Review of Grizzly Bear Data and Population Estimates for the Northern Continental Divide Ecosystem

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Executive Summary

Population estimates for grizzly bear in the Northern Continental Divide Ecosystem (NCDE) in northwest Montana (N = 765 in 2004; N = 960 in 2014) are based on findings that grizzly bears have recently come through a period of population growth leading to range expansion at the rate of 2000km^2 annually.

Some believe the Primary Conservation Area (formerly known as the Recovery Area) may be approaching carrying capacity (K) and is producing dispersing bears that are exploiting new territory.

I discuss that given several mitigating factors, the N = 960 estimate may be overoptimistic, and should be supplemented by additional analysis. Research is required to better understand distribution and trends in mortality; habitat use in response to disturbance; the effects of human access on mortality and habitat security; source-sink habitat relationships; annual and long-term trends in climate and precipitation.

I argue that in the absence of this necessary information, it is premature to use the estimations for total population size and annual sustainable mortality as a basis for removing Endangered Species Act protections, reinstitution of hunting or for land management planning including the Flathead and Lolo National Forest Plan Revisions and the Four National Forest Plan Amendments for Grizzly Bear Habitat Management in the NCDE.

Introduction

Human population growth, drought, climate change and rapidly changing landscapes are a challenge to grizzly bears in the Northern Continental Divide Ecosystem (NCDE). Recent population estimates have projected sustained population growth. The State of Montana is now considering whether to administer a hunting program for grizzly bear if and when Endangered Species Act protections are removed. Costello, et al. (2016) evaluate data from 2004-2014 and use multivariate statistical modeling to estimate vital rates. They conclude the NCDE grizzly bear population now numbers ≈ 960.

In order to put their findings in context, it is important to gain an understanding of what the state of the population was in 2004 and what has happened since.

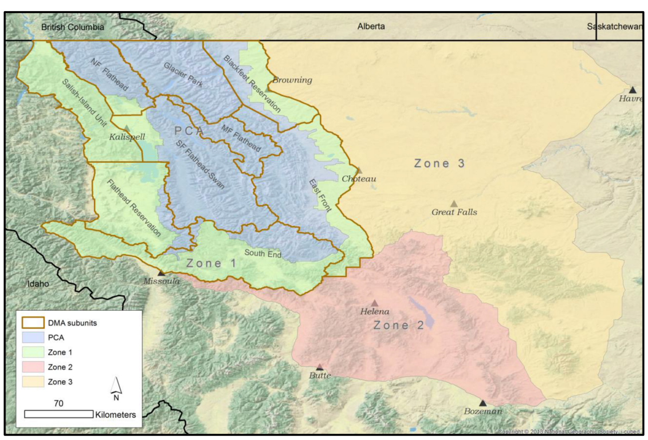

Figure 1. The Demographic Monitoring Area for the NCDE. From Costello, et al. (2016).

Background

Mattson, et al. (1995) estimated the NCDE population at ≈ 453 (mid-point of two mean estimates using data from Montana FWP and assuming 22.8% adult females and 60% sight-ability).

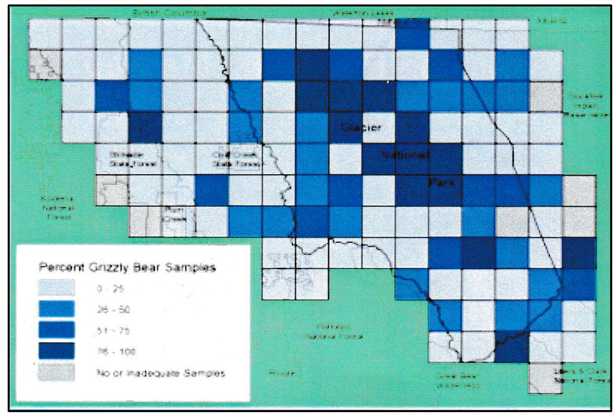

Figure 2. Bear Samples From Kendall, et al. (2000) USGS.

Kendall, et al. (2008), in a first-of-its-kind study using hair traps and DNA analysis, estimated a total census of N = 240 within their 7,933km^2 study area and mean density of ≈ 30/1000km^2.

Kendall, et al. (2009) estimated N = 765 across a total distribution area of 33,480km^2.

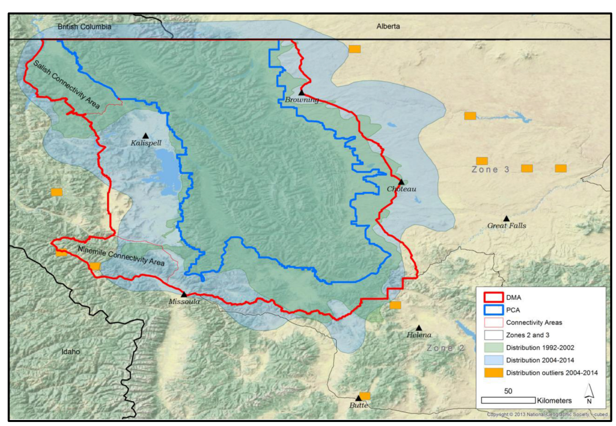

Figure 3. Estimated Distribution of Grizzly Bears in the NCDE. From Costello, et al. (2016).

Mace, et al. (2012) estimated that between 2004-2009, annual growth rate was 3.0%. Costello, et al. (2016) estimate N = 960 over 55,200km^2 (Figure 3) and annual growth rate of 2.3%.

Methods and Assumptions

The use of the models and equations in Costello, et al. are not questioned. Of more interest are the values and assumptions that went in and the final results that came out.

Costello, et al. use methods included in previous studies. These include using data sets from the most productive and secure areas in the NCDE, with presumably higher annual survival rates. Not only did they focus trapping where densities were highest, at page 35 they show mortalities by management unit. Their study area had the least and second least, respectively, mortality as a percent of total NCDE mortalities. Mace & Roberts (2011) also noted they had a trap bias because they focused their efforts in areas with high bear density.

Costello, et al. make some assumptions that could bias their results. In looking at mortality they assessed the period during their study 2004-2014, which is a period when annual mortality was in decline.

In another example, the maximum age of senescence in adult females (the end of reproductive ability) is set at 28 years when their oldest observed female with a litter of cubs-of-the-year was 26 and there was no indication the cubs survived to adulthood. In fact, very few female grizzly bears even live to age 25, let alone successfully defend and raise cubs. Schwartz, et al. (2003) found rapid senescence after age 25 is not that important because few individuals survive that long. Of Schwartz, et al.'s sample size (n = 4,726) ≈ 10% were age ≥ 20 and only 2.1% were ≥ 25 years. They found "Our results conform to senescence theory and suggest that female age structure in brown bear populations is considerably younger than would be expected in the absence of modern man."

Doak & Cutler (2014) detected a similar issue with modeling of grizzly bear vital rates in the Yellowstone ecosystem where studies assumed no reproductive or survival senescence occurred until age 30. One bear out of a sample of thousands can be considered a statistical outlier rather than being a model parameter.

Mace, et al. (2012: 126) wrote: "Our oldest known-aged female was 27 years old and produced cubs the previous year. In our estimate of population trend, we assumed all females died after age 27, although females are known to live longer (Schwartz et al. 2003). We do not believe that omitting these older females influenced our estimate of population trend, as very few individuals this old would be present in the population." Then why did Costello, et al. set senescence at 28?

Costello, et al. (2016:61) observed a higher proportion of females at older age classes. It must be kept in mind their study area was located within some of the highest productivity and most secure habitat, with presumably higher annual survival rates, so older females might make sense within that constrained area, but cannot be extrapolated across the NCDE.

Other estimated values trended towards being higher than the observed values. For example, the annual survival rate for males based on observed values was 80.5-91.6 while the estimated value was 89.5, well above the mean.

Another issue of concern is estimation of unreported mortality. Underestimated values could affect annual survival rates. Costello, et al. also assumed a "high rate" of self-reporting for mistaken identity kills.

On page 75 they state that underestimated unreported mortality leads to a higher survival rate for males, potentially skewing the probabilities of increase or decline. In fact, in discussing their estimates for annual sustainable mortality they write at page 85: "direct application of these numbers as mortality thresholds requires additional evaluation."

Another potential bias is the practice of not counting any mortality that occurs > 16km (10mi) from the Primary Conservation Area (PCA). Presumably, the majority of these bears are dispersers who were born within the PCA, and thus were counted towards natality but then later are not counted towards mortality. There were two such bears in both 2013 and 2014.
At page 90 Costello, et al. conclude " ≈ 10-28 additional mortalities would likely be sustainable."

Mortality

Major studies in the NCDE have documented negative population growth and excessive annual mortality amongst females. Mace & Waller (1997) documented a negative annual growth rate of - 2.3% in their demographic study of bears in the Swan Mountains and S. Fork Flathead River. Given that Costello, et al. report 34% of all NCDE mortalities 2004-2014 occurred in this area gives little confidence that the trend has reversed.

Kendall, et al. (2009) expressed concern that in their study area annual mortality was 4.6%, above the 4% threshold for annual sustainable mortality, and they found "the high proportion of female mortalities raises concern."

McClellan (2015) documented population decline from 1999-2010 in the North Fork of the Flathead River drainage north of the U.S./Canada border.

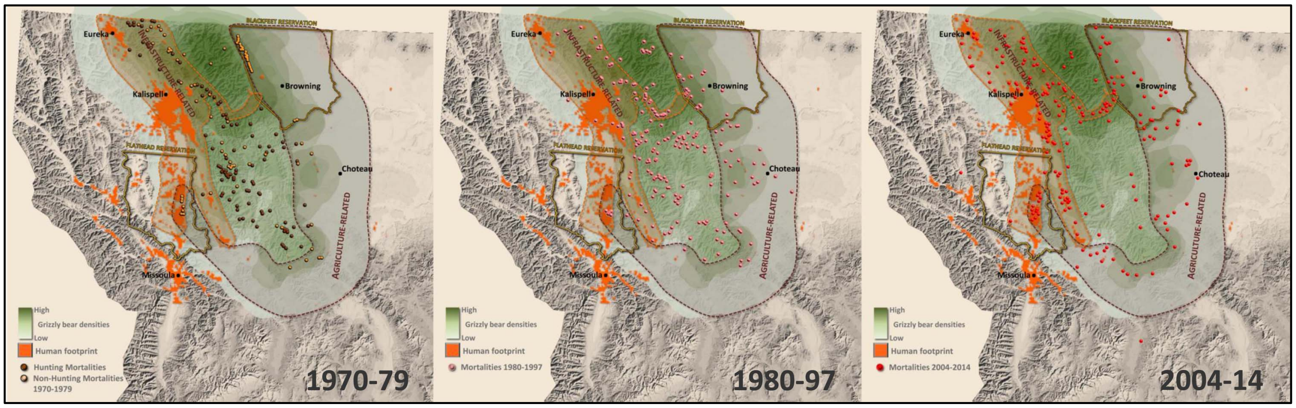

Figure 4. Grizzly Bear Mortalities in the NCDE, 1970-2014. Courtesy Dr. David J. Mattson.

Post-Hunting Mortality Shift

Bader (2000a) found that during hunting seasons in the NCDE, the wilderness/non-wilderness ratio was 1:1.2. Following the end of hunting it was 1:4.5. Since that time that trend has strengthened. From 2004-2014 there were just a handful of mortalities within the wilderness habitats of Glacier National Park (GNP, n = 3) and the Bob Marshall Wilderness (Figure 4).

Costello, et al. at page 31 showed that mortalities outside the PCA were 18% of the total in 2004 and more than doubled to 44% in 2014. Over that same time period they estimated that mortalities in the NCDE increased at the rate of 2-3%/year.

Bader (2000a) also found that following the end of hunting, the mortalities/year declined in both the NCDE (from 19.1 to 13.0) and the Yellowstone ecosystem, suggesting that hunting represents additive rather than compensatory mortality. If the population has really grown from N = 453 to N = 960 during the post-hunting period, it provides some evidence that hunting in the NCDE suppressed population growth.

The response of bears to hunting was not well understood. Presumably, they used the security of mountainous wilderness. One male was known to make a beeline for the Sun River Game Preserve each fall just prior to hunting season.

If hunting is resumed, pressure may initially target bears on the periphery. The bears at the edge of the range may play an important role in exploring and adapting to new habitats and food resources. If the population continues to run into a wall of mortality at the edge of the distribution area, then new adaptations are not available to be passed on through the population.

Habitat Security

Costello, et al. (2016) did not assess habitat security in relation to mortality risk or habitat selection. Their "Proposed Monitoring and Reporting Protocols" (p. 111-113) are limited to demographic numbers within the DMA and make no recommendations for habitat security monitoring or evaluation of source-sink relationships.

Increased habitat protection measures and standards should be applied throughout the DMA (the PCA, Zone 1 and the linkage areas to the Cabinet-Yaak, Bitterroot and Yellowstone ecosystems). This should include the Amendment 19 habitat management plan on the Flathead National Forest. An exception is that secure "core" area should not shift over time. Under the current strategy, by the time a bear learns an area is secure, a new project comes in and the bear must move to another area, most likely already occupied. Or, it can stay and face increased mortality risk.

In Zone 1, management should focus on increasing the potential for residential occupancy by female/cub groups through increased habitat security.

Linkages should address and support both demographic and migratory functions. Linking "demographic stepping stones" of secure, roadless areas ≥28.3 km^2 (7,000 acres) (Mattson 1993) with low road density areas could support female/cub groups. These need to be spatially located within estimated dispersal movements for female grizzly bears.

The idea is to grow isolated populations together, as opposed to maintaining movement "highways." Linkages with low security are mortality sinks and will not provide genetic rescue effects or expansion of habitat area continuously occupied by female/cub groups.

Habitat Productivity, Past and Future Disturbances

In looking at habitat productivity using annual precipitation as a proxy, Bader (2000c) found that 46% of the PCA receives < 102 cm of annual precipitation (≈ 50 inches), most of which falls as snow (Figure 6). The areas with the highest reported grizzly bear densities correspond with areas having ≥ 127cm of annual precipitation. These areas comprised ≈ 36% of the PCA. Considering the period of drought, these proportions may have shifted.

When looking at the total reported distribution area of 55,200km^2, the high productivity areas shrink as a percentage of the total area. Bader (2000c) and Mowat, et al. (2013:8) found that grizzly bears do not and will not likely exist in meaningful densities in areas with < 50cm (20in) annual precipitation.

Moreover, the NCDE area has experienced a prolonged drought over the past ten years and remains so in 2016 (www.droughtmt.gov).

Based on stable isotope analysis, bears in the NCDE have two basic economies (Figure 5). In the mesic northwest, huckleberries are a major resource and home ranges are smaller and density higher. In the xeric east, bears have high meat protein, primarily from livestock carrion, and home ranges are much larger and densities lower.

McClellan (2015) found that a period of poor huckleberry crops coincided with a significant period of population decline in the North Fork Flathead, B.C.

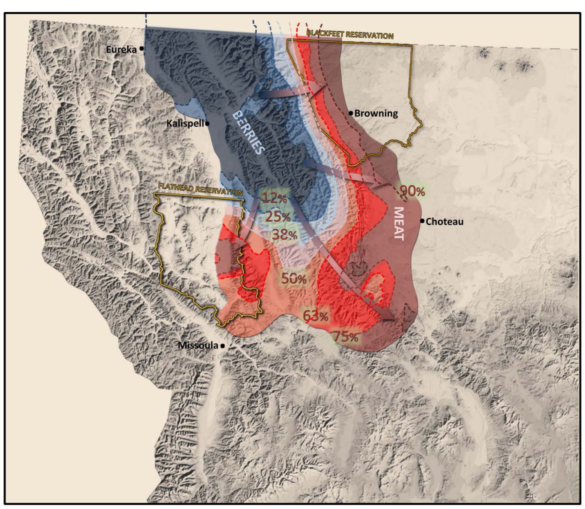

Figure 5. Northwest and East Front Grizzly Bear Food Economies in the NCDE. Courtesy Dr. David J. Mattson.

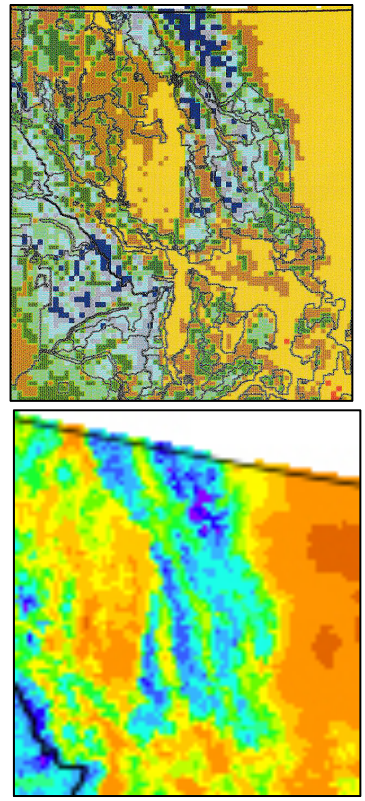

Figure 6a. and b. Annual Precipitation in the NCDE Top: 1961-1990; bottom 1981-2010. Dark blue colors = mesic areas (≈ 100-175cm/yr.); light blue, green, yellow & brown = xeric areas (≈ 20-50cm/yr.) Source: PRISM Climate Group. Oregon St. University.

Simonin (2000) found that big huckleberry is adapted to sprouting after fire from deep and shallow rhizomes and root crowns and is also efficient at storing nutrients released during burning. It will generally survive low to moderately severe fire, attaining pre-fire coverage within 3-7 years, with increases in stem numbers and density.

On the other hand, high severity burns may cause moderate to high mortality. After strong decreases, recovery may take 15-20 years or more and oftentimes does not achieve pre-fire levels.

However, fire *exclusion* also has deleterious effects on big huckleberry production. Simonin (2000) cited Miller (1978) who found a 3237ha (8000 acre) huckleberry field in Washington had diminished to 1011ha (2,500 acres) following 40 years of fire exclusion, as much of the field was replaced by trees and brush. Zager, et al. (1980) found similar effects within the NCDE.

Thus, exclusion of wildfire can have long-term negative effects on production of key food resources. Low severity fires can have positive effects after about 5 years. Conversely, moderate to severe intensity wildfires can have both long and short-term effects, depending on the location and severity of the fire and its spatial relationship to other similar events.

Post-fire recovery of shrub and berry fields is slower and less effective in dry areas with rocky soils (Simonin 2000).

Prolonged drought conditions are more likely to support moderate to severe intensity wildfires over larger areas. Harvey, et al. (2016) found that from 1984 to 2010, the percentage of severe, stand-replacing fire within fire perimeters in the northern Rockies increased from 22% to 27%. Stand-replacing fires burned ≈ 5% of the total forested area, with most of the stand-replacing fire occurring in patches larger than 100ha (75%) and 1000ha (50%), respectively. They concluded "If trends continue on the current trajectory…fires may produce larger and simpler shaped patches of stand-replacing fire with more burned area far from seed sources."

There have been several large-scale fires in the NCDE over the past 30 years (Harvey, et al. (2016). What effects these have had on bear distribution, densities and trends is not known. However, it makes intuitive sense that if a large area of a bear's home range is temporarily unavailable as a foraging area due to disturbance from either fire or human development and use, it will have to move to another area that may already be home to a bear(s), increasing stress and potential conflict within the population. In the context of source-sink dynamics, pockets of high density may not necessarily be a sign of population growth but rather a result of temporary "crammage" or a bleeding of bears from source habitats into sink areas.

This effect is noticeable in the Swan Mountains, a narrow area of roadless habitat separated from the Great Bear Wilderness by an extensive network of logging roads, clearcuts and the Hungry Horse Reservoir. Bears in this area may never have recovered from the direct habitat loss caused by the reservoir and the logging and roadbuilding activity. This landscape still lacks adequate security for the population to rebound.

Grizzly Bear Density

Kendall, et al. (2008) estimated that grizzly bear densities inside Glacier National Park (GNP) were ≈ twice those outside the Park *within* their study area (Figure 7). At a 2:1 ratio of inside vs. outside, approximate densities would be $39/1000km^2$ inside the Park, and $20.1/1000km^2$ outside. These figures are important for comparison of densities in other portions of the NCDE.

Kendall, et al. (2009) estimated N = 765 across a total distribution area of $33{,}480km^2$, which results in a total mean density for the NCDE of $22.8/1000km^2$. Separating the $7933km^2$ and N = 240 from Kendall, et al. (2008) yields a mean density of $20.6/1000km^2$ for the ≈ 76% of the NCDE distribution area south of Glacier National Park.

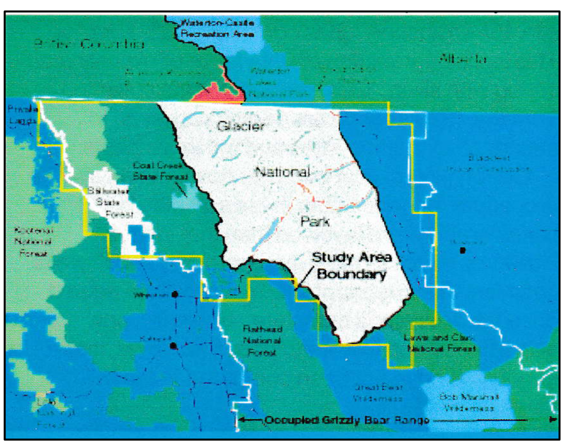

Figure 7. Kendall, et al. Study Area Boundary in Yellow. USGS.

Kendall, et al. (2009; Figure 8) display relative density per hair trap in 2004 based on 7 x 7km cells. It may be the only sample of the NCDE based on equal sampling effort. Large areas of the NCDE had low relative density.

Naturally, bears do not occur in a uniform density across large landscapes. In discussing total distribution Bader (2000b:327) observed: "This broader boundary provides no information on the density, population trend or health of the populations within, and it encompasses areas that may be occupied sporadically, at low frequency and at low densities."

As such, to support a mean density of $20.6/1000km^2$ over this vast area, certain areas would have to support densities approx. equal to those inside GNP ($> 35/1000km^2$). However, previous estimates from the NCDE outside GNP have all reported densities $\leq 20/1000km^2$ (Table 1).

Bears in the lower 2/3 of the NCDE, where conditions are more xeric, berries are far less of the diet and home ranges significantly larger than those in the upper 1/3, are unlikely to exist at the same densities as those immediately adjacent to Glacier National Park.

Mace, et al. (2012:122) calculated "percent relative population density" of radio-collared females from 2004-2009. They showed 38.5% in GNP and 31.5% in the areas adjacent to GNP (Blackfeet Reservation/Badger-Two Medicine; North Fork Flathead River; Middle Fork Flathead River-Great Bear Wilderness). Thus 70% of the relative population density of female grizzly bears was located in the northern 1/3 of the NCDE.

Table 1.
Density Estimates from the NCDE.

Source	**Area**	**n/1000km2**
Servheen (1981)	Mission	20.4
Aune, et al. (1986)	East Front	13.5-19.6
Mace & Waller (1997)	South Fork	10.0-20.3
Kendall, et al. (2008)	Glacier	30.0

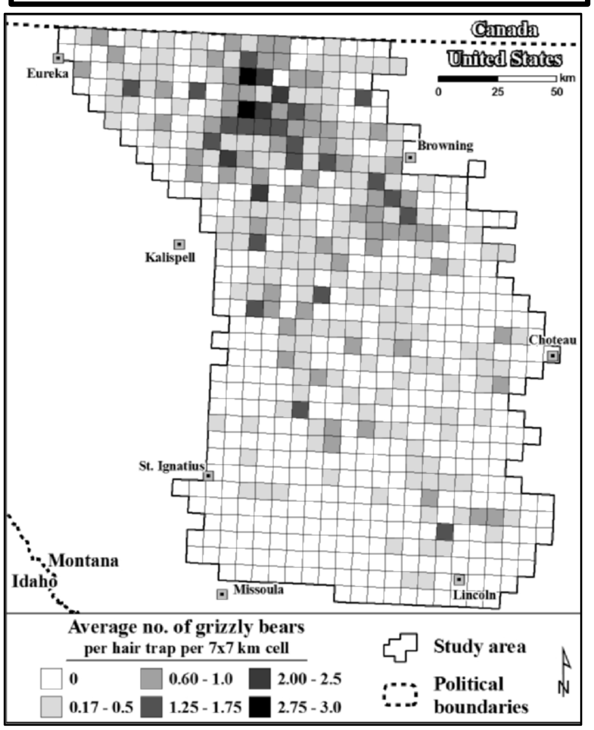

Figure 8. Grizzly Bear Density in the NCDE. From Kendall, et al. (2009).

Bears adjacent to GNP also have the advantage of using portions of GNP on a seasonal basis, providing added productivity and security (Figure 9).

Conversely, the large area comprised by the Bob Marshall Wilderness, Rocky Mountain East Front and Scapegoat Wilderness (more than half of the PCA) had just 17.5% of the relative population density. The South End and the Swan Valley- Mission Mountains contributed just 3.3%.

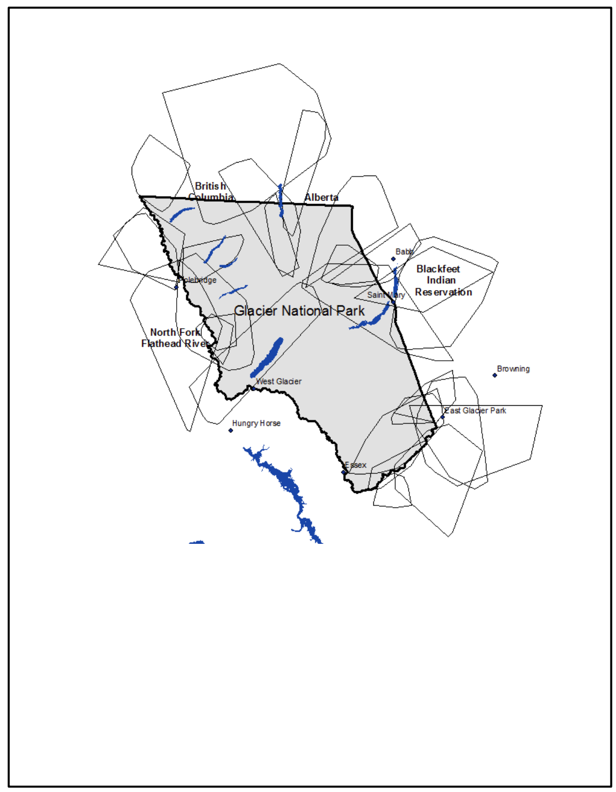

Figure 9. Grizzly Bears Outside GNP With Home Ranges That Include Part of GNP. From Mace & Roberts (2011).

Costello, et al. did not calculate mean density as per Kendall, et al. (2008). However, at pages 22-23 they explain how they calculated relative densities of male and female bears based on the

Kendall, et al. data from 2004 and displayed the results (Figure 10). They are consistent with Mace, et al. (2012). Densities of both female and male grizzly bears peak in the core of GNP and steadily wane going south. Densities in the core of GNP are many times those in other areas of the PCA.

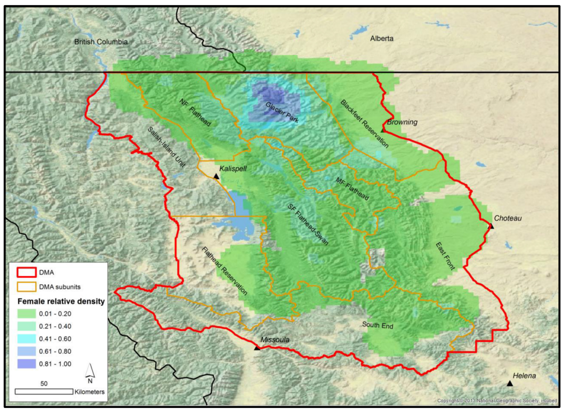

Figure 10. Relative Female Grizzly Bear Density in 2004. From Costello, et al. (2016).

The total estimated NCDE distribution area has increased from 33,480km^2 (Kendall, et al. 2009) to 55,200km^2 (Costello, et al. 2016). Part of this increase is due to Costello, et al. considering grizzly bear observations between the Cabinet-Yaak Recovery Area and the PCA to be part of the NCDE population. Bader (2000b) found significant overlap between the population data sets for the two areas. Kasworm, et al. (2015:19) show Cabinet-Yaak observations up to the western boundary of the NCDE. Is the area between the two part of the Cabinet-Yaak distribution area, the NCDE, both or neither?

Another factor is Costello, et al. used different grid sizes for calculating relative population density (7km^2) and distribution (49km^2). Thus, large areas of low productivity habitats beyond riparian corridors and bone yards were included on farm and ranchlands with cattle, orchards, bee hives, chickens, etc. that are hostile habitat. In reality grizzly bear densities are probably < 2/1000km^2 in these areas.

If outlying observations and their geographic area are excluded, based on the grizzly bear literature, the remaining area is not likely to sustain densities that would support N = 960.

Studies (Craighead et al. 1982; Kendall et al. 2008, Kendall et al. 2009; Mace et al. 2012; Costello, et al. 2016) show an area within the Bob Marshall Wilderness that has had consistently low density. This area includes Danaher Basin, Slategoat Mountain and the Chinese Wall with its sheer cliff faces.

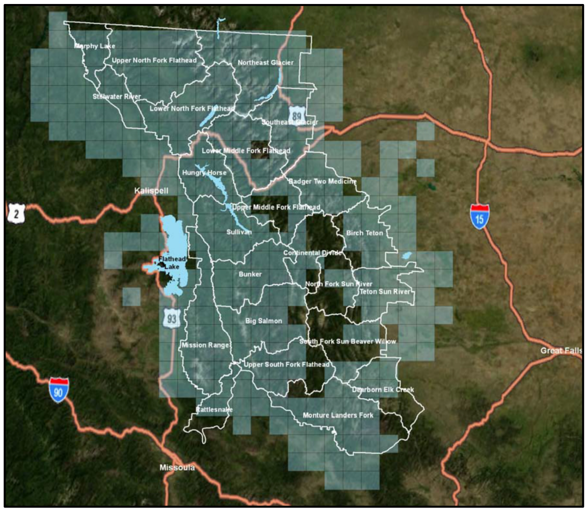

Figure 11. Telemetry Locations of Females 2004-2011. Mace & Roberts (2011).

Costello, et al. at page 15 show that two Bear Management Units, the South Fork Sun/Beaver-Willow and Dearborn/Elk Creek, had occupancy by females with cubs, yearlings or two year olds just five, and six, respectively out of 10 years from 2004-2014. Another BMU, North Fork Flathead north of the Whitefish Mountain Resort, had occupancy just four out of the 10 years. Based on their reported data, on average 26% (6 of 23) of BMUs *did not* contain reproductive females annually. Mace & Roberts (2011) also mapped areas where females were not detected by telemetry (Figure 11), but non-detection may be due in part to the remoteness of the areas.

Moreover, if the population in the PCA is actually approaching K, theory suggests grizzly bears should show the effects of density-dependent population regulation including lower birth rates and higher incidence of intraspecific killing and cub mortality. McClellan (1994:15) wrote: "In reality however, human influences may rarely permit brown bear populations from attaining these levels." The only possible exception in the NCDE is inside GNP, where hunting is not allowed and mortality is limited.

Costello, et al. did not find lower mean litter sizes or evidence of excessive cub mortality.

The Effective Distribution Area

Mortalities and observations increase with human density and viewing opportunity and are more a result of where the people are, thus biasing the distribution of observations towards the periphery of the PCA. Different parts of the NCDE have different sight-ability. For example, the South End has open, rolling terrain where a bear may be sight-able from long distances by different groups of people.

Using the data presented in Mace & Roberts (2011) and their map figure based on 2004 data from Kendall, et al. (2009)(Figure 12), I calculated an "effective distribution area." Just as the effective population, N_e is a fraction of the total population size, the effective distribution area D_e the area where breeding occurs, cubs are being born and reared is some fraction of the total distribution area.

Summing the $10km^2$ grids outside the PCA that were occupied by both males and females (Figure 12), there are ≈ 71 grids accounting for ≈ 710 km^2.

Added to the PCA area of $23{,}133km^2$ D_e was ≈ $23{,}843km^2$ in 2004 and was ≈ 76% of the total distribution area.

At N = 765, the mean density within the effective population area was ≈ $32/1000km^2$, even higher than the $30/1000km^2$ reported by Kendall, et al. (2008). Given previous estimates

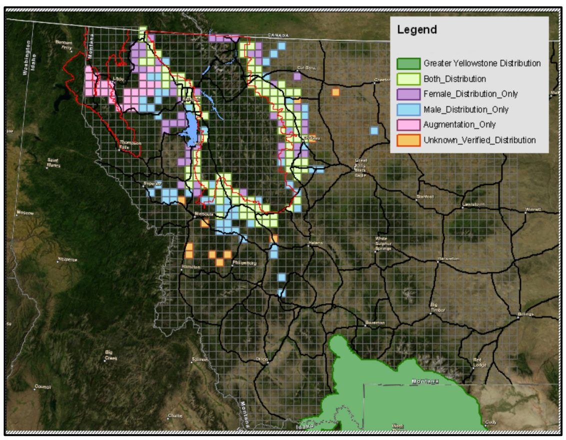

Figure 12. Grizzly Bear Occupancy Outside the PCA, from Mace & Roberts (2011).

which cluster in the range of 10-$20/1000km^2$, and the much drier southern and eastern portions of the NCDE, this is very unlikely.

There are limits to the grid method because one bear on a dispersing or seasonal movement can "light up" several cells, perhaps overstating the amount of overlap between males and females, whereas other occurrences are not detected. The data also represents total observations from 2004-2011, so variations between seasons are masked.

Mattson (1997) documented expanded home ranges during drought years while Mattson (1998) and Jonkel & Cowan (1971) found direct links between years of poor whitebark pine and huckleberry production, respectively, and elevated levels of bear mortality and management actions. K, N_e and D_e change from year to year within ecosystems. Narrow or peninsular reserves will create 'crammage' even in good food years, and elevate mortality risk and stress within bear populations in drought or poor food source years.

In the absence of increased habitat security, it has to be asked what portion of range expansion actually makes a positive contribution towards population recovery and viability?

Many of the forays far onto the plains (Figure 2) are by bears following riparian corridors, primarily in search of chokecherries. Once away from the mountains, they have opportunities to come into contact with grain bins and livestock.

One-way forays into high-risk habitats are a drain on the population rather than evidence of population growth.

Morever, the Costello, et al. review of mortality reveals most of the mortalities at the edge or beyond the

PCA and DMA are young males. Why? Because the whole area within the PCA is full? Or because large areas within the PCA have been disturbed by natural and man-made events and what is left is full? The release of competition in the area beyond may be driving some of the range expansion.

The review of mortality distribution reveals that D_e has certainly shrunk as a percentage of the total distribution area, which should provide cause for additional analysis.

It is important to calculate D_e on an annual as well as cumulative basis (not every 1-5 years as recommended by Costello, et al.) to better understand movements in relation to annual seasonal as well as long-term changes in habitat, climate and habitat use.

Conclusion

Several aspects of the status of the grizzly bear population in the NCDE remain unknown and require further detailed evaluation.

The reasons behind recent expansions in the total distribution area are not yet well understood, and could be due to factors other than rapid, sustained population growth.

A question that must be answered is: was the condition of the grizzly bear population in 2004, (in the midst of a prolonged drought and in the wake of findings of negative population growth and excessive female mortality) really N = 765 and poised for ten years of population growth and range expansion at the rate of 2000km^2/year?

It would be remarkable if the population more than doubled between 1995-2014 (from 453 to 960) in the face of drier conditions and large-scale habitat disturbances, years with excessive mortality and other years where some BMUs did not have females with offspring, increased human population growth and visitation. As such, there are credible reasons for considering N = 960 as optimistic and I believe there may well be an equally compelling alternative narrative.

Additional research is required to better understand distribution and trends in mortality, habitat use in response to disturbance, the effects of human access on mortality and habitat security, source-sink habitat relationships and annual and long-term trends in climate and precipitation.

In order to expand D_e, the effective distribution area, increased habitat protection measures and standards must be applied to the PCA, Zone 1 and the linkage areas to the Cabinet-Yaak, Bitterroot and Yellowstone ecosystems. In Zone 1, management should focus on increasing the potential for residential occupancy by female/cub groups through increased habitat security.

I argue that in the absence of additional necessary information and habitat security measures, it is premature to use the estimations for total population size and annual sustainable mortality as a basis for removing Endangered Species Act protections, reinstitution of hunting or for long-term land management planning including the Flathead and Lolo National Forest Plan Revisions and the Four National Forest Plan Amendments for Grizzly Bear Habitat Management in the NCDE.

Literature Cited

Aune, K, Madel, M. and C. Hunt. 1986. Rocky Mountain Front grizzly bear monitoring and evaluation. Montana Department of Fish, Wildlife & Parks. Helena. 175 p.

Bader, M. 2000a. Wilderness-based ecosystem protection in the northern Rocky Mountains of the U.S. Pages 99-110 in: Wilderness Science in a Time of Change Conference. USDA Forest Service, Rocky Mtn. Res. Sta. Ogden, UT.

Bader, M. 2000b. Distribution of grizzly bears in the U.S. northern Rockies. Northwest Science 74(4): 325-334.

Bader, M. 2000c. Spatial needs of grizzly bears in the U.S. northern Rockies. Peer-reviewed presentation at the Society for Conservation Biology 2000 Conf. 25 p.

Costello, C.M., R.D. Mace, and L. Roberts. 2016. Grizzly bear demographics in the Northern Continental Divide Ecosystem, Montana: research results (2004–2014) and suggested techniques for management of mortality. Montana Department of Fish, Wildlife and Parks. Helena.

Craighead, J.J., J.S. Sumner and G.B. Scaggs. 1982. A Definitive System for Analysis of Grizzly Bear Habitat and Other Wilderness Resources. Wildlife-Wildlands Institute Mono. No. 1.
U of M Foundation, U. of Montana, Missoula. 279 p.

Doak, D. F. and K. Cutler. 2014. Re-evaluating evidence for past population trends and predicted dynamics of Yellowstone grizzly bears. Conservation Letters, May/June 2013, 7(3):312–322.

Harvey, B.J., D.C. Donato and M.G. Turner. 2016. Drivers and trends in landscape patterns of stand-replacing fire in forests of the US Northern Rocky Mountains (1984–2010). Landscape Ecology.

Jonkel, C.J. and I. McTaggart Cowan. 1971. The black bear in the spruce-fir forest. The Wildlife Society Monograph No. 27. 57p.

Kasworm, W. F., T. G. Radandt, J.E. Teisberg, A. Welander, M. Proctor, and C. Servheen. 2015. Cabinet-Yaak grizzly bear recovery area 2014 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. 96 p.

Kendall, K.C., J. Stetz, D.A. Roon, L.P. Waits, J. Boulanger and D. Paetkau. 2008. Grizzly Bear Density in Glacier National Park, Montana. J. of Wildl. Manage. 72(8):1693-1705.

Kendall, K. C., J.B. Stetz, J. Boulanger, A. MacLeod, D. Paetkau, and G. White. 2009. Demography and Genetic Structure of a Recovering Grizzly Bear Population. J. of Wildl. Manage. 73(1): 3-17.

Mace, R.D. and Waller, J.S. 1998. Demography and population trend of grizzly bears in the Swan Mountains, Montana. Conserv. Biol. 12(5): 1005-1016.

Mace, R. and L. Roberts. 2011. Northern Continental Divide Ecosystem Grizzly Bear Monitoring Team Annual Report, 2009-2010. Montana Fish, Wildlife & Parks, 490 N. Meridian Road, Kalispell, MT 59901. Unpubl. data.

Mace, R.D., D. W. Carney, T. Chilton-Radandt, S. A. Courville, M. A. Haroldson, R. B. Harris, J. Jonkel, B. Mclellan, M. Madel, T. Manley, C. Schwartz, C. Servheen, G. Stenhouse, J. S. Waller, and E. Wenum. 2012. Grizzly bear population vital rates and trend in the Northern Continental Divide Ecosystem, Montana. J. of Wildl. Manage. 76(1):119–128.

Mattson, D.J. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone ecosystem. Coll. For. Wildl. Range Sci. U. of Idaho. 17p.

Mattson, D.J., G.W. Wright, K.C. Kendall and C.J. Martinka. 1995. Grizzly bears. Pages 103-105 In: Our Living Resources – Mammals. USDI, Natl. Bio. Serv.

Mattson, D.J. 1997. Sustainable grizzly bear mortality calculated from counts of females with cubs-of-the-year: an evaluation. Biol. Conserv. 81: 103-111.

Mattson, D.J. 1998. Changes in mortality of Yellowstone's grizzly bears. Ursus. 10: 129-138.

McClellan, B.N. 1994. Density-dependent population regulation of brown bears. Pages 15-24 *In*: Density-Dependent Population Regulation of Black, Brown and Polar Bears. Ninth Intl. Conf. on Bear Res. Manage. Mono. Series No.3. M. Taylor (ed.) 43 p.

McClellan, B.N. 2015. Some mechanisms underlying variation in vital rates of grizzly bears on a multiple use landscape. J. of Wildl. Manage. 79(5):749–765.

Mowat, G,. Heard D,C., Schwarz C.J. 2013. Predicting grizzly bear density in western North America. PLoS ONE 8(12): e82757.

Schwartz, C.C., Keating, K.A., Reynolds, H.V., Barnes, V.G., Sellers, R.A., Swenson, J.E., Miller, S.D., McClellan, B.N., Keay, J., McCann, R., Gibeau, M., Wakkinen, W.F., Mace, R.D., Kasworm, W., Smith, R., and S. Herrero. 2003. Reproductive maturation and senescence in the female brown bear. Ursus 14(2): 109-119.

Servheen, C. 1981. Grizzly bear ecology and management in the Mission Mountains, Montana. Ph.D. dissertation. U. of Montana, Missoula.

Simonin, Kevin A. 2000. Vaccinium membranaceum. In: Fire Effects Information System, [Online]. USDA, Forest Service, Rocky Mtn. Res. Sta., Fire Sci. Lab.

Zager, P, C. Jonkel and J. Habeck. 1980. Logging and wildfire influence on grizzly bear habitat in northwest Montana. Int. Conf. Bear Res. and Manage. 5:124-132.