, both species face significant challenges in an era of shifting climate. Increasing stream temperatures are expected to reduce the availability of suitable habitat for bull trout, and increase levels of hybridization between westslope cutthroat trout and non-native trout species. In November 2014, the Crown Managers Partnership, The Wilderness Society, the Crown Conservation Initiative and the Northern Rockies Adaptation Partnership held a workshop in Montana entitled, 'Piloting Adaptation Strategies to Reduce Vulnerability and Increase Resilience for Native Salmonids in the Crown of the Continent Ecosystem'. Other partners for this event included the CRT, the U.S. Geological Survey, and the Great Northern LCC's Rocky Mountain Partnership Forum. This workshop was widely attended by scientists, non-governmental organizations and agency managers. Ground-breaking work by Clint Muhlfeld and colleagues to project climate change impacts on suitable habitat provided attendees with a scientific basis for workshop discussions, which continued with jurisdictional perspectives, case studies and the identification of potential strategies. Following the workshop through extensive work with partners, a short list of initial pilot projects were identified. Their purpose is to increase resilience, secure and restore critical habitat and protect native (non-hybridized) population.
Efforts during the 2016 – 2020 period will focus on the implementation of these strategies:

- Conduct a conservation population assessment for native salmonids in the Crown;
- Replicate, restore and/or translocate native salmonid populations to cold water refugia in priority transboundary watersheds east of the Divide;
- Export successful bull trout translocations piloted in the North Fork of the Blackfoot to other landscapes; and suppress invasive rainbow trout in the Transboundary Flathead and implement best management practices to other locales (if translocation is unsuccessful)'

Cross, M., Chambers, N., Hansen, L., and G. Tabor. 2013. Workshop Summary Report: Great Northern Landscape Conservation Cooperative Rocky Mountain Partner Forum Climate Change and Cold Water Systems. Wildlife Conservation Society, Center for Large Landscape Conservation, EcoAdapt and the Great Northern Landscape Conservation Cooperative. Available for download at: http://ecoadapt.org/data/documents/RMPF_climate_workshopreport_FINAL_small.pdf

Fisheries and Oceans Canada. Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada [Final]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. iv + 28 pp + Appendices
http://www.sararegistry.gc.ca/default.asp?lang=En&n=DB347DE3-1#summary

From the Executive Summary: 'This recovery strategy has been prepared to guide the recovery of this Threatened species over the next five years and beyond. The population and distribution objectives are: ***"To protect and maintain the existing ≥ 0.99 pure populations at self-sustaining levels and re-establish additional pure populations to self-sustaining levels, within the species original distribution in Alberta."*** Key objectives of the strategy are to: identify and protect critical habitat for the remaining pure populations, improve knowledge of population genetics, size, distribution, and trends, identify opportunities to help recover pure and near-pure populations, increase education and awareness of the species for their conservation, re-establish pure populations in sites within the original Westslope Cutthroat Trout distribution and determine the role that introduced pure Westslope Cutthroat Trout may play in the recovery effort.'

Global Forest Watch – Bulletin 3 -- Linear Disturbance in the Castle: Implications for Grizzly Bear and Trout

http://globalforestwatch.ca/sites/gfwc/files/publications/2016%20Sept%2020%20Castle%20Bulletin%203%20SAR_0.pdf

'This is the third bulletin of a series examining the human footprint in the Castle proposed protected areas (the Castle) in Alberta. This Bulletin examines the implications of linear density for three species-at-risk in the Castle: grizzly bear, westslope cutthroat trout, and bull trout.
The key findings in this Bulletin are:

- The density of linear disturbances in the Castle Provincial Park far exceed thresholds to meet habitat requirements for grizzly bears or both trout species.
- Grizzly bear habitat security, areas where high quality forage in available and where human use is low, was concentrated in the southern portions of the proposed Wildland Provincial Park.
- The proposed Wildland Provincial Park contained 254 km^2 of low access, productive habitat whereas the proposed Provincial Park contained only 1.54 km^2.
- Further research should be conducted to examine grizzly bear home range distribution to determine which individuals and age/sex classes are most being impacted by the very low habitat security in the proposed Provincial Park.
- All westslope cutthroat trout and bull trout critical habitats were located in watersheds and areas with linear disturbances beyond recommended thresholds for population viability.
- The impacts of linear disturbance to trout populations are potentially severe; these habitats are in urgent need of restoration if these trout populations are to be recovered.
- Restoration to reduce linear disturbance density is urgently required, particularly for critical cutthroat trout habitat.

The authors studied the cumulative effects of forestry-related activities on the abundance of westslope cutthroat trout in southeastern B.C. The land use activities would be consistent with the footprint of activities in southwestern Alberta. They found there was a statistically significant negative relationship between cutthroat abundance and road density, roads on erodible slopes, roads within near-stream zones and logging to stream banks. These results have relevance to the Alberta situation in the Castle. They also noted the impacts, even on non-fish bearing tributary streams had negative downstream effects on westslope cutthroat populations.'

Haak, A.L., Williams, J.E., Isaak, D., Todd, A., Muhlfeld, C., Kershner, J.L., Gresswell, R., Hostetler, S., and H.M. Neville. 2010a. The potential influence of changing climate on the persistence of salmonids of the inland west: U.S. Geological Survey Open-File Report 2010–1236, 74 p. http://pubs.usgs.gov/ of/2010/1236/

Herrero, Stephen (Editor). 2005. Biology, demography, ecology and management of grizzly bears in and around Banff National Park and Kananaskis country: The Final Report of the Eastern Slopes Grizzly Bear Project, University of Calgary, Alberta, Canada.
http://www.canadianrockies.net/grizzly/final_report.html

Isaak, D.J., Young, M.K., Nagel, D., Horan, D.L., and M.C. Groce. 2015. The cold-water climate shield: delineating refugia to preserve salmonid fishes through the 21st century. Global Change Biology, Vol 21:2540-2553. http://www.fs.fed.us/rm/pubs_journals/2015/rmrs_2015_isaak_d001.pdf

Mayhood, D.W. 2013. Suspended Sediment in Silvester Creek and its Potential Effects on the Westslope Cutthroat Trout Population. FWR Freshwater Research Limited.
http://www.fwresearch.ca/Library_files/Mayhood%202013a.pdf

Morehouse, Andrea T., and Mark Boyce. 2016. Grizzly Bears without Borders – Spatially Explicit Capture-Recapture in Southwest Alberta. The Journal of Wildlife Management; DOI: 10.1002/jwmg.21104
https://www.researchgate.net/publication/304315751_Grizzly_Bears_Without_Borders_Spatially_Explicit_Capture-Recapture_in_Southwestern_Alberta

Nelson, R. 2014. A Climate Change Adaptation Gap Analysis for the Crown of the Continent. Commissioned and published by the Crown Conservation Initiative. Available for download at:
http://static1.1.sqspcdn.com/static/f/808688/25678703/1416253186333/CC_Gap_Analysis_Report_Public_FINAL_v2+copy.pdf?token=0OlV723%2BbCGnaxlPat4OZwr9mDE%3D

Nelson, R., Cross, M., Hansen, L., and G. Tabor. 2016. A three-step decision support framework for climate adaptation: Selecting climate informed conservation goals and strategies for native salmonids in the northern U.S. Rockies. Wildlife Conservation Society, EcoAdapt, Center for Large Landscape Conservation. Bozeman, MT, USA.
http://rmpf.weebly.com/cold-water-ecosystem-management-tool.html

Northrup, J. M., J. Pitt, T. B. Muhly, G. B. Stenhouse, M. Musiani, and M. S. Boyce. 2012. Vehicle traffic shapes grizzly bear behaviour on a multiple-use landscape. J. Appl. Ecol.49: 1159–1167 (doi: 10.1111/j.1365-2664.2012.02180.x).

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2012.02180.x/abstract

'Synthesis and applications. Grizzly bear responses to traffic caused a departure from typical behavioural patterns, with bears in our study being largely nocturnal. In addition, bears selected private agricultural land, which had lower traffic levels, but higher road density, over multi-use public land. These results improve our understanding of bear responses to roads and can be used to refine management practices. Future management plans should employ a multi-pronged approach aimed at limiting both road density and traffic in core habitats. Access management will be critical in such plans and is an important tool for conserving threatened wildlife populations.'

Valdal, E.J. and M.S. Quinn. 2010. Spatial analysis of forestry related disturbance on westslope cutthroat trout (Oncorhynchus clarkia lewisi): Implications for policy and management. Applied Spatial Analysis DOI 10: 1007/S 12061-009-9045-5.

https://www.researchgate.net/profile/Michael_Quinn9/publications

'Univariate analyses within a blocked regression design resulted in statistically significant ($p<0.05$) negative relationships between cutthroat trout abundance and road density, roads on erodible soils, roads within near-stream zones and two measures of logging to the stream bank. There was no statistically significant relationship between cutthroat trout abundance and equivalent clear-cut area (km2/km2). Roads over erodible soils within near-stream zones emerged as the most significant individual variable. A multivariate model to predict cutthroat trout abundance included roads within near stream zones and recent logging adjacent to streams. Evidence from this study indicates that logging of non-fish bearing perennial and ephemeral streams is likely a key factor that has negative downstream effects on cutthroat trout abundance. Contrary to many conventional forest management approaches, this study suggests that considering the spatial distribution of disturbance is at least as important as the total amount of disturbance and that disturbance types can accumulate to produce negative effects on cutthroat trout abundance.'

Castle Management Plan Implications

Grizzly Bear – The proposed Castle parks are considered core habitat for grizzly bears (Alberta Grizzly Bear Recovery Plan 2016 (Draft; http://aep.alberta.ca/files/GrizzlyBearRecoveryPlanDraft-Jun01-2016.pdf) with surrounding area as secondary and supporting habitat. The grizzly bear population in southwest Alberta are considered recovered due to the population distribution being shared with B.C. and Montana, however, this does not provide assurance of continued viability in Alberta due to the sub-optimal habitat effectiveness in the proposed parks. The proposed provincial park has only 1.54 km^2 of low access, productive habitat, while the proposed Wildland Park has 254 km^2. (Global Forest Watch – Bulletin 3).

Linear feature disturbance densities are significantly over the 0.6 km/ km^2 threshold for grizzly bears, with 3.5 km/ km^2 in the proposed provincial park, and 1.0 km/ km^2 in the proposed wildland park. A total combined linear disturbance density for both parks is 1.76 km/ $km^{2.}$ (Global Forest Watch – Bulletin 2). Assessment of linear disturbance to determine priorities for reclamation and restoration is needed in both proposed parks.

The home range distribution of grizzly bears in the Castle area show avoidance of the core Castle parks area (in 2013 – 2014) by both female and male grizzly bears (Morehouse and Boyce, 2016. P.10). Further research is greatly needed to determine grizzly bear home range distribution and how individuals and age/sex classes are being impacted by the very low habitat security, specifically in the proposed Provincial Park (Global Forest Watch; Bulletin 3).

Westslope Cutthroat Trout(WSCT) and Bull Trout (BTR) – WSCT and BTR are both requiring immediate and focused management action for recovery and persistence. Key requirements for action include identifying and protecting critical habitat for remaining pure and near pure populations; identifying opportunities for recovery of pure and near-pure populations within the original WSCT distribution region, and addressing the pressing need to address climate change projections and subsequent impacts on WSCT and BTR – both require clear, cold, clean and connected streams to persist. Restoration and re-founding of populations in the best possible climate change refugia is greatly needed in order to safeguard the persistence of these two native salmonids. Preliminary climate change projections suggest that the Oldman headwaters could be the last best place for ensuring WSCT persistence in the Crown of the Continent ecosystem.

Five Needled Pines – As a key landscape within the Crown of the Continent, it is important to participate in identifying existing distribution and status of whitebark and limber pine in the proposed Castle parks. Climate change impacts will have adverse effects on the status of whitebark and limber pine – and a need to develop and implement climate-smart restoration strategies.

Elk

From: George Wuerthner <gwuerthner@gmail.com>

Subject: Paper on road impacts on elk (clue elk avoid roads)
Date: December 1, 2016 at 9:54:59 AM MST
To: Michael Garrity <wildrockies@gmail.com>

https://era.library.ualberta.ca/files/cmp48sd008/Prokopenko_Christina_M_201605_MSc.pdf

Elk responded to roads as they would natural predation risk. Elk selected areas farther from roads at all times of day with avoidance being greatest during twilight. In addition, elk sought cover and moved more when in the vicinity of roads. Road crossings were generally avoided, but this avoidance was weakest during daytime when elk were both moving and closer to roads. Energy development is transforming landscapes in western North America with the proliferation of roads, which I show is having substantial and multifaceted negative effects on elk behaviour across multiple scales. Consequently, any new road construction or increases in existing road-use intensity would have detrimental effects on migratory elk populations by restricting space-use

Paton, Dale G. 2016. Connectivity for Elk Movement along Highway 3. Presentation at Highway 3 Linking Landscapes and Wildlife along the Hwy 3 Transportation Corridor. Workshop October 6, 2016**.** (available as pdf from author).

Paton, Dale G. 2012. Connectivity of Elk Migration in southwestern Alberta. Masters of Science Thesis, University of Calgary, Alberta.

Pg. 41-2 **"**Beyond the ecological influences of elk distribution and densities to the land, an understanding of the growing effects of human disturbance is a prerequisite for management and distribution of elk populations (Lyon and Ward 1982, Millspaugh et al. 2001). Research has shown human activities requiring or creating roads caused avoidance responses by elk to the human use of roads (Cole et al. 1997, Frair et al. 2008, Lyon 1983, Rowland et al. 2000), including land uses and recreation (Cassier et al. 1992, Ferguson and Keith 1982, Morgantini and Hudson 1985, Naylor et al. 2009). There have been indirect habitat losses caused by avoidance of roads and trails by elk in both protected and non-protected public lands (Gagnon et al 2007, Naylor et al. 2009, Rogala et al. 2011). While studies of elk populations in areas of no elk hunting such as those on private land or of protected areas noted human activity indirectly created a spatial refuge (Hebblewhite et al. 2005). Others have determined elk can benefit from industrial activity such as timber management (Rumble and Gamo 2011) and road management (Cole et al. 1997, Forman et al. 2003, Frair et al. 2008). Road management by decommissioning roads or using gates to control access is beneficial to many species including elk (Frair et al. 2008, Northrup 2010). These documented effects of human activity indicate that an increase in human land use without planning for wildlife habitat use and movement requirements may have adverse or beneficial effects to migrating elk and landscape connectivity for wildlife.

Numerous types of human activity such as roads, resource extraction, residential development, and other forms of habitat alteration can reduce the landscape connectivity required for migration and dispersal between meta-populations (Friar et al. 2008, Gagnon et al. 2007, Lyon 1979, Rowland et al. 2000). Understanding what degree of landscape connectivity is essential to the greatest diversity of species and at-risk animals is an evolving science. Understanding migration movements and dispersal patterns of elk on public lands and factors that affect these movements will facilitate elk management and help to develop management strategies to benefit elk and other species using land resources (Benkobi et al. 2005).**"**

Pg. 129 "In Chapter Four, I develop a spring and fall resource selection function (RSF) for female elk migration to understand their patterns of selection for stopovers and possible differences between seasons. There were differences in use between stopovers by female elk during spring and fall migrations. A comparison of habitat characteristics of stopover sites with random locations within the Castle-Carbondale elk home range found stopover sites were in areas of rugged terrain, with low canopy cover, mid elevations, and at least 500m away from roads."

Pg. 131. "Reduce and control human activity on roads within migration routes particularly new road

developments using a 300 - 1000m buffer from the migration route. The buffer size will depend upon site conditions such as topography and forest cover. In dense forest a 300m buffer is adequate, but in open meadows or clearcuts elk can be disturbed by certain types of disturbance 1 km away. Likewise terrain, measured by viewscapes could have large effects. Since the intensity of road use is typically more critical than road densities, in most cases the use of a gated road could be acceptable. New roads closer than 500m from stopover sites may be acceptable if access within appropriate distance (point 5) is controlled using gates and the roads are decommissioned after they are no longer being used by industry. Continuing to remove roads by gating or re-sloping road bed to reduce traffic volumes in wildlife movement corridors would be another positive step to maintaining and increasing connectivity for animals."

Prokopenko, Christina Marie (2016). Multiscale Habitat Selection and Road Avoidance of Elk on their Winter Range. Masters of Science Thesis, University of Alberta.
https://era.library.ualberta.ca/files/cmp48sd008/Prokopenko_Christina_M_201605_MSc.pdf

Pg ii: 'Elk responded to roads as they would natural predation risk. Elk selected areas farther from roads at all times of day with avoidance being greatest during twilight. In addition, elk sought cover and moved more when in the vicinity of roads. Road crossings were generally avoided, but this avoidance was weakest during daytime when elk were both moving and closer to roads. Energy development is transforming landscapes in western North America with the proliferation of roads, which I show is having substantial and multifaceted negative effects on elk behaviour across multiple scales. Consequently, any new road construction or increases in existing road-use intensity would have detrimental effects on migratory elk populations by restricting space-use.'

Pg. 49: 'Moreover, roads of all classes and at all times of day were avoided be elk, which indicates that they are a significant source of disturbance regardless of traffic. However, when spatial or temporal use was lower, avoidance of roads was less. Further, in areas with higher road density, elk selected to be closer to low use roads. Thus, roads with less traffic could relax the pressure of higher traffic roads. In agreement with this, Montgomery et al. (2013) found that elk selected for closed roads. Even more, grizzly bears in this study area selected for higher density but lower use roads (Northrup et al. 2012). In conclusion, the incorporation of intensity of use in my analyses demonstrates that limiting the development of roads in core areas is key, but once present, reducing traffic can help mitigate their influence'

Prokopenko, C.M., Boyce, M.S. & Avgar, T. Landscape Ecol (2016). doi:10.1007/s10980-016-0451-1 http://link.springer.com/article/10.1007/s10980-016-0451-1?no-access=true
Context: In southwestern Alberta, human development, including roads, is encroaching on the landscape and into the range of a partially migratory population of elk (*Cervus elaphus*).
Result of the study: Roads had a ubiquitous influence on elk across scales. Elk, individually and as a population, avoided roads when migrating to their winter range and within this seasonal home range. Individual elk that avoided roads more strongly relative to the population did so at both scales of analysis. Further, the avoidance of low-use roads decreased with increasing road density. These results

support bottom-up habitat-selection patterns (i.e., scale-independent) and functional response in habitat selection.

Conclusions: Overall, using a multi-scale habitat selection analysis, we show that road avoidance is a major determinant of elk space-use behaviour across multiple scales. Consequently, any new road construction or increases in road-use intensity could have detrimental effects on migratory elk populations by restricting space-use.

Simone Cuiti, Tyler B. Muhly, Dale G. Paton, Allan, D. McDevitt, Marco Musiani and Mark S. Boyce. Human Selection of Elk Behavioural Traits in a Landscape of Fear. 2016. Proceedings of the Royal Society. doi:10.1098/rspb.2012.1483.
https://www.researchgate.net/publication/230804322_Human_Selection_of_Elk_Behavioral_Traits_in_a_Landscape_of_Fear

Abstract

'Among agents of selection that shape phenotypic traits in animals, humans can cause more rapid changes than many natural factors. Studies have focused on human selection of morphological traits, but little is known about human selection of behavioural traits. By monitoring elk (*Cervus elaphus*) with satellite telemetry, we tested whether individuals harvested by hunters adopted less favourable behaviours than elk that survived the hunting season. Among 45 2-year-old males, harvested elk showed bolder behaviour, including higher movement rate and increased use of open areas, compared with surviving elk that showed less conspicuous behaviour. Personality clearly drove this pattern, given that inter-individual differences in movement rate were present before the onset of the hunting season. Elk that were harvested further increased their movement rate when the probability of encountering hunters was high (close to roads, flatter terrain, during the weekend), while elk that survived decreased movements and showed avoidance of open areas. Among 77 females (2-19 year olds), personality traits were less evident and likely confounded by learning because females decreased their movement rate with increasing age. As with males, hunters typically harvested females with bold behavioural traits. Among less-experienced elk (2-9 year olds), females that moved faster were harvested, while elk that moved slower and avoided open areas survived. Interestingly, movement rate decreased as age increased in those females that survived, but not in those that were eventually harvested. The latter clearly showed lower plasticity and adaptability to the local environment. All females older than 9 year olds moved more slowly, avoided open areas and survived. Selection on behavioural traits is an important but often-ignored consequence of human exploitation of wild animals. Human hunting could evoke exploitation-induced evolutionary change, which, in turn, might oppose adaptive responses to natural and sexual selection.'

Castle Management Plan implications:

Reducing the density of linear disturbances should benefit elk populations and the most significant aspect of this appears to be reduction of motorized activity on roads and trails. Where roads and trails must be retained, staff should consider spatial buffers and strict limitation of motorized traffic. These controls are particularly important in proximity to elk migration routes and stopover sites, and it should be noted that both fall and spring routes and sites must be considered. Non-motorized disturbances may deserve attention as well.

Amphibians

Amphibians are one of the most at-risk taxa in the world (Wilson 2016); that is not an exception within Alberta. The Castle area is host to at least five of Alberta's ten known amphibian species, most of which are provincially and/or federally listed species at risk (Pearson 2005).

Amphibians are well-known indicators of ecological integrity and provide important linkages between aquatic and terrestrial habitats. In the Castle, virtually every standing waterbody, from muddy 'puddles' along roadsides to large subalpine lakes, is of value to breeding amphibians (Pearson 2004a). Intact terrestrial areas surrounding those waterbodies are equally important. Western toads are unique in that they are especially wide-ranging as adults and may be found considerable distances from waterbodies (Pearson 2004b).

Pearson, K.J. and C.P. Goater. 2008. Distribution of long-toed salamanders and introduced trout in high- and low-elevation wetlands in southwestern Alberta, Canada. Ecoscience 15:453-459. https://www.jstor.org/stable/42902418?seq=1#page_scan_tab_contents

Long-toed salamander larvae are naturally top predators in most of their native habitats. Since the 1930s, non-native trout have been introduced to most lentic (standing) waterbodies in the Castle area to provide recreational angling opportunities. Most of the introduced non-native trout populations remain self-sustaining and some have continued to be augmented in recent years by the Alberta Government. This has had devastating effects on long-toed salamander populations and likely other species such as Columbia spotted frog; they have been entirely extirpated from many waterbodies which now host non-native fish. These species are at risk of regional extirpation in the mid- to long-term due to the ongoing presence of introduced trout in naturally fishless amphibian habitats. Active trout stocking should be ceased and restoration of key amphibian habitats to fishless states is strongly recommended.

Beebee, T.J.C. 2003. Effects of road mortality and mitigation measures on amphibian populations. Conservation Biology 27:657-668. http://onlinelibrary.wiley.com/doi/10.1111/cobi.12063/full

Roadways have substantial negative impacts on amphibian populations, due primarily to direct mortality but also as a result of pollution and genetic isolation due to migration barriers. Waterton Lakes National Park installed permanent amphibian under-road tunnels to reduce amphibian mortality at a key habitat in 2009. The project is looked at as an example of roadway mortality mitigation in western Canada and has inspired several others. Similar roadway mitigation projects could be considered at key amphibian habitats bisected by high-traffic roads within the Castle.

K. Pearson. 2004a. Habitat suitability index model for the long-toed salamander (*Ambystoma macrodactylum*) Pp. 136-147 *in* Blouin, F., B.N. Taylor, and R.W. Quinlan (eds). 2004. The southern headwaters at risk project: A multi-species conservation strategy for the headwaters of the Oldman River. Volume 2: Species Selection and Habitat Suitability Models. Alberta Sustainable Resource

Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 90, Edmonton, AB. http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/species-at-risk-general/documents/SAR090-SHARP-MultiSpeciesConservationOldmanRiver-Vol002-Nov2004.pdf

K. Pearson. 2004b. Habitat suitability index model for the western toad (*Bufo boreas*) Pp. 148-159 *in* Blouin, F., B.N. Taylor, and R.W. Quinlan (eds). 2004. The southern headwaters at risk project: A multi-species conservation strategy for the headwaters of the Oldman River. Volume 2: Species Slection and Habitat Suitability Models. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 90, Edmonton, AB. http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/species-at-risk-general/documents/SAR090-SHARP-MultiSpeciesConservationOldmanRiver-Vol002-Nov2004.pdf

Pearson, K.J. 2005. Southern headwaters at risk project (SHARP) amphibian and western painted turtle (*Chrysemys picta*) surveys, 2003-2004. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 97, Edmonton, AB. 29 pp. http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/species-at-risk-general/documents/SAR097-SHARP-Amphibian-WesternPaintedTurtle-Surveys-Mar2005.pdf

Wilson, E.O. 2016. Half Earth: Our Planet's Fight for Life. Liveright Publishing Corporation, New York. 259 pp.

Meso-carnivores

The importance of conservation of meso-carnivores has been a focus of the Crown Managers Partnership (CMP Strategic Plan 2016-20), and is a key concern for the Castle parks.

Multi-year research on this elusive and important meso-carnivore is in process. Two key research projects need to be brought into future conservation efforts in the Castle parks. The population of wolverine in Canada will be a critical source for ensuring wolverine persistence in the United States. (communication with Tony Dr. Clevenger).

Wolverine research underway – Dr. Tony Clevenger

Dr. Clevenger is currently completing the final year of wolverine surveys, in order to understand impacts of highways and human disturbance on this species' distribution and genetics. His work since 2010 has covered 60.000 square kilometres south of Banff National Park to Waterton-Glacier International Peace Park, and from the Front Ranges to the Rocky Mountain Trench. To date, he has found only two wolverine in the proposed Castle parks area, with significantly more on the B.C. side in the Flathead area. Dr. Clevengers' research outcomes will be important to consider in the management of the proposed Castle parks in light of the need to address habitat security for wolverine.

Round River Institute – Wolverine Project http://www.roundriver.org/wolverine/

Wolverine – Winter Recreation Research Project: Investigating the Interactions between Wolverines and winter recreation. Winter recreation activities surveyed include snowmobiling and ski-touring.

Researchers: Kimberly Keinemeyer, Round River Conservation Studies and John Squires, Rocky Mountain Research Station.

'The goal of the Wolverine – Winter Recreation Study is to robustly identify and evaluate wolverine responses to winter recreation. The field data collection for the wolverine-winter recreation project is completed. Our focus is now on the analyzing responses of wolverines to winter recreation, associated report and publication preparation and presentation, assisting agencies and stakeholders in interpreting the results of the research and continuing outreach efforts. **The majority of the analysis and reporting is expected to be completed by the end of 2016.'**

Castle Management Plan implications:

The Round River Institute research will help determine the impacts of snowmobiles and ski touring on wolverine, in particular the response from females and young.

Results of Dr. Clevenger's multi-year research project will provide evidence of the population of wolverine in the Castle area, and implications for management of this important meso-carnvivore.

Environmental and Recreation impacts of OHV use

Adams, Paul W. "Policy and Management for Headwater Streams in the Pacific Northwest: Synthesis and Reflection" (2007) Forest Science 53:2 104

https://www.researchgate.net/publication/233609616_Policy_and_Management_for_Headwater_Streams_in_the_Pacific_Northwest_Synthesis_and_Reflection

Andereck, Kathleen L., *et al.*, "Differences Between Motorized and Nonmotorized Trail Users" (2001) 3 J Park Rec Admin 62.

http://www.scirp.org/reference/ReferencesPapers.aspx?ReferenceID=1450055

Barber, J.R., Crooks, K.R. and Fristrup, K.M. 2009. The cost of chronic noise exposure for terrestrial organisms. Trends in Ecology and Evolution 25(3):180-189.

http://www.nature.nps.gov/naturalsounds/pdf_docs/wildlifebiblio_Aug2011.pdf

Noise management is an important issue, especially in protected lands. The road network is the source of anthropogenic noise that is most spatially widespread.

Masking of natural sounds affects communication and reproduction. In these situations both senders and receivers may alter behaviour within the lifetime of the animals or they may adapt across generations through natural selection. More importantly, masking of sounds affects an animal's ability to detect danger. There is no co-adaptation here between sound producers (predators inadvertently producing sounds) and sound receivers (prey attempting to detect predators). The burden is all on the prey.

Such noise disturbances can lead to population declines. Individual responses, such as hearing loss and increased stress hormones, can occur at noise exposure levels as low as 55-60dB. Noise can interfere with breeding behaviour such as territorial defense and mate attraction. More importantly, it can interfere with the perception of alarm calls and signals that promote social interactions and group cohesion.

Pg. 183-184. "Recent research has reinforced decades of work [44,45] showing that human activities associated with high levels of anthropogenic noise modify animal ecology: for example, the species richness of nocturnal primates, small ungulates and carnivores is significantly reduced within ~ 30 m of roads in Africa [46]; anuran species richness in Ottawa, Canada is negatively correlated with traffic density [47]; aircraft overflights disturb behavior and alter time budgets in harlequin ducks (*Histrionicus histrionicus*; [48]) and mountain goats (*Oreamnos americanus*; [49]); snowmobiles and off-road vehicles change ungulate vigilance behavior and space use, although no evidence yet links these responses to population consequences [50,51]; songbirds show greater nest desertion and abandonment, but reduced predation, within 100 m of off-road vehicle trails [52]; and both greater sage-grouse (*Centrocercus urophasianus*;[53]) and mule deer (*Odocoileus hemionus*; [54]) are significantly more likely to select habitat away from noise- producing oil and gas developments. Thus, based on these studies alone, it seems clear that activities associated with high levels of anthropogenic noise can re-structure animal communities; but, because none of these studies, nor the disturbance literature in general, isolates noise from other possible forces, the independent contribution of anthropogenic noise to these effects is ambiguous." Masking has been shown to interfere with the ability to use natural sounds for spatial orientation.

"Chronic noise exposure is widespread. Taken individually, many of the papers cited here offer suggestive but inconclusive evidence that masking is substantially altering many ecosystems. Taken collectively, the preponderance of evidence argues for immediate action to manage noise in protected natural areas."

"The costs of noise must be understood in relation to other anthropogenic forces, to ensure effective mitigation and efficient realization of environmental goals. Noise pollution exacerbates the problems posed by habitat fragmentation and wildlife responses to human presence; therefore, highly fragmented or heavily visited locations are priority candidates for noise management. Noise management might also offer a relatively rapid tool to improve the resilience of protected lands to some of the stresses imposed by climate change."

Barton, D.C. and Holmes, A.L. 2007. Off-highway vehicle trail impacts on breeding songbirds in northeastern California. Journal of Wildlife Management 71(5):1617-1620.

The authors make the following statement relative to management implications:
"Management of OHV trail development should consider possible negative impacts on nesting success and abundance of breeding birds. Areas within 100m of OHV trails may provide reduced-quality habitat

to nesting songbirds, particularly for species that suffer significant losses of annual fecundity due to abandonment or desertion of individual breeding attempts."

Boyd, William, Douglas A. Kysar & Jeffrey J. Rachlinski "Law, Environment, and the "Non-Dismal" Social Sciences" (2012) U of Col L Sch Legal Studies Working Paper 12-01 available online: http://ssrn.com/abstract=1991258

Brown, K.J. 1994. River-bed sedimentation caused by off-road vehicles at river fords in the Victorian Highlands, Australia. Water Resources Bulletin Vol. 30, No. 2: 239-250.
https://www.researchgate.net/publication/229620917_River-Bed_Sedimentation_Caused_by_Off-Road_Vehicles_at_River_Fords_in_the_Victorian_Highlands_Australia

Jones, C., D. Newsome and J. Macbeth. 2016. Understanding the conflicting values associated with motorized recreation in protected areas. *Ambio.* 45:323-330.
https://www.ncbi.nlm.nih.gov/pubmed/26508175

'Abstract: The International Union for the Conservation of Nature World Parks Congress in 2014 reported that the quality of management of protected areas is crucial in halting the loss of the world's biodiversity and meeting global environmental challenges. However, increasingly high-impact activities, including motorized recreation are occurring in protected areas such as national parks, creating an ongoing clash of values and further compromising protected area management. This paper discusses the values of protected areas in the context of increasingly high-impact motorized usage, the impact of divergent values placed on green spaces such as national parks, and perceptions about these spaces. Given the changing global context of this millennium, and increasing populations requiring space for high-impact activities including motorized recreation, rethinking recreation in protected areas is needed.'

'The quality of management of protected areas is crucial in halting the loss of the world's biodiversity and meeting global environmental challenges. Given the changing global context and increasing populations requiring spaces for high-impact activities including motorized recreation, rethinking recreation in protected areas is needed' (p. 322).

'Government approval of high-impact recreation activities and adventure sports that is out of step with key conservation objectives of protected areas sends a conflicting message about protected area values. It also conflicts with sustainable and ecotourism objectives of protected areas.' (p. 327)

'There is a need for governments to understand and accommodate outdoor activity demands of increasingly urbanized populations in ways that support rather than further denigrate precious ecosystems. (p. 327). Rather than continuing to operate in a context of conflicting values, opportunities for renewal of private and public degraded lands for greenspaces for a range of recreation are needed.' (p. 327).

'Outdoor recreation should be planned for in its own right as a separate use of land to conservation purposes, with research, education and training from social sciences rather than being an additional responsibility of ecological professionals.' (p. 327).

'A protected area classification to accommodate high-impact activities away from vulnerable natural areas may assist in maintaining protected area quality. Use of protected areas such as national parks for increasingly high-impact activities, such as motorized recreation, needs to be rethought given the changing global context of this millennium. Adequate regional park networks including the reclamation of degraded lands that can meet the needs for a range of outdoor activities offer some potential toward bridging the current clash of values, and alleviating unsustainable high-impact activity demands on protected areas. Better public policy, informed by environmental and social knowledge, and a coordinated approach are needed to meet the values and needs of environmental conservation and outdoor recreational demand, and in particular motorized activities. More work is required to create a conceptual knowledge base about motorized and other high-impact recreation and sports activities to inform policy and management to meet populations' needs without further complicating and compromising protected area management effectiveness.' (p. 328).

Dodds, Walter and Robert Oakes. 2008. Headwater Influences on Downstream Water Quality. 41:3 Environmental Management 367.
http://link.springer.com/article/10.1007%2Fs00267-007-9033-y

Driedzic, Adam. 2015. Managing recreation on public land: how does Alberta compare? Environmental Law Centre, Edmonton, Alberta.
https://albertawilderness.ca/managing-recreation-on-public-land-how-does-alberta-compare/
Abstract: Recreational use of public land in Alberta is creating significant management challenges as the demands for recreational opportunities and the impacts of recreational activity are increasing together. These challenges are shared by many western jurisdictions and have intensified in recent decades due to increases in motorized recreation. This review by the Environmental Law Centre (ELC) compares the legal framework for recreation management in Alberta to other Canadian provinces and US jurisdictions. These comparisons include the provinces of Ontario, British Columbia and Nova Scotia, the US Bureau of Land Management, the US Forest Service, and the States of Colorado, Utah and Oregon.

Erdle, H.M. 2011. Effects of ATV use, cattle grazing, logging and petroleum development on westslope cutthroat trout (*Oncorhynchus clarki lewisi)* habitat in an Alberta foothills stream. ENSC 504 Research Project in Environmental Science Report (unpublished). Environmental Science Program, University of Calgary, Calgary, Alberta.

Fiorino, Daniel J. "Streams of Environmental Innovation: Four Decades of EPA Policy Reform" (2015) 44 Env L 724

Fitch, Lorne "Two Fish, One Fish, No Fish – Alberta's Fish Crisis", unpublished essay provided by author.

Forman, Richard T. and Alexander, Lauren E, "Roads and Their Major Ecological Effects" (1998) 29 Ann R Ecol & Systematics 207.

Haddock, Rachelle L and Quinn, Michael S., "An assessment of public engagement for access management planning in southwestern Alberta, Canada" (2015) Journal of Environmental Planning and Management, online: http://dx.doi.org/10.1080/09640568.2015.1063481

Haddock, Rachelle L and Quinn, Michael S., "Recreational Access Management Planning: Understanding Perceptions Regarding Public Forest Lands in SW Alberta" (2015) 5 Open J of Forestry 387, online: < http://dx.doi.org/10.4236/ojf.2015.54033>

Herbert, Steve, Brandon Derman & Tiffany Grobelski "The Regulation of Environmental Space" (2013) 9 Ann R L & Soc Sci 227
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2350737

Hill, Carey, Kathryn Furlong & Karen Bakker. "Harmonization Versus Subsidiarity in Water Governance: A Review of Water Governance and Legislation in the Canadian Provinces and Territories", (2008) 33:4 Can Water

Huddart Kennedy, Emily et al, "Why We Don't 'Walk the Talk': Understanding the Environmental Values/Behavior Gap in Canada" (2009) 16:2 Res in Human Ecol 151
https://www.researchgate.net/publication/230752660_Why_We_Don%27t_Walk_the_Talk_Understanding_the_Environmental_ValuesBehaviour_Gap_in_Canada

Krauss, Emily Marie *et al* "Ten Years of All-Terrain Vehicle Injury, Mortality, and Healthcare Costs" (2010) 69:6 Journal of Trauma-Injury Infection & Critical Care 1338 doi: 10.1097/TA.0b013e3181fc5e7b
https://www.researchgate.net/publication/49676316_Ten_Years_of_All Terrain_Vehicle_Injury_Mortality_and_Healthcare_Costs

Kil, N., Holland, S.M. and Stein, T.V. 2012. Identifying differences between off-highway vehicle (OHV) and non-OHV user groups for recreation resource planning. Environmental Management 50:365-380.
https://www.researchgate.net/publication/228104569_Identifying_Differences_Between_Off-Highway_Vehicle_OHV_and_Non-OHV_User_Groups_for_Recreation_Resource_Planning
Abstract: Off-highway vehicle (OHV) riding is among the fastest growing recreational activities in the

United States. However, little research exists about the central components of outcomes-focused management (OFM) as it relates to motorized recreation. Utilizing a two-activity dichotomy, OHV and non-OHV centric user groups were compared on several key concepts associated with OFM, including desired experiences, perceived and desired recreation opportunity spectrum-type settings, and intentional behaviors (i.e., place-protective behavior, spending-time intentions) toward potential changes in settings.

Results indicated that the two groups were different in terms of intensity and relative rankings of their perceived experiences and settings. Although both groups preferred social bonding, stress relief, nostalgia and learning experiences, the OHV user group ranked using equipment and achieving physical fitness experiences as more important than the non-OHV group. The non-OHV user group preferred enjoying nature and solitude/tranquility experiences more strongly than the OHV user group. Further analysis found that both groups perceived settings that they recreated in to be pristine and preferred such conditions, and both groups preferred moderate levels of rules and regulations. Finally, the OHV user group was more reactive to rules and regulations, while the non-OHV user group expressed stronger intentions to protect the environmental quality of recreation areas. The results suggest that planners and managers who understand OHV user's perceptions and behaviors could provide enhanced recreation opportunities potentially providing additional beneficial outcomes for motorized and non-motorized groups in spatially different zones. Additional implications for planners and managers and future studies are discussed."

Marion, D.A., J.D. Phillips, C. Yocum, and S.H. Mehlhope. 2014. Stream channel responses and soil loss at off-highway vehicle stream crossings in the Ouachita National Forest. Journal of Geomorphology 216: 40-52.

Meadows, D., Foltz, R. Geehan, N. 2008. Effects of all-terrain vehicles on forested lands and grasslands. San Dimas Technology and Development Center Report 0823 1811-SDTDC. USDA Forest Service, San Dimas, CA.
http://www.treesearch.fs.fed.us/pubs/34167

This research study addressed three questions: are natural resources affected by ATV traffic on forested lands; if so, by how much; and does the way an ATV is equipped make a difference to these affects? The effects are considered adverse when natural resources (vegetation, soil, water and air) are reduced or changed in a manner that prevents them from maintaining and performing their ecological functions. The study concluded that ATV traffic can adversely affect natural resources and the way it is equipped does not make a statistically significant difference. All ATVS contribute to the effects regardless of type and equipment. Limiting OHV use to trials is not enough to protect natural resources. Under OHV use runoff increased 56% and sediment loads by 625% over un-impacted, adjoining landscapes.

Ouren, D.S., Haas, C., Melcher, C.P., Stewart, S.C., Ponds, P.D., Sexton, N.R., Burris, L., Fancher, T., and Z.H. Bowen. 2007. Environmental effects of off-highway vehicles on Bureau of Land Management lands: A literature synthesis, annotated bibliographies, extensive

bibliographies, and internet resources: U.S. Geological Survey, Open-File Report 2007-1353, 225 p.

https://www.researchgate.net/publication/242537198_Environmental_Effects_of_Off-Highway_Vehicles_on_Bureau_of_Land_Management_Lands_A_Literature_Synthesis_Annotated_Bibliographies_Extensive_Bibliographies_and_Internet_Resources

From the Executive Summary:

'This report and its associated appendixes compile and synthesize the results of a comprehensive literature and Internet search conducted in May 2006. The literature search was undertaken to uncover information regarding the effects of off-highway vehicle (OHV) use on land health, or "natural resource attributes," and included databases archiving information from before OHVs came into existence to May 2006. Information pertaining to socioeconomic implications of OHV activities is included as well. The literature and Internet searches yielded approximately 700 peer-reviewed papers, magazine articles, agency and non-governmental reports, and internet websites regarding effects of OHV use as they relate to the Bureau of Land Management's (BLM) standards of land health. Discussions regarding OHV effects are followed by brief syntheses of potential indicators of OHV effects, as well as OHV-effects mitigation, site-restoration techniques, and research needs.'

The Praxis Group. 2015. Albertans' Values and Attitudes toward Recreation and Wilderness: Final Report. Commissioned by the Canadian Parks and Wilderness Society (CPAWS) Northern and Southern Alberta Chapters.

http://lin.ca/resources/albertans%E2%80%99-values-and-attitudes-toward-recreation-and-wilderness

'Highlights of the Study:

A random sample telephone survey of Albertans was fielded April 27th through May 5th, 2015. The survey ran an average of 14.3 minutes in length and there were 1,300 completed interviews.

The margin of error associated with a sample of this size is +/- 2.71%, 19 times out of 20. The sample was designed to allow for analysis by Land Use Framework (LUF) regions.

- Most Albertans participate in some form of outdoor recreation (76%). Those who participate in outdoor recreation are more likely to support land being set aside for wilderness and less likely to support wilderness areas being used for consumptive purposes than those who do not participate in outdoor recreation.
- The most frequent outdoor recreational activities tend to occur close to home. As such, the extent and type of activities are related to supply and opportunity. Cycling for example is a frequent activity among those living in Calgary, whereas fishing, hunting and off-highway vehicle (OHV) use are the most popular activities among those living in northern areas away from large cities. Similarly, those living closest to national parks tend to visit the parks most often. Proximity to parks and protected areas is an important driver in use.
- The choice of activities and the frequency of participation are influenced by age, education, gender and income. For example, walking for pleasure, golf and gardening are more popular among those over 65 years of age, while downhill skiing and cycling are less popular in this age group.
- Those with lower education and income participate less in outdoor recreation than those with higher education and income.

- Men are more likely than women to participate in team sports, fishing, power-boating and hunting.
- Most Albertans who participate in outdoor recreation travel outside the city or town where they live at least once a year (88%). Almost half travel to an outdoor recreation destination between 1 and 14 days in a year.
- Most Alberta campers (77%) choose designated campgrounds over random camping. Those camping in designated campgrounds do so mainly because of a preference for amenities and services as well as convenience and access. Those choosing random camping do so because of low cost and a preference to get away from crowds and noise.
- The vast majority of Albertans (90%) prefer to recreate outdoors with family or friends.
- Recreating in areas where there are no other people present appeals to a smaller percentage of Albertans (21%) than recreating in areas where there are people present (44%). There is also a preference for recreating outdoors near home (44%).
- A majority of Albertans (67%) have a preference for non-motorized outdoor recreation.
- The vast majority of Albertans feel it is important (88.4%) to set aside land for protection of wilderness.
- Ninety-four percent of Albertans agree that wilderness areas are important because they help to preserve plant and animal species. There is also strong support for the contribution wilderness areas have to better local, national, and global air and water quality (92%) and the intrinsic value of just having wilderness even if not used (83%).
- Almost one-third of Albertans indicated there is insufficient supply of places for non-motorized water recreation and 29% feel there is inadequate supply of RV and towable camping places.
- Places for on-land motorized recreation such as OHVs had the highest percentage of respondents indicating an over-supply 33%, although 25% felt there was not enough supply.
- Albertans are most disturbed when recreating outdoors by seeing garbage left behind, mechanized recreation use such as ATVs, dirt bikes and OHVs, noise from other users, such as parties, loud music and drinking, and seeing damage and or disrespect to the area caused by users.
- Most Albertans support the need to fund recreational development on Crown Land. However, most also feel this funding should come from operators, associations and individual users, rather than general taxation.
- Non-motorized recreation on Crown Lands is substantially favoured over both industrial development and motorized recreation. In turn, wildlife protection on Crown Lands is favoured over non-motorized recreation placing this at the top of the priority list.'

The Praxis Group. 2012. Community Values Assessment for the M.D. of Pincher Creek No. 9. For the Southwest Alberta Sustainable Community Initiative and The Municipal District of Pincher Creek No. 9.

In 2012, the Praxis Group was contracted to complete a community value survey for the Municipal District of Pincher Creek. The outcomes of the survey of residents provided some key values for future planning in the MD. Environmental conservation was identified as a priority, including conserving and

protecting water resources and protecting the natural environment around the MD. Recreation values were also clearly stated:

'Survey and small group participants generally agreed that having ready access to a range of outdoor recreational opportunities is a valued benefit of living in the MD, and survey respondents strongly supported increasing non-motorized recreational opportunities. That said, concern was raised in the small group sessions about the negative impacts of unrestricted recreational land use on public lands, and both sets of participants backed enforcing appropriate use of public lands. In this vein, when asked about land use options, telephone survey respondents were in greater opposition to increased opportunities for motorized recreation (OHVs, dirt bikes, etc.).' (P. 1)

MD residents also saw the need for economic diversification and maintaining a sustainable economy as a priority. Agriculture is considered a mainstay, but a knowledge-based economy, and low impact development that does not encroach on the environment were also important. Jobs in the green, knowledge and digital economies were also strongly supported.

Riedel, M.S. 2006. Quantifying trail erosion and stream sedimentation with sediment tracers. Second Interagency Conference on Research in Watersheds. USDA Forest Service. Southern Research Station, Coweeta Hydrologic Laboratory, Otto, NC, pp 1-9.
http://www.treesearch.fs.fed.us/pubs/28852

Steenhoff, Karen, Jessi L. Brown, Michael N. Kochert. 2014. Temporal and spatial changes in golden eagle reproduction in relation to increased off-highway vehicle activity.
http://onlinelibrary.wiley.com/wol1/doi/10.1002/wsb.451/abstract
We used >40 years of data on golden eagles (*Aquila chrysaetos*) nesting in southwestern Idaho, USA, to assess whether the proportion of territories and pairs producing young has changed over time, and whether territories in areas where off highway vehicle (OHV) use has increased significantly were less likely to be productive than those in areas that continued to have little or no motorized recreation.

Thompson, Katherine A., Pierskalla, Chad D., Shuett, Michael A. 2008. Management Perceptions of Off Highway Vehicle Use On National Forest System Lands in Appalachia.
http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs-p-23papers/42thompson-p23.pdf
also http://www.treesearch.fs.fed.us/pubs/13893
Abstract: In 2005, the U.S. Forest Service (USFS) issued new standards for dealing with unmanaged recreation. All National Forest System units are to develop travel management plans by 2009. The purpose of this study was to determine differences in perceptions between USFS managers of national forests in Appalachia with low and high levels of off-highway vehicle (OHV) use regarding OHV-related issues and management tactics. This information will help managers in this region make informed decisions about OHV management when developing travel plans. Managers with high levels of OHV use reported more physical impacts, safety issues, and use of more management tactics. It is recommended

that managers weigh the costs, benefits, and resource impacts of OHV use prior to designating additional areas for OHV recreation.

Pg 301: The primary social issue related to OHV recreation is user conflict. The recreation conflict literature indicates that some conflict between mechanized and non-mechanized recreationists is related to the rate of speed at which their preferred activities take place and the noise generated by recreation machines (Krumpe & Lucas, 1986; Vittersø et al., 2004). Conflict between mechanized and non-mechanized recreationists tends to be asymmetrical; that is, non-motorized recreationists tend to experience goal interference from mechanized or motorized recreationists more than their mechanized or motorized counterparts experience from them (Krumpe & Lucas, 1986).

Pg. 303-304: As managers on national forests near the deadline to develop their new travel management plans, DRs in Appalachia who are considering increasing the amount of OHV recreational opportunities on their districts will need to weigh these costs and benefits. Unauthorized and illegal use do not seem to decrease when more trails are added, so expanding recreation opportunities for OHV users may not necessarily decrease the number of user-created trails or issues with riders leaving designated areas. Overall, adding more OHV trail opportunities may have other drawbacks for managers. More trails may increase the costs of personnel and trail management, necessitate the implementation of a fee system, and/or may necessitate using more varied management tactics to deal with OHV-related impacts. Managers who add more OHVs in their Districts, however, may experience an increase in volunteerism by OHV users and an increase in positive encounters with those users. Increasing the amount of OHV-related recreational opportunities should not be predicated upon whether more trail budget money might become available or whether OHV users might be more likely to volunteer. Choosing to add or open more OHV trails should be based on the suitability of the resource for such trails on the resource's capacity; and on the district's ability to support and maintain the trails over time. When these conditions cannot be met, providing additional trail opportunities may have more drawbacks than benefits.

Tull, J.C. and Brussard, P.F. 2007. Fluctuating asymmetry as an indicator of environmental stress from off-highway vehicles. Journal of Wildlife Management 71(6):1944-1948.

http://onlinelibrary.wiley.com/doi/10.2193/2006-397/abstract

Vertebrates exhibit bilateral symmetry in that our left and right sides are reflections of each other. A and high performing individuals within a population whereas high measures of asymmetry are associated with lower quality individuals. Asymmetry accumulates during development in stressful conditions. Here, the authors measure fluctuating asymmetry in samples of western fence lizards.
For three locations separated by at least 45km, the authors paired a local OHV site with a nearby (<7.5km) non-OHV site with matching vegetation characteristics. At least 55 individuals were captured and photographed at each site and they measured scales on both sides of the head to assess asymmetry.

Asymmetry was significantly greater in each of the OHV sites compared with the paired non-OHV sites. There was no evidence of differences in population density. This suggests that OHV uses causes stress

and that this stress influences physiology and development. Thus, assessment of fluctuating asymmetry may be a method of detecting impacts before they become large enough to affect population size.

Webb, R and H.G. Wiltshire, Editors. 1983. Springer-Verlag Publishers. Environmental Effects of Off-Highway Vehicles. W.J. Knockelman, 'Management Concepts.'

Summary of some of the findings:

- The US Bureau of Outdoor Recreation (1976) found widespread conflicts between OHV users and other recreationalists- most non-motorized forms of outdoor recreation were disrupted and hurt by OHV use. This is not a trivial matter and suggesting (as several have) that there may be a corner or two in the Castle that could accommodate OHV uses is off-base with park intents and fails to recognize there is a planning process required to first identify the natural resources, other recreational uses and constraints to trail development before this is ever envisioned.
- OHV use is consumptive and the noise and disruption pre-empts and drives out activities that are quieter, less consumptive and contemplative. OHV use shrinks the amount of land available to other recreational users, creating an exclusive use (and in the process shrinks the space that is the defining element of wilderness). It would be a serious mistake to believe that "skilled, courteous, well-intentioned OHV users can operate their machines with minimal effects on the environment and with no conflict with other users". OHV use is consumptive of valuable resources and is not compatible with a "sustained-yield" concept; there is no possibility of setting a realistic level of use because any level of use is destructive.
- The distinction between "responsible" and "irresponsible" OHV users is irrelevant since it is not in the nature of the equipment used, the goals of OHV users, the frequency and intensity of use, or the failure to avoid wet periods or areas that are prone to damage or erosion to leave an area unaffected by OHV use.
- Regulations (and enforcement) are "monumental and probably impossible". To be effective there needs to be constant and effective management of OHV users; enforcement efforts directed to OHV users diverts resources away from other resource management priorities; attempts to regulate OHV numbers are difficult/impossible; the magnitude of the problem discourages proper oversight and enforcement; some OHV users are nearly impossible to regulate; and, regulations fall short of the level of environmental protection contemplated, promised or proposed.
- Almost all of the OHV costs (i.e. impacts) are borne by people other than OHV users. OHV users pay none of the costs resulting from conflicts with other recreational users (and other legitimate land users) and none of the costs resulting from destruction of resources. Questions asked include: Should other users bear the costs of the benefits derived by OHV users? Should others pay the costs for destruction of natural resources? Is it just, politically, ethically or morally, for others to bear the costs of a use whose benefits accrue to one user group? "The premise that local, state or federal governments are obligated to provide public lands and the services of public employees for a use that is consumptive of resources and that conflicts with virtually every other use cannot be defended and sets a poor precedent."
- OHV use and protection of biological resources are mutually exclusive. "Even OHV use under the most stringent regulations, carefully and meticulously enforced, causes irreversible impacts on

the nation's resources".

- Presuming that OHV use can occur requires;
    - OHV users, agency staff, politicians and the public are cognizant of the issues with OHV use.
    - Other users will accept OHV use if conflicts can be avoided, minimized and natural resources destroyed with OHV use are within carefully selected, inventoried and managed sacrifice areas.
    - Provincial legislation is in place to provide regulatory oversight.
    - Agency staff are available, sufficient and well-funded to inventory, select, design, construct, patrol and enforce OHV users (probably should assume a maintenance budget as well).
    - OHV users are law-abiding, educated about the issues and are willing to assume the full and true costs of their use.
    - Prior to any decision about OHV use there is knowledge of existing land uses, resource values, resource sensitivities, erosion risk, biological/ecological benchmarks in place. "It is simply impossible to minimize damage to soil, watershed, vegetation, wildlife and other resources unless the resource base is adequate assessed." OHV activity has to be restricted to the capability of the land to sustain it.

Welsh, M.J. 2008. Sediment production and delivery from forest roads and off-highway vehicle trails in the upper South Platte River watershed, Colorado. MSc Thesis, Department of Forest, Rangeland and Watershed Stewardship, Colorado State University, Fort Collins, Colorado.

http://warnercnr.colostate.edu/~leemac/Thesis_abstracts/Welsh-thesis_final.pdf

Castle Management Plan implications:

Ecological:

Both Erdle (2011) and Welch (2008) quantified the amount of sediment produced from off highway vehicle (OHV) trails and stream crossings. Welch found the mean annual sediment production from OHV trails was 35kg/m with a range of 0.9 to 73kg. About a quarter of the OHV trail length delivered sediment directly into a stream course. Erdle measured total suspended sediment from OHV crossings on Silvester Creek, Alberta and concluded these crossings were the greatest sediment source to a stream containing westslope cutthroat trout. Total suspended sediment concentrations were felt to be seriously harmful to cutthroat trout and would cause population-level effects.

The effects of OHV activity on streams and stream crossings were studied by Marion et al (2014) in a mountain setting in western Arkansas. They found significant soil removal at stream crossing sites with depths of soil removed ranging from 30 to 45cm. Ongoing weathering of exposed rock resulted in continual loosening of material by OHV traffic and availability of sediment to erode. Stream channel banks were obliterated at crossing sites. Downstream effects included an increase in fine grain sizes (i.e. sediment) at 5 out of 8 sites and an increase in "mud coatings" (i.e. sediment covering larger substrate

materials). Researchers also observed, from OHV activity, a plume of readily suspended, fine sediment that resulted in high turbidity for several minutes following OHV crossings and, the trapping of sediment behind downstream obstructions (i.e. micro-habitats).

The mechanism of erosion and subsequent sediment movement was researched by Brown (1994). The author summarized the five processes as: bank erosion as a result of a vehicle generated "bow-wave" of water hitting the bank; creation of wheel ruts which concentrate surface runoff; backwash created by water draining from a vehicle as it emerges from the crossing; exposed soil surface; and, the compaction and reduction of infiltration rates of soils which increases surface runoff.

Meadows et al (2008) carried out experimental studies on OHV use in seven National Forests (Montana, Louisiana, Kentucky, Missouri, Minnesota, Arizona and Washington) to define impacts of OHV use on runoff characteristics and sediment generated by OHV traffic. Runoff from OHV trails increased 56% and sediment increased 625% compared to undisturbed forest. Olive and Marion (2009) found OHV trails in a National Park Service managed park located in south central Kentucky and north central Tennessee contributed an average of 143.9m^3 of sediment/km (approximately 173kg/m). The authors equate this to 19 single axle dump trucks of sediment produced from a kilometer of OHV trail. Riedel (2006) found OHV traffic resulted in the transport of tracer sediment to a stream at rates 400 times over natural background levels.

Socio-Ecological

In the Castle Management Plan process, it is very important to understand the global implications for protection of ecological health in vulnerable landscapes. As noted in the previous bibliographic reference (Jones et al, 2016), the International Union for the Conservation of Nature World Parks Congress states the quality of management of protected areas is very important in the protection of biodiversity. There is recognition that increasingly high-impact activities, including motorized recreation, are occurring in protected areas and are creating a clash of user values and a threat to the effectiveness of protected area management. High impact activities need to be re-thought in the context of protected areas and parks, especially in light of the global context of this century.

Within the proposed Castle parks, ecological health is a stated goal for management planning, and use of the parks is to be predicated on nature-compatible activities. The evidence provided here supports the need for addressing high-impact motorized recreation outside of the proposed Castle parks, and careful planning for other recreation and tourism use around the key indicators of ecological health in the proposed Castle Provincial Park and Castle Provincial Wildland Park.