Cumulative Effects of Human Activity in the Yellowstone to Yukon

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An environmental impact is the negative effect on a resource of some change in the environment. A cumulative impact is the total accumulated effect on the resource of all environmental changes. The concept is an important one. It holds that, while individual impacts may be small in themselves, the overall impact of all environmental changes affecting the resource taken together can be significant. Moreover, successive environmental changes may damage an ecosystem not only in an additive way, but in complex ways that are difficult to predict beforehand and difficult to measure after the fact. This is because biological processes are rarely linear over wide ranges of conditions, but typically have thresholds beyond which they fail to operate or break down entirely. When a resource is near a threshold, a small change can drive it over the edge.

An example of a threshold phenomenon important in conservation biology is the minimum viable population, the smallest population of a given species that has a high probability of persisting indefinitely despite the foreseeable effects of chance events and natural catastrophes. Should a population be near its minimum viable size, even a small impact could extirpate it. It has been postulated that whole ecosystems may have a critical viable size as well. It is the threshold phenomenon, coupled with the smallness of the individual impacts, that makes the problem of cumulative impacts so insidious. Each small bit of damage in itself might well be insignificant, but the cumulative damage is just as real as if it had occurred suddenly from some dramatic and obvious change.

There are three important implications of a commitment to prevent cumulative environmental impacts. First, there are no minor environmental impacts. Even if an environmental effect is judged acceptable or unavoidable for some reason, at some point the cumulative damage from repeated acceptable/unavoidable changes will be unacceptable. Second, because it is the natural condition of the ecosystem that must be used as the baseline against which cumulative impacts are measured, (not any presently existing, partially damaged condition), determining what the natural condition of the landscape and its ecosystems are (or might have been) is one of the principal objectives of a regional cumulative effects assessment. Third, due to our imperfect understanding of complex natural systems that make up the Y2Y bioregion, we cannot know with certainty when a threshold may be breached.

In this paper the density of linear disturbance is used as a proxy for cumulative effects. There are several reasons for adopting this approach. First, human use of the Y2Y has resulted in the construction of an extensive network of roads, trails, seismic lines, pipelines, and powerlines. Regardless of why or where these activities occur in the bioregion, they can result in long-lasting and extensive damage to vegetation, soils, and wildlife populations. Second, there is a growing body of literature that we can use to assist us in interpreting disturbance densities. Finally, using disturbance densities for assessing the health of the Y2Y simplifies cumulative effects assessment greatly.

Linear disturbances in the Y2Y

Within the Y2Y there are currently 676,957 km of linear disturbance (enough to go around the earth 16.8 times). The average linear disturbance density is 0.54 km/km^2. While this disturbance density may seem low, it is noteworthy that over 620,000 km^2 or 48% of the total area of the Y2Y is comprised of lands in the Yukon and Northwest Territories and northern British Columbia. These areas are relatively pristine and have very low disturbance densities. As a result the actual mean linear disturbance density for the balance of the Y2Y landscape is approximately 1.0 km/km^2. Those areas in the southern half of Y2Y that are not within existing protected areas have much higher mean disturbance densities because of the arithmetic effects of large national parks and wilderness areas on mean disturbance densities. The table below shows the area of lands within the Y2Y in various density classes.

Disturbance Density Class	Area (km2)
0 km/km2	800,205
>0 to 1.0 km/km2	108,466
>1.0 to 2.0 km/km2	118,725
>2.0 to 5 km/km2	104,886
>5.0 km/km2	10,920

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1 Using data provided by Bill Haskins of the Ecology Center, Inc.

Another perspective on the extent of disturbance in the Y2Y can be had by considering the extent of linear disturbance by watershed. The total Y2Y area is encompassed in 320 5th- or 6th-order watersheds, of which 28 are entirely roadless. At the opposite end of the spectrum is the Latornell River basin in Alberta with a mean linear disturbance density of 4.5 km/km^2. Within that range, 176 watersheds have linear disturbance densities between 0.0 and 1.0 km/km^2; 79 watersheds have linear disturbance densities between 1.0 and 2.0 km/km^2; and 35 watersheds have linear disturbance densities greater than 2.0 but less than 5.0 km/km^2. All but four of the watersheds with linear disturbance densities greater than 2.0 km/km^2 occur in Canada, predominantly in Alberta.

An analysis of inter-regional differences in disturbance densities indicates that generally, the highest densities are expected in areas where intensive forestry and oil and gas activities occur concurrently. These areas fall within the Y2Y portion of the western Sedimentary Basin in northeastern British Columbia and along Alberta's east slopes. Areas where forestry occurs in the absence of oil and gas activity also tend to be heavily roaded but generally not to the same extent. An analysis of disturbance densities in the Alberta portion of Y2Y found mean disturbance densities of 2.7 km/km^2 and maximum densities in excess of 8.0 km/km^2.

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What do these densities of linear disturbance mean for conservation planning in the Y2Y? To put that question into perspective, consider that the U.S. Forest Service (USFS) has developed a grizzly bear habitat effectiveness model based on road densities which shows the erosion of habitat effectiveness as road densities increase. At road densities of 0.8 km road/km^2, habitat effectiveness is reduced to 50%; at road densities of 1.6 km road/km^2, habitat effectiveness is further reduced to 25%. The USFS established a management goal of maintaining habitat effectiveness in occupied grizzly bear habitat at 80% of its potential. To meet this standard, road densities in occupied grizzly bear habitats should be maintained at below 0.3 km/km^2. Notwithstanding apparently low mean disturbance densities in the Y2Y as a whole, average habitat effectiveness for grizzly bears may be below 70%.

In some areas in the southern half of Y2Y outside of existing protected areas, average habitat effectiveness for grizzly bears is below 25%. This low level of habitat effectiveness likely has serious implications for large carnivore conservation efforts.

Core areas

Core areas were calculated by buffering all linear disturbances by 500 m and eliminating all resulting areas that were less than 10 km^2. This analysis resulted in 931,746 km^2 or 72% of the Y2Y being identified as core areas. The mean core area size was 426 km^2 and the maximum core area was a 182,493 km^2 area in the central Yukon, extending across the border into unroaded country in the Northwest Territories. As with disturbance densities, these results should be interpreted with caution, as they are heavily skewed by the large unroaded areas found in the Yukon, Northwest Territories and northeastern British Columbia. Although a separate analysis of the core areas in the southern half of the Y2Y has not been completed, it is expected that they will be considerably smaller than their northern counterparts. An analysis of core areas along Alberta's east slopes (but excluding national parks) determined that in the Alberta portion of Y2Y there were less than 900 core areas, with a mean size of 22 km^2 and maximum size of 932 km^2 (associated with the Willmore Wilderness north of Jasper National Park). These results are probably more representative of the southern areas of Y2Y.

Conclusions

Clearly much more work needs to be done on the varying patterns of human disturbance across the Y2Y landscape and the effect that disturbance has on the ecological integrity of the region. Fully accepting that conclusion, this preliminary disturbance inventory indicates that bear populations in the southern half of Y2Y are living in a highly fragmented landscape with greatly reduced habitat effectiveness. In the northern Y2Y, habitat effectiveness and core area analysis indicates that there is currently sufficient habitat for viable grizzly bear populations, but that these areas do not currently have adequate protected areas (core areas) to ensure that future development pressures will not result in the loss of those areas of secure grizzly habitat.

Yellowstone to Yukon
Linear Disturbance Density

*Fort Good Hope
*Dawson
*Fort Norman
YUKON TERRITORY
*Fort Simpson
*Whitehorse
NORTHWEST TERRITORIES
*Watson Lake
*Fort Liard
*Cassiar
Liard River
*Meander River
*Fort Nelson
*Dease Lake
*Fort Vermillion
*Telegraph Creek
ALBERTA
*Fort McMurray
*Fort St. John
*Peace River
*Dawson Creek
*Mackenzie
*Smithers
*Grand Prairie
*Prince George
*Edmonton
*McBride
*Hinton
BRITISH COLUMBIA
*Jasper
*Clearwater
Banff
Calgary
*Canmore
*Vernon
*Kelowna
*Lethbridge
*Crahbrook
*Vancouver
*Cut Bank
MONTANA
*Bonners Ferry
*Kalispel
*Great Falls
*Spokane
*Lewistown
WASHINGTON
*Missoula
*Helena
*Lewiston
*Billings
*Butte
*Bozeman
*Salmon
*Cody
*Challis
OREGON
*Boise
*Idaho Falls
*Pocatello
IDAHO
*Twin Falls
WYOMING
*Salt Lake City

Yellowstone to Yukon Conservation Initiative

LEGEND

Protected Areas

Linear Disturbance Density
- 0 km/sq km
- > 0 - 1
- > 1 - 2
- > 2 - 5
- > 5
- Outside of study area

50 0 50 100 150 200 Miles

75 0 75 150 225 300 375 Km

Ecology Center
GIS