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Connecting The Gems

The Northern Rockies of the United States, comprised primarily of western Montana, central and northern Idaho and northwestern Wyoming, are home to some of the last remnants of North America's rich biological past (Walker and Craighead 1997). Two of the most intact and important ecosystems in the world's temperate zone are found within this region. The Greater Yellowstone Ecosystem and the Salmon-Selway Ecosystem, which includes the Frank Church River of No Return Wilderness in central Idaho, are large, wild, and mostly undisturbed landscapes. Because these areas are still intact, we are fortunate enough to have all of the native vertebrates with the exception of Passenger Pigeon that were here when Lewis and Clark came through (Brock interview 2010). Here, wolf, lynx, wolverine, grizzly bear, black bear, and puma contribute to a feeling of true wilderness unlike any other in the lower 48 states. It is believed that the best chance for management of a viable carnivore community in North America is the Northern Rocky Mountains of the United States and the Southern Rocky Mountains of Canada. It may be the last place in the lower 48 states where this opportunity exists (Ruediger 1999 as cited in Davidson 2004).

With increasing human development, wildlife habitat in this area is becoming extremely fragmented. Habitat loss and fragmentation has been widely acknowledged as a primary cause of the decline of numerous species throughout the world (Ehrlich 1986 as cited in Davidson 2004). When populations of animals exist in isolation, they are left without the ability to maintain genetic diversity. Simply put, when wildlife can no longer migrate or disperse to new habitats, the long-term health of the population is in jeopardy. It is therefore essential that we maintain clear migration and dispersal routes between protected ecosystems. By connecting the gems that are these ecosystems, we can better ensure healthy populations of grizzly bears, wolverines, moose, mountain lion, and so many other species.

Throughout the last several months I have been conducting a research project to understand this problem, identify the key people involved, gather specific information including but not limited to the dispersal and migration patterns of the mammals in these areas, habitat assessments, resource availability, human impact, existing conservation practices, and future predictions for localized impacts caused by climate change. To date, I have met with several members of the conservation community, land managers from the National Forest Service, and private land owners. In addition, I have reviewed several papers from the scientific literature focusing on connectivity and habitat fragmentation. In the summer of 2010, I will trek between these two isolated ecosystems to further gain insight into the issue, and to get an otherwise unattainable and tangible understanding of this area and the issues it faces from an animal's point of view.

The following is a summary of my findings to date, with specific focus on the interviews and the common threads between them as well as the literature. I will then speak to future research goals, and the needs of this project moving forward.

The area:

GYE

The Greater Yellowstone Ecosystem (GYE) was first defined as "the area necessary to sustain the Yellowstone population of grizzly bears" (Craighead 1979). Today, the GYE is the southernmost area in North America that still contains a full array of native carnivores, along with other wilderness characteristics (Clark et al. 1999). The GYE is a 10.8 million hectare area spanning across three states including Montana, Idaho and Wyoming. Currently 27% of the GYE holds a protected status, however the protected portion of this area does not include many important biological areas and fails to represent all natural communities. (Noss et al. 2002). At the heart of this area lies Yellowstone and Teton National Parks. In addition to the parks, 1.6 million hectares of federally designated wilderness can be found within the GYE. As of 2002, 36% of the GYE was private land and 64% was public (Noss et al. 2002). Main biological communities in the GYE are separated primarily by elevation with the lower elevations consisting largely of grass-shrub dominated communities, and middle to high elevations consisting of primarily coniferous forests (Noss et al 2002). The region encompasses key migration routes and winter ranges for vast herds of elk, bison, and pronghorn. It is home to the world's largest concentration of bighorn sheep and provides some of the last habitat for the continent's great predators including wolves, grizzlies, mountain lion and wolverines (Walker and Craighead 1997).

Frank Church Wilderness

Named for US senator Frank Church who was instrumental in protecting the area, the Frank Church River of No Return Wilderness is the largest intact area of protected wilderness in the lower 48. Created in 1980 by an act of congress, it is comprised of 2.3 million acres, and is the core of a 3.3 million acre roadless area in the heart of the Salmon-Selway Ecosystem. Although this area has historically supported grizzly populations, and though it remains on of the few areas considered to be suitable habitat for grizzly bears, no established populations are known to exist. "The Frank Church wilderness is the key to really securing the future of grizzly bears, and other carnivores in the Northern Rockies for the long haul" (Brock interview 2010). In addition, the Frank Church offers some of the most critical habitat for wolverines in the lower 48 states (Walker and Craighead 1997).

Connecting the two areas

Between the Greater Yellowstone Ecosystem and the Frank Church lies roughly a 380 kilometer distance thru the Madison Range, Centennial Mountains, and the Lemhi Range in Idaho. The landscape is rugged, and due to its remoteness remains largely unstudied. This potential travel route is deemed a central ‘‘artery’’ for wolverine gene flow in the Rocky Mountains (Swartz et. al. 2009). Maintaining linkage opportunities between grizzly bear populations in the GYE and the Salmon-Selway Ecosystem could enhance their recovery in the United States (Servheen et al. 2001). Brent Brock, a landscape ecologist with the Craighead Enviornmental Research Institue believes that the linkage between the area is key to the existence of a flourishing population.

> If we want to maintain grizzly bears along this knife edge of being a threatened species or not a threatened species then we should continue to do what we are doing, but we have this vast area up to the west that could support a large population of grizzly bears, and if we can maintain connectivity with that area and get them reestablished there, and also have that population connect to the Glacier, Crown of the Continent population, then we've got a truly robust population and this discussion about whether or not they are a threatened or endangered species will go away. We will be able to start managing grizzly as a wildlife species like we do others that have been recovered or never got into trouble in the first place (Brock interview 2010).

This area represents one of the last critical barriers to a connection between northern populations and the Frank Church, the fate of many species may depend largely on their ability to move through this area.

The need for connectivity.

“Critical wildlife migration corridors and crucial wildlife habitats are necessary to maintain flourishing wildlife populations“ (Western Governors Association 2007). Before human settlement, natural landscapes were mainly large expanses of contiguous habitat supporting many wide-ranging species (USEPA 1999). Several studies have made clear that if species become isolated across the landscape, gene flow simply cannot occur. In one particular study to assess the effects of major highways and other recently constructed anthropogenic barriers upon genetic diversity in a population of desert bighorn sheep, Clinton W. Epps and his team found that nuclear genetic diversity of desert bighorn sheep populations was negatively correlated with the presence of human-made barriers that prohibit dispersal to nearby populations. (Epps el. al. 2005). A loss of connectivity is believed to impede exchange of individuals among populations, thereby exacerbating the loss of genetic diversity because of genetic drift (in small populations) (Frankel & Soule 1981; Hedrick 2005 as cited in Epps et. al. 2005). In addition Epps et al. reported that reduced genetic diversity is likely to increase population extinction rates both in the short term because of inbreeding, (Saccheri et al. 1998; Westemeier et al. 1998; Coltman et al. 1999 as cited in Epps et. al 2005), and in the long term by reducing the ability of a population to adapt to future changes in biotic and abiotic factors such as climate change. (Frankel & Soule 1981; Lande 1998; Fraser & Bernatchez 2001; Hedrick 2005 as cited in Epps et. al. 2005).

Brent Brock likens the need for genetic diversity to having a really big Swiss army knife with a lot of fancy tools. He says that, "You may never need any of those tools, but if the world changes around you and suddenly you find out need an extra tool to survive, you're going to have the ability to adapt and continue to reproduce and send offspring into the future. Genetic diversity is that Swiss army knife with all of the tools you may need. When you don't have enough diversity in the gene pool, a species will loose vigor." (Brock interview 2010).

Forest Service biologist Randy Swilling agrees that there exists the potential for catastrophic occurrences with a loss of connectivity

> With a lack of connectivity, there is potential for reduced diversity in populations and with that reduction in diversity you run into issues such as inbreeding depression and compromising the reproductive capacity of certain species. Ultimately these islands of habitat will support less diverse plant and animal communities, when you start loosing that diversity ultimately you get into a complete ecosystem collapse where you have species becoming isolated and disappearing, then we start to get local extirpations, which some species may be able to support if they are more widely distributed, and then there are other species that may have very specific habitat environments, and that is a much bigger issue (Swilling interview 2010).

Wildlife Conservation Society biologist Pete Coppolillo points out that when looking at the issue of connectivity, it is essential that we look at it on a species by species basis.

> Loss of connectivity really depends on the species. It means that we need to look at why they needed to move. In some cases, the population wouldn't collapse and we see that with bison in the park, they're kept in and that population would move a lot more if is wasn't kept in, all the way to the other end of the spectrum where species that, like wolverines, if they didn't or weren't able to disperse and find home ranges, that would be it. We wouldn't have wolverines here. (Coppolillo interview 2010).

Coppolillo further points out that even the term connectivity itself can mean several different things, and that we need to be careful when distinguishing between types of connectivity.

> In this part of the world, some people say connectivity, some people say corridors, some say linkage zones, and now freedom to roam is a big phrase that everybody likes to use, that is a catch all for a lot of different things, so you might have an A to B migration, that the best example is the path of the pronghorn. Pronghorn go all the way down from Grand Teton National park all the way down to the gas fields near Pinedale, WY for winter range. It's an invariant path, they do it exactly the same way every year, they do it about the same time every year, and they go right through there, that is a classic

> migration, about the simplest case, a little more complicated kind of connectivity is what they do when they get to the gas fields, and that's the part of the story most people don't know is that once they are in those gas fields, they wonder nomadically through those gas fields tracking areas of low snowfall. So they need connectivity that needs to be a permeable landscape, but we can't really predict where they are gonna go, its low snowfall and that is a very dynamic thing that varies from one month to the next. So this nomadic movement, that is another kind of connectivity. Another one is like what happens with the bison here and in Yellowstone. You have a core population that expands contracts and depending on local resources sort of bumps up against the areas adjacent to, that doesn't happen every year, but it happens when there is deep snow fall or when populations get larger that happens with a lot of elk and a lot of winter ranges. That is a whole different kind, and then you have things like grizzly bears where they are expanding their range, so we know grizzlies may use and may only go through an area once and then there is a grizzly population on the other side and that's that. So connectivity zones are complex things and they matter for a lot different reasons. All the way from every individual every generation like wolverines, to every individual every year, like the path of the pronghorn, to one individual every once in awhile like genetic interchange for wolves and criteria for delisting them, to one that just has to happen once (Coppolillo Interview 2010).

There can be little doubt that individual animals disperse over long distances from their birthing areas and that these movements foster gene flow and demographic interchange between populations (Walker and Craighead 1997). Habitat fragmentation is a serious threat to biological diversity (Wilcox and Murphy 1985). Fragmented systems containing small isolated populations suffer increased extirpation or extinction probabilities (Lande 1988; Woodroffe & Ginsberg 1998 as cited in Proctor 2004). What is perhaps of biggest concern is that scientific evidence is showing that the current US system of federally protected areas is likely too small and fragmented to protect against the decline and loss of native species diversity or to facilitate large natural ecosystem processes (Wright, Dixon & Thompson 1933; MacArthur & Wilson 1967; White 1987; Wilcove 1989; Baker 1992; Turner et al. 1993; Noss & Cooperrider 1994; Reice 1994; Newmark 1995; Sinclair et al. 1995; Soule & Terborgh 1999 as cited in Crist 2005).

It should be noted that in the past there existed quite a bit of skepticism about the whole idea of corridors by people who believed that there was not enough evidence to show that corridors would work as they were intended, and in fact several papers argued that there may in fact be negative consequences to certain species (e.g. Hanski 1997; McCallum & Dobson 1995; Hess 1996; Gog et al . 2002). However, it has been shown that the benefits of corridors and other connections that allow species to disperse through the landscape far outweigh the possible risks ((McCallum & Dobson 2002). The evidence supporting the use of corridors is overwhelming and widely accepted in the scientific community. In addition, opponents of the idea of corridors felt that the cost of making and protecting the corridors would outweigh the benefits associated with them.

According to Walker and Craighead this may be the case in highly developed landscapes where habitat must be restored in expensive real estate areas in order to provide a corridor, but it is of much less of a concern in landscapes like the Northern Rockies where the intact habitat and the connections between them still exist but are rapidly being changed (Walker and Craighead 1997).

Obstacles to connectivity:

Roads

There exists an overwhelming amount of literature about the negative effects of roads on ecosystems. They are wildly considered a major cause of landscape fragmentation, and barriers to wildlife movements. In addition, roads have been linked to increased mortality, drastic changes in animal behaviors, habitat loss, erosion, the spread of invasives, and many other negative effects on ecosystems. When asked about the biggest barriers to connectivity, Kim Ragotzkie, the stewardship director the Henry's Fork Foundation, and who was formerly a biologist with the Idaho Department of Fish and Game for fifteen years says that, "For any wildlife species, it is the big highways, they're really hard on wildlife. We have the I-15 corridor running north to Dubois, further north, the I-90 corridor, It has been demonstrated that it is an issue for bears specifically, and is for many other species as well" (Ragotzkie interview 2010). Brent Brock believes that transportation infrastructure is perhaps the most important impediment to wildlife connectivity, and it is even more important than rural development in most areas (Brock correspondance 2010). In fact, the issue with roads is so great that according to Forman and Alexander, "Few environmental scientists, from population ecologists to stream or landscape ecologists, recognize the sleeping giant, road ecology" (Forman and Alexander 1998). In the United States, 6.5 million km of public roads are used by 250 million vehicles (US DOT 2008; Rita 2007). Overall, 20% of the land is within 127 m of a road, and 83% was within 1061 m of a road. Only 3% was more than 5176 m away (Ritters and Wickham 2003). Roads are also precursors to future impacts, because when roads come, along with them comes land development and the further expansion of the road network itself (USEPA 2002 as cited in Forman and Alexander 1998). Forman estimated that a minimum of 22% of the total land area of the contiguous US was ecologically affected by roads (Forman 2000). Ritters and Wickham had perhaps the most interesting approach to looking at the data. They point out that, "If you imagine that the conterminous US has been subdivided into 8.6 billion parcels the size of a baseball diamond infield, and then consider standing on home plate in each one." According to their data model, "In one out of 22 cases you will find a road no farther away than second base (~43 m). In one out of every five cases, the road is no further away than the center-field fence in Yankee Stadium (~125 m)". The authors also point out that humans can drive to within a kilometer of 82% of all land in the lower 48 (Ritters and Wickham 2003).

Negative effects of transportation corridors have been documented for numerous wildlife species including woodchucks (Marmota monax,), sandhill cranes (Grus canadensis,), ravens (Corvus coraxc,), passerines, deer (Odocoileus spp.), and bumblebees (Bombus spp.); (Woodward 1990; Dwyer and Tanner 1992; Knight and Kawashima 1993; Reijnen and Foppen 1994; Romin and Bissonette 1996; Bhattacharya et al. 2003 as cited in Waller and Servheen 2005). In a study to designed to asses the impacts of roads on grizzly bear populations in Yellowstone National Park, the interagency grizzly bear study team determined that avoidance of roads and developments by grizzly bears in Yellowstone Park probably resulted in poorer conditioned adult females and, as a result, higher death rates and lower fecundity for the cohort (Mattson, Knight, and Blanchard 1987). Several potential solutions have been developed to mitigate the problem with roads. For example, wildlife overpasses and underpasses have been used to promote wildlife movements across roadways. However, Corlatti et al. points out that, "so far, there is no evidence that wildlife overpasses do or do not efficiently address genetic issues, and that long-term monitoring programs, including fieldwork and genetic analyses, are needed on the issue" (Corlatti et. al. 2009). A second mitigation technique is to prevent the problem from getting worse. Crist, Wilmer and Aplet found that maintaining roadless areas enhances overall landscape connectivity by reducing isolation among protected areas and allowing for a more dispersed conservation reserve network, which is important for preserving many species movements (Crist, Wilmer, and Aplet 2005). Whatever the solution, it is clear that with increasing populations and roadways, wildlife populations are bound to suffer and measures must be taken to help control the problem.

Development

"For the first time in more than a century, more people are moving to rural areas than from rural lands" (Johnson 1998 as cited in Hansen et. al 2005). Exurban development, low-density housing in a landscape dominated by native vegetation is the fastest growing form of land use in the United States (Brown et al. 2005 as cited in Hansen et. al 2005). Since 1950, there has been a five-fold increase in the area within the contiguous United States that is occupied (Brown et al. 2005 as cited in Hansen et. al 2005). This is of particular concern because many native species incur reduced survival and reproduction near homes and consequently native species richness generally declines with increased housing densities (Hansen et. al 2005). Development affects wildlife habitat directly and accordingly wildlife indirectly. Native vegetation is frequently removed during construction of buildings and roads and as a result of landscaping practices (Riebsame, 1995). Thoebold, Miller, and Hobbs argue that while each single land use change often results in a negligible impact, the accumulation of these individual changes over time, may result in a major impact (Theobold et al. 1997). With a human population that by latest estimates is more than 6.8 billion and growing, it seems likely that human encroachment on wildlife habitat will continue to isolate populations and cut off potential dispersal and migration routes. However, and somewhat surprisingly, the general attitude seems to be a bit more optimistic. There exists a widespread belief that "most people that actually move out to these rural areas really want that kind of close intimate relationship

with wildlife" (Brock interview 2010). Tad Sweet, an Idaho landowner and conservationist agrees, stating that, "When we look at things with more understanding and new information we have found we have a lot in common and shared objectives. When people who otherwise might not trust each other out of ignorance can get together, we find that we have something in common, and it's amazing what has happened" (Sweet interview 2010). Brock believes that a large part of the change that has occurred in recent years is due to a fundamental change in the way that interactions between the conservation community and developers are occurring.

> In the past, a developer would develop their plans, spend money to hire the consultants, spend lots of money up front trying to develop these plans and trying to take it to the county and at that point finding out that there might be wildlife issues involved there. That's at the point when it is pretty expensive for them to go back and rewrite their plans, and rehire the consultants, and rethink their development and that is when the shouting begins. What we are working towards is a more proactive approach where we provide the information up front and everybody knows right up front that in this particular location, yes it is important for wildlife, but here are some guidelines that can be followed to avoid the problems and make sure that wildlife can still live in this area or move through this area. Now when a developer takes it to the county everybody is on the same page and we have made all of our changes and our revisions to our proposal up front when it is easy and cheap rather than afterwards (Brock interview 2010).

Randy Swilling agrees that things have changed and believes that this is largely due to the fact that incentives for developers to consider the needs of wildlife when building, will greatly reduce the potential impacts in coming years.

> Luckily on the Gallatin National Forest, we are probably not going to be seeing an issue in the near future. We will continue to have housing developments go in. In my recent experience however, with a lot of these new housing developments, they are interested in setting up conservation easements to allow wildlife passage, and to allow corridors. They love to see the wildlife. The smaller towns, they want to stay tuned in, and because the tourism money that comes in here is big for them they care about the wildlife (Swilling interview 2010).

Still, Swilling feels that caution is necessary when assuming that we are in the clear when looking at future development.

> There is still potential there for some of the ranchers who haven't bought into the idea of conservation easements, that they up and decide to sell off, subdivide, then I think eventually it could get to that critical mass where we are impacting some movements just by widdling away the amount of winter range. (Swilling interview 2010).

Sweet agrees that there have been significant changes, and also cautions that we are not in the clear just yet.

> We're not that far away, its just overcoming ignorance, and then we can truly collaborate. But, the way we're racing the clock, if you loose 1000 acres to a 1000 homes, it's not too easy to reverse (Sweet interview 2010).

What may be of equal or even greater concern to the rural housing boom, is the potential for new energy development to have an impact on wildlife.

> Energy development is something we really need to be thinking more about. Wind energy, we want clear renewable energy on the landscape, there are some areas that we just shouldn't put wind energy (Brock interview 2010).

Still, it seems that the general consensus is that with the new tools, including a healthy dialogue that exists in current times, both developers and environmentalists can peacefully coexist and find viable opportunities to appease both sides.

> Two decades ago the farmer and the rancher was the enemy. He was eating up all the grass and polluting everything, and now the farmer and the rancher become the ally of people who want to maintain conservation, this something that is happening in our community. (Sweet interview 2010).

> The more we can work to get tools that help us predict what the impacts on wildlife are going to be upfront, the more we can actually accomplish. We don't want to be telling people or just saying no all the time. No don't put it here, because there is wildlife. We want to be able to say here is where we think you should put it. Here are some good areas that satisfy the criteria you need to have a good economically viable wind development, or coal bed, or methane development, or whatever it is without suffering the adverse impacts. That is sometimes going to mean that some projects just don't get approved, because they just aren't going to be compatible with wildlife and those are judgments that society is going to have to make, but the more information we can get up front to actually try to predict these before the shovels hit the ground, the better off I think we are gonna be (Brock interview 2010).

Despite optimistic attitudes, what is potentially the most troubling about all of this is that the change that is occurring in the way that people are communicating and finding common ground may not actually change the way that we do rural development. Peterson, Chen, and Liu found a rather surprising phenomenon when looking at who lives and are building homes in rural settings that are considered to be fragile environments. According to the authors, “Choosing the type and location of one’s home is potentially the most pervasive and direct link between human attitudes and intentions and their physical effects on the land.” Still, they conclude that older highly educated immigrants with environmentally conscious attitudes are the ones who to live in natural areas (e.g., riparian zones, wetlands, critical winter range for wildlife) in disproportionately high

numbers, whereas immigrants with the lowest levels of education and least environmentally conscious attitudes choose to live in previously established residential areas in disproportionately high numbers (Peterson et. al 2007). In fact, many immigrants choosing to build homes in riparian areas or on hillsides even held advanced degrees in closely related fields such as wildlife ecology, fisheries, zoology, and forestry (Peterson et. al 2007). Clearly, environmentally oriented attitudes, intentions, and education do not guarantee more environmentally sensitive behavior, and the reality is that often what people say they do differs significantly from what they actually do (Argyris & Schon 1978; Argyris 1992 as cited in Peterson et al.) Linking household location decisions to environmental attitudes is a necessary step for conserving biodiversity. "Environmentally conscious decisions about home appliances, food consumed, family planning, voting, donations, activism, and transportation alone will not protect biodiversity unless people make the environmentally conscious decision regarding their homes" (Peterson et. al 2007). It seems essential that the conservation community takes responsibility for the choices being made by itself if there is ever going to be hope of influencing the actions of others.

Climate Change

Another major concern when talking about habitat fragmentation is the effect that climate change will have on wildlife species. Particularly, the wolverine's ability to move is likely to be affected by climate change. Significant reductions in spring snow cover associated with climatic warming have already occurred in some portions of the wolverine's range in the contiguous US (Copeland et al. 2009). Jedediah F. Brodie and Eric Post published a paper in which they set out to determine just how a declining snowpack is affecting the wolverine. The specific research goals that the authors had were, "to test whether annual snowpack levels have detectable influence on wolverine population dynamics, to test whether temporal trends in snowpack correspond to trends in wolverine harvest levels, and to determine if spatial synchrony in snowpack dynamics drives synchrony in wolverine population dynamics, as population synchrony is a known determinant of extinction risk." (Brodie and Post 2009) When the authors compared the depth of snowpack to the growth rate of the wolverine, they found that there is a strong positive correlation between the two. When there is more snowpack, growth rate is higher. Similarly they found that as there was an increase in the rate of snowpack decline, there was a decrease in this growth rate in all cases except in the Northwest Territories for which may have eschewed numbers due to increased rates of immigration on account of the deeper snowpack found there. Also of concern was the fact that the researchers also found a strong positive correlation between the rate of snowpack decline and the wolverines' trends in spatial synchrony. Spatial synchrony refers to coincident changes in the abundance or other time-varying characteristics (growth rate, death rate, time of birthing, etc.) of geographically distinct populations (Liebhold 2004). Unfortunately for the wolverine, there is a tight positive correlation between global extinction rate and the level of synchrony in dynamics among subpopulaitons (Heino 1997). It is clear from this research that spring snowpack has been declining across western and northern Canada over the last 30 years, that the declining snowpack and

subsequent habitat fragmentation is negatively affecting the population dynamics of wolverines, and furthermore that these trends in declining snow appear to be driving trends in wolverine synchrony across populations. Because it has been shown that wolverine distribution can be tied to persistent spring snow cover, it is clear that climate change will continue to have a significant impact on the size and connectivity of their habitat.

Swilling feels that while there are clear changes happening, it may be too early to link those to climate change.

> Different models provide different answers. We do see changes on the landscape, and some dramatic changes. Whether or not you can tie that directly back to global climate change, its possible, but don't have the knowledge or the brain power to think like that and try to say definitely right now what is going on (Swilling interview 2010).

Still, the forest service is making an effort to incorporate those potential changes into policy decisions.

> I see things changing on the ground… Global climate change is on a lot of the minds of a lot of employees of the forest service. Now we incorporate effects analysis for global climate change into our environmental documents. As a government agency, we recognize that yes, there could potentially be changes based on global climate change. We are going to incorporate that into our analysis of our environmental documents (Swilling interview 2010).

Coppolillo seems more convinced that the changes that are already occurring are due to climate change.

> The bottom line is that we know it is happening. No one credible really questions whether it is happening or not. There are some credible people who question whether it is anthropogenic or not, but frankly if you are trying to manage wildlife, it really doesn't matter where it is coming from. The reality is that they are changing. Those signals are all around, whether it is the times of birds' nests, or the water temperature in the Yellowstone River, there are lots and lots of places to see it (Coppollilo interview 2010).

While he wasn't willing to concede that the whitebark pine mortality was directly linked to climate change, Swilling acknowledges the urgency of the issue with a changing forest, especially with how it may affect the grizzly bear.

> It's pretty dramatic what has happened with whitebark pine. We are seeing major changes in those high elevations with mass die offs of whitebark pine. We have folks working on the district who just came here recently that had worked here ten years ago, and they go back in the areas that they were that were once just flourishing whitebark pine communities, and they are no longer there. They are

> skeletons. We are seeing a drastic change at those high elevations with whitebark pine. We are loosing them, and we are loosing them fast. Grizzly bears late in summer are really dependant on those whitebark pine nuts. So it pretty alarming what you have going out at those higher elevations. We have anecdotal information from some of our outfitters that are guiding hunters that have noticed that grizzly bears in the high country are focusing more on elk, so the bears seem to be changing their dietary preferences with whitebark pine on the decrease.

While Swilling has not seen and increase in human encounters with the grizzlies as a result of the decreased availability of whitebark pine, Schneider and Root found that "overwhelmingly, mortality of grizzlies can be attributed to conflicts with humans, and that a higher frequency of encounters with humans occurs when remote food sources become unavailable, forcing grizzly bears to seek out foods distributed close to human settlements" (Knight et al. 1988, Mattson 1990; Mattson et al. 1995; Mattson 1997 as cited in Schneider and Root 2002). Schneider and Root go on to say that the relationship between grizzly bears, human encounters, and whitebark pine crop size variability has been shown empirically, and is strongly correlated. "Studies have revealed that the frequency of grizzly bear captures in the GYE increases sixfold during years of low whitebark pine seed production, and bear mortality rates are two to three times higher" (Mattson and Reinhard 1997 as cited in Schneider and Root 2002).

While the direct effects of climate change cannot be predicted, if we can help facilitate genetic diversity now, we will be helping to arm populations with the Swiss army tools necessary to withstand potentially drastic change. With those tools they will stand a far greater shot of surviving through whatever disturbances they may face in the not so distant future.

The intangibles.

There exists many more potential infringements to connectivity, and as Coppollilo points out many of them may not be so clear when looking at the landscape.

> Another whole set of barriers to connectivity are the ones that we cannot see. When you look at the map, you fly over, you walk though these areas, it looks perfect, it looks like perfect habitat, but it's not occupied. The reasons are non-structural, things like conflict. Sometimes, just the expectation that an animal is carrying disease is enough for people to not want them around and that can be a huge barrier for connectivity. There is really nothing physical that prevented wolves from making it between central ID and the GYE, but it took a really long time and the reason for that was conflict when wolves showed up in the intervening areas and got killed. Conflict doesn't always have to end in mortality; bears being chased out of subdividsions or out of grazing allotments or places like that can still be considered conflict.

In many cases, Coppollilo feels that this can tougher to deal with than the physical barriers, because there is nothing to remove or get around. This phenomenon will surely be diminished as ranchers, landowners, and land managers find successful ways of working together to coexist with wildlife populations. Furthermore, a new generation of people living closely with nature have different values, and beliefs than the "older" generation.

Future Research.

It is my goal over the next few months to learn more about the opposing side of things. To hear the ranchers, land owners, and others who may not feel so fondly about the wildlife on their land. In addition, I would like to learn more about the experimental sheep station that exists in the Centennials. Also, I feel that recreation is a key part of this picture as well. Specifically snowmobile and other motorized types of recreation. I also will be talking with the city commissioners and planners that are the ones taking in the information and ultimately making the decisions about how to respond to the science at hand. I would also like to focus portions of my research on the ways that other countries handle connectivity, and the differences in responsibility that ranchers have in preventing conflict themselves under different systems.

Conclusion

Overall, there appears to be great progress in the awareness of the need to promote the ability of wildlife to move between protected areas. Working with those that come into contact with the wildlife on a regular basis will be essential in preserving the integrity of so many species for years to come. With so many unknowns about the ways in which the planet and our interaction with it will change in coming years, it is impossible to know the fate of species that will require the ability to move through the landscape in order to survive. What is clear is that if we can foster genetic mixing between populations, we will be helping to equip species with the tools necessary to survive in an ever-changing climate both social and physical. By expanding as a global population, we are consistently encroaching further on wildlife habitats, and we must find a way to prevent the disappearance of one of our nations most treasured and important natural resources.

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