Spring 4-28-2017

Scene of a changing climate

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SCENE OF A CHANGING CLIMATE

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PROFESSIONAL PORTFOLIO
Presented for the partial fulfillment of the requirements
for the degree of

Master of Arts
Environmental Science and Natural Resource Journalism

The University of Montana
Missoula, Mt

April 2017

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Nazeri, Mona, MA, May 2017
Environmental Science and Natural Resource Journalism

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Abstract Content:

For the last 500,000 years, the world climate has been in transition from warm to cold and vice versa. However, recent human-caused climate change has increased the rate of change in extreme and average climate conditions. Globally, people are facing higher than average temperatures as well as accelerated rates of drought and flooding. According to the Intergovernmental Panel on Climate Change (IPCC,) natural systems around the globe are being affected by regional climate change, mainly temperature increases. They IPCC found that 20-30% of plant and animal species are likely to be at increased risk of extinction if global average temperatures rise by more than 1.5-2.5°C.

In recent years, scientific studies have provided valuable information that helps understand the effects of climate change on natural systems. Translating and simplifying the data through interactive maps and incorporating real-world examples will make these studies and their outcomes more meaningful and useful to policy makers and to the general public. I am using my GIS, remote sensing and my interest in understanding the effects of climate change on terrestrial ecosystems to make interactive web maps and infographic to show this effects for general public.

The three stories in this portfolio depict the effect of climate change on natural resources. Chapter one is a narrative outlining the stories, my reportage and plans for publication. Chapter two: Missing Migration: The Elk of Ya Ha Tinda. Chapter three: Drier, Hotter, Faster: How Climate Change and Drought Affect Wildfire. Chapter four: Roaring Lion Fire: Climate Change Hits Home.

CHAPTER I
Narrative

Drought, increasing wildfire, shifting wildlife distribution and decreasing migration ranges are some of the most dramatic impact of climate change that researcher find human finger prints on. These are the focus of my portfolio.

These obvious effects of human-caused climate change have already affected a diverse set of physical and biological systems in different parts of the globe. Some examples of observed changes include thawing of permafrost, later freezing and earlier break-up of ice in lakes and rivers, longer growing seasons, the decline of some plant and animal populations, increased risk of floods and droughts and shifts of plant and animal ranges.

In recent years, long-term scientific studies have provided valuable information that helps understand and explain the effects of climate change on natural systems. Journalists, like myself, who are interested in using maps to translate and simplify data are charged with incorporating real-world examples and creating appealing interactive maps to make these studies and their findings more meaningful and useful to policy makers and to the public.

For my portfolio, I sought novel stories capable of showing the effects of climate change on natural resources. My primary medium is cartography and I focused on two situations for which the data were available and that had the potential to become effective maps with policy implications. My third story is a written feature story that explores the experience of a community when a relatively small wildfire burns through a residential area with a modern intensity scientists attribute to climate change.

Missing Migration: The Elk of Ya Ha Tinda

Across the globe, migratory animals are moving less. The reasons why are poorly understood, but the impact of reduced migration can affect ecosystems, predator-prey relationships and tourism, among other things. The first story I produced was a topographic map and an infographic for Associate Professor Mark Hebblewhite's lab. For almost 20 years, the lab has radio-collared 100 female elk on the Ya Ha Tinda Ranch, just east of Banff National Park in Alberta, Canada. Using extensive data sets provided by the researchers, I "tracked" two individual elk that approached the Ya Ha Tinda Ranch from different directions and stayed there for winter.

In order to make this map, I considered what stories the data held that might create a clear, accurate image that would be useful to the public. I choose to extract the data for only two elk because consistent data was available for those animals and using two animals to represent the trends kept the infographic simple but meaningful.

Interestingly, the two-elk followed the same elevation contour. I made an infographic based on these radio collar data showing both elk with symbolic icons on the map and below the map showing the elevation that they followed as a chart.

This topographic base map and the elk data on top of that allow wildlife policy makers and managers to make migration corridors for elk more permeable. It allows them to visualize where there are barriers to migration so they might pursue policy that ensures these migration routes stay connected. Wildlife managers could use this map to identify where there is a habitat treatment to prioritize. Without this kind of map, they risk spending a lot of money intended to benefit migration corridors on ineffective measures.

I made every effort to achieve a high level of accuracy and low level of factual errors in all the maps that I produced. The base map was produced on 1:100,000 scale.

Hebblewhite and his team are going to use the base map that I created as a reference map on their camp station. They are going to print it out and use it in their station to have a better view of their study area.

Drier, Hotter, Faster: How Climate Change and Drought Affect Wildfire

Recording setting drought and catastrophic wildfires move at different speeds across the landscape. Both capture news headlines, and it is easy for most people to imagine they are related to each other. But both fade from the public eye when their crisis stage has passed. For my second project I produced a series of interactive maps that make the relationship clear over time. My second map series show the change in wildfire intensity relative to drought across the U.S. over time.

First, I created a map showing the trend of wildfire season length using data from a paper published in 2015 by U.S. Forest Service fire ecologist Matt Jolly in Nature Communication. The paper is titled "Climate induced variations in global wildfire danger from 1979 to 2013". Along with that map, and based on the available data on drought monitor (http://droughtmonitor.unl.edu/) I created interactive maps that show how drought grew from 2000 to 2015. I also created an animation showing the changes in drought each 5 years for the years 2000-2015.

Higher temperatures brought on by climate change are expected to increase the amount of moisture that evaporates from land and water. That evaporation will also cause rainfall patterns to shift. In many areas, these changes are expected to lead to more frequent and severe droughts, which occur when an area receives less precipitation than usual. This condition increases the likelihood of wildfires.

During long periods of drought, however, most of the fuel can be consumed resulting in a potentially more damaging fire with high intensity and rapid spread. Such fires will also burn deeper into the duff and are more difficult to control.

The map swipe of drought enables the audience to interact with two layers of web maps in a single view to see how drought has changed during 15 years.

One of the great things about web mapping is the ability to share and distribute information to the general public. Web mapping is also an opportunity to make attractive, fast, interactive, beautiful and detailed map. Web GIS makes this procedure easier for its user, both viewer and cartographer.

Web mapping also makes it easy to link database features to supporting documents, which makes it a great tool for journalists.

The wildfire trend map clearly shows wildfire increased in the western U.S. and I plan to bring this map to my third story, which is about the Roaring Lion fire in Hamilton, Montana.

Roaring Lion Fire: Climate change hits home

The last piece of my portfolio is a written story about how climate change affects wildfire behavior and wildfire severity with focus on the 2016 Roaring Lion Fire in Montana. I interviewed scientists, local residents, fire experts, fire managers to help me explain to my readers the significance of climate change effects on natural resources. For the last written piece, I supplemented my reporting by watching documentaries and reading newspaper editorials. Ethically, the first hurdle of this project was not letting my scientific background inflict bias on my stories. As an environmental scientist and ecosystem modeler, I can say clearly that there is much pressure on different ecosystems because of climate change and its ripple effects. I spoke with a number of scientists and non-scientists for each story of my portfolio. In every interview, I tried to see the issue from my source's point of view and represent that viewpoint faithfully within the broader context of the issue.

I plan to pitch the second map story to national magazines such as National Geographic and High Country News, and pitch the last written piece to the Missoulian and other local media.

CHAPTER II
Missing Migration: The Elk of Ya Ha Tinda

The history of where animals go has been a history of physical traces. Today it is done electronically. Radio collaring or in a simple word "Tagging" is the process in which a scientist attaches a device to an animal. With the rise of mobile technology and computer power, these devices are able to gather gigabytes of biological and ecological data such as daily movement, behavioral, physiological on every animal from bumblebees to elephants.

Where an animal goes not only depends on what species we're talking about, but also on which individual we are following. Animals are not furry robots. Like us, each one is searching for food, water and security and making individualized choices on how to obtain those essentials, in the most practical way.

Since 2001, Hebblewhite and his team have been conducting research in Alberta, Canada and radio collared more than 200 adult female elk. This study created in consistent, readily accessible database, and has been the longest running elk project in North America. Their study area covers part of Banff National Park and Ya Ha Tinda ranch, which is located 5 km east of Banff National Park boundary.

I combined my skills in GIS and remote sensing, data processing, design and journalism to take my readers to the forefront of this elk-tracking revolution. I've spoken to Mark Hebblewhite from the University of Montana and analyzed their periodical data to visualize their cutting-edge studies.

For the past 15 years, Hebblewhite has led an ongoing study comparing the migratory and resident elk of the Ya Ha Tinda herd in Banff National Park. His research has advanced a clearer understanding of the forces that push elk to migrate or compel them to stay put. It's a balancing act between availability of forage and presence of predators, with elk caught in the middle.

Ya Ha Tinda ranch is surrounded by timberland, national park land and a mix of grazing leases, and plays an important role in elk conservation. However, the elk population declined from 2500 to 500 during the last 25 years, and this change has been one of the main focuses of Hebblewhite and his team's research.

I created a base map, based on remote sensing layers. Then I extracted the available database and followed only 2 individual elk whose data were available for a long time of 5 years, and showed them on the base map.

In the next stage I made a chart based on the elevation that they followed. Interestingly, although these two elk came from different directions, they followed almost the same elevation contour. I made an infographic, replaced the elk locations with elk symbols and showed the winter and summer ranges of these two elk. Below that map I created the elevation chart.

Data clearly show that some of the elk never migrate out of the Ya Ha Tinda ranch. And

those that do migrate all come back to Ya Ha Tinda as winter range. I interviewed Hebblewhite to see what is the reason behind this behavior. Why Ya Ha Tinda is an important place for them. And what condition makes this place a suitable habitat for elk.

"That's the main focus of our research, and it's both food and safety," Hebblewhite said.

"Ya Ha Tinda as a winter range provides snow free, high elevation, really great food relative to the rest of the foothills and that's why they stay on the ranch. "

Plants don't start growing until the snow melts, and these emerging plants are the most highly nutritious for angulates. In July when the grass and flowers comes emerge from the snow, they produce the highest digestible energy, "It's like eating baby spinach," Hebblewhite said. "There is a reason for eating baby spinach vs Bolton spinach."

Forage quality is greater at higher elevation on average in the summer and that was the whole point of Hepplewhite's PhD studies. "That translates to about 5-6 percent higher digestibility of the diet of elk that migrate vs ones that stayed at the ranch. It also translates to the higher pregnancy rates because being fatter as a female in November leads to higher pregnancy rate, which leads to higher birth weight of calves, and it leads to higher calves' survival," He said.

Elk want to have the higher forage quality, the additional advantages of migrating to the top of the mountain is that wolves are less likely to find them there.

"25 years ago, everybody migrated," Hebblewhite said. "Now only about 15 percent of the animals migrate. From the ecological perspective, that's cool but, why is it?"

Because many elk are staying in the ranch all summer long, they are overgrazing. On the other hand, humans scare away wolves and grizzly bears by trapping around the ranch. "Elk are saying 'I am not going to migrate to go and get really great food; I'm just going to eat crap at the ranch, but I am also not going to see any carnivores,'" Hebblewhite said.

Ya Ha Tinda is the winter range for elk in most of Banff National park, about 65 percent of the elk in Banff come from Ya Ha Tinda. "The winter range is just like the northern range for elk in a large part of Yellowstone," Hebblewhite said.

It is not easy to study the effect of climate change on wildlife because of the lack of data. "You can imagine, 16 years of data, that's not enough to look at the climate change, but we are starting to."

Hepplewhite's team hasn't seen a clear climate signature on calf survival or on elk survival in general. The team hasn't really looked at any changes in migration or predation as a function of climate change. "We can explain it mostly by fire, changes in fire and changes in wolf predation probably," he said. "But, we will get to the climate change eventually," he added.

Parks Canada do a lot of prescribed fire as part of their management plan. Hepplewhite's study area includes 200 square km of burned land, "Everywhere is burning." He said. "The burns are a big part of the story."

“The whole reason for our project to start was that this was new, why were elk not migrating anymore?”

All the maps for this story attached as a JPEG.

CHAPTER III
Drier, Hotter, faster: How Climate Change and Drought Affect Wildfire

Higher temperatures brought on by climate change are expected to increase the amount of moisture that evaporates from land and water that will also cause rainfall patterns to shift. More evaporation, causes dead grasses, leaves, and needles to dry more quickly. Fire scientists call these dead grasses, leaves, and needles, "dead fuels", and when fuels are dry, large fires become more likely. "With climate change, there is reason to expect that there will be longer periods of time each year when the landscape is flammable due to the increased temperatures, and that the short windows of time with extreme fire weather will grow longer or occur more frequently," said Karin Riley, a Research Ecologist at the US Forest Service and an Affiliate Professor at the College of Forestry and Conservation, University of Montana.
In many areas, these changes will lead to more frequent and severe droughts, which occur when an area receives less precipitation than usual. This condition also increases the likelihood of wildfires.

The analysis of 35 years of meteorological data, which was the combination of high temperature, low humidity, rain-free days and high winds, led by U.S Forest Service ecologist Matt Jolly, confirms fire seasons have become longer. Fire season is defined as the time of year when wildfires are most likely to happen.

In some areas, extending the fire season by a bit each year added up to a large change over the full study period. For instance, parts of the western United States now face wildfire seasons that are more than a month longer than they were 35 years ago. The authors believe that the longer season in the western United State results from the changes of timing of snow melt, vapor pressure, and the timing of spring rains, all of which have been linked to climate change.

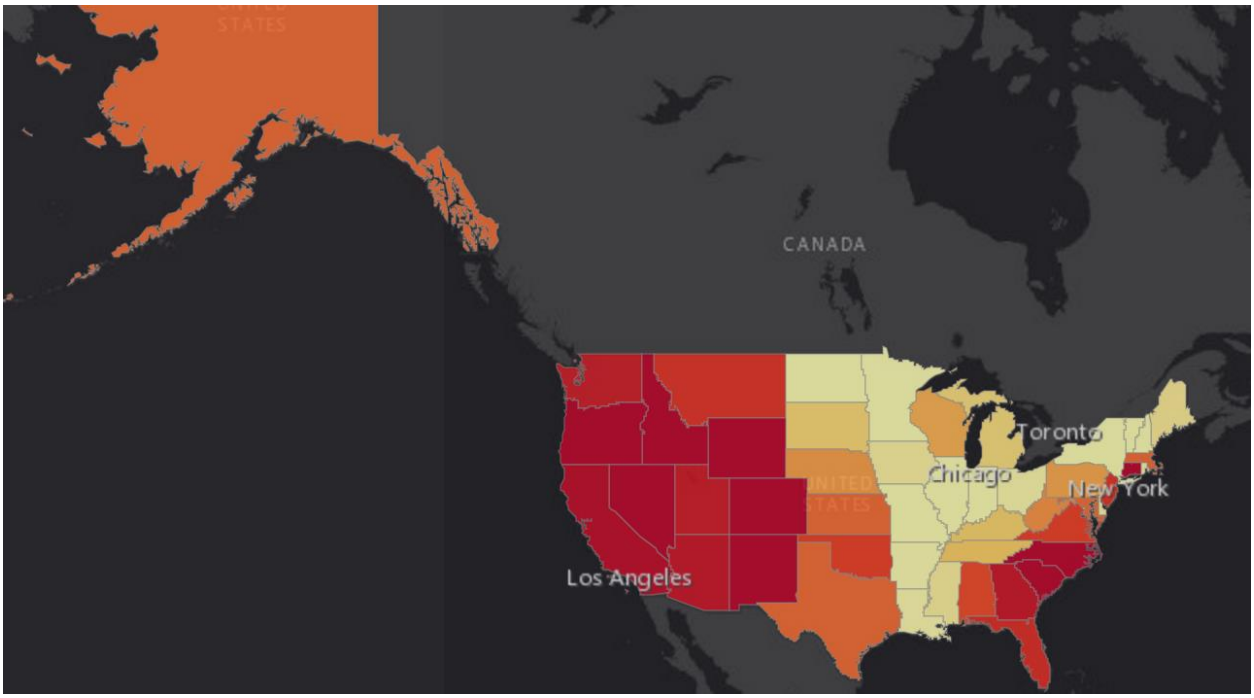

Figure 1. The map shows steady trends in wildfire season length. Areas where the fire season lengthened between 1979 and 2015 are shown with shades of orange and red. Areas where the length of the fire season stayed the same are light yellow. (Map created based on Matt Jolly data)

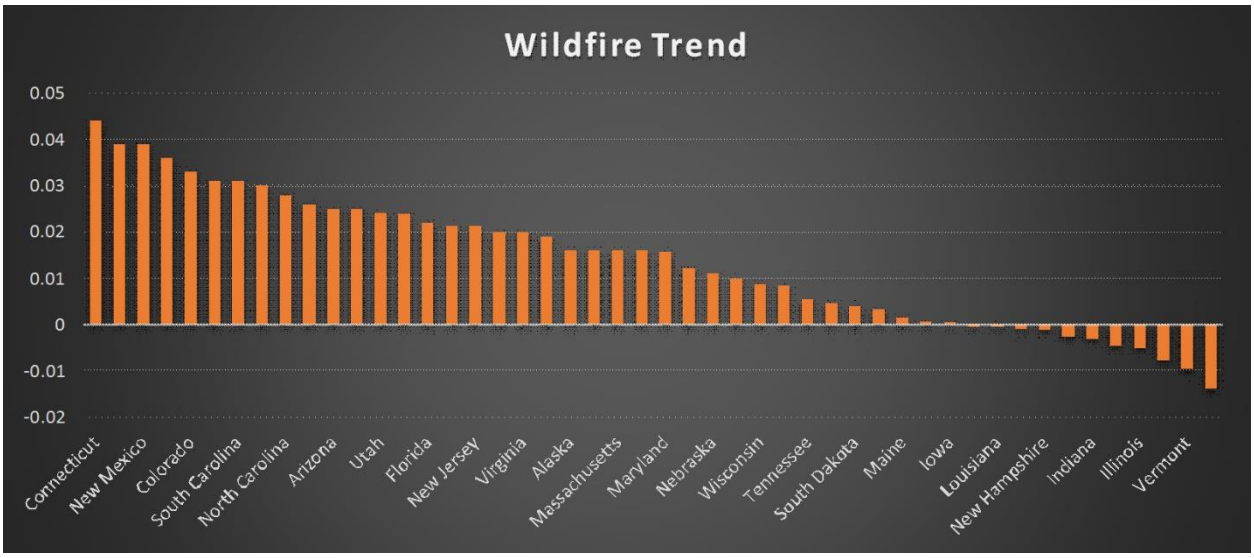

Figure 2. Connecticut, New Mexico-Colorado, South Carolina show the increasing trend most clearly while Vermont and Illinois show a decreasing trend. (Chart created based on Matt Jolly data).

"As far as climate change, it's difficult to forecast the exact timing and amount of rain under future climate change, and that's a critical thing to know as far as determining whether fires will increase in the future," said Riley. "However, we can be pretty certain that the climate will be growing hotter almost everywhere in the United States."

A new NASA study predicts that by the end of the 21st century the American South West and Great Plains are likely to experience longer and more severe droughts than at any other time in the last thousands of years. Many other studies find a connection between wildfires and drought. "I don't even like to call it drought to tell you the truth, because drought implies something exceptional and what people have to understand is that the normal climate now is drier than it was 50 years ago; It is now the normal climate. It is not a permanent drought. What climate change is generating is a permeant condition of dryer climate than we had before," Steve Running, a regents professor of ecology at the University of Montana's College of Forestry and Conservation says. "However, to label that as drought implies that it is an episodic event, and that pretty soon we are going back to normal and it will be more mild, but that's not going to happen."

The Drought Monitor, which collects data from 50 different weather indicators, has a database beginning in 2000. Based on these data, I created a Time Aware App with ArcGIS online showing how drought has changed during the 16 years 2000-2015. To show the changes more clearly, I created another app called Story Map Swipe and Spyglass and showed two different layers of drought for the years of 2000 and 2015.

When I showed the swipe map of drought to Running he said "I am starting to see these little swipes recently, Earth Observatory is starting to use that now. This is great."
I also found it a very interesting opportunity to show the small multiples depicting information, with repeating images of weekly drought, with R programming languages for the years 2013, 2014 and 2015. The maps show changes over time very well.

Figure 3: Drought shows within a U.S for the year of 2000

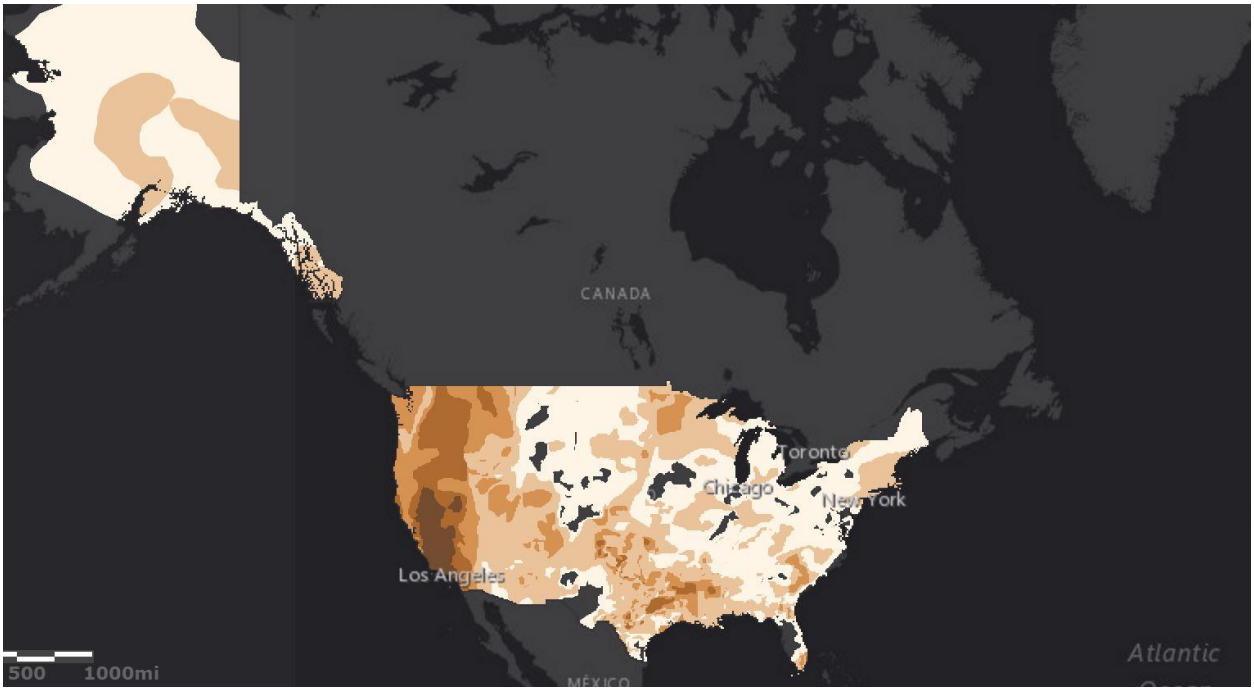

Figure 4: Drought shows within a U.S for the year of 2015

These maps are all interactive and web-based map.

CHAPTER IV
Roaring Lion Fire: Climate Change Hits Home

On Sunday July 31, 2016, not long after breakfast, Dave Campbell and Anita Harper Poe went to work stacking wood in their wood shed. They hauled logs and split wood for several hours that hot summer day, unaware that they were making more fuel for a wild spark that would blow up to be the Roaring Lion fire.

Campbell, a retired Forest Service district manager, will turn 65 this year. He started working with the Forest Service on the Roosevelt National Forest in Colorado when he was 18 -- just after high school. He worked as a summer seasonal employee while attending college in Colorado, then he received a permanent position in 1979. He had been around wildfires all his career, and it's been his call on close to 300 fires whether he would allow them to burn or not in the wilderness.

In 2004, the couple moved into their home on the flanks of the Bitterroot Mountains, a beautiful house with big windows and a breathtaking view of Ward Mountain.

It is surrounded by a natural meadow to the west and north. An aspen stand shimmers within 20 feet of the house on the south side, providing shade in summer and allowing sun in winter when the leaves are off. The closest pine tree is about 25 feet away.

When he decided to buy the house, Campbell wanted to make sure that it would have a fire-resistant landscape around it. The white-barked aspen act as a fuel break because they do not burn easily. The natural grass under the trees keeps any fire burning slowly, on the ground. The pine tree has no branches below 10 feet, so that it would not, in most conditions, support a fire moving from the ground in to the crown.

"We are living in a pretty fire-defensible space," Campbell said, and he credits the open space with protecting his home from the damage that many of their neighbors' houses suffered that cloudless summer day in 2016.

That morning was beautiful: hot and calm at Judd Creek Hollow, a couple miles up Roaring Lion Road southwest of Hamilton, Montana.
But that afternoon was unusual.

After the woodshed job was done, the Campbells went inside, and relaxed with the air-conditioner on. At 2:30, while they were sitting in the living room, Campbell noticed an orange glow on top of the mountain from the window. Stepping on the porch, he immediately realized there was a fire in Roaring Lion.

Poe's first reaction when she saw the fire was, "Ah, I am too tired to have a fire." But when she saw the fire from the road she just knew that this was a catastrophe and she was very afraid. They couldn't see the fire well, so they drove down to the highway at the bottom of the Roaring Lion Road for a better view. Having worked with the Forest Service for 40 years, Campbell

realized this was going to be serious. It was already out of control and it had only just been discovered.

Climate change is producing conditions ripe for wildfires and tipping the scales in favor of the dramatic increases in large wildfires we have seen across the Western U.S. since the 1970s. Snowpack is melting earlier, and in most states, an increasing percentage of winter precipitation is falling as rain. Summer temperatures also are rising, and the number of extremely hot days increasing. These conditions are creating more days where forests are dried out and ready to burn. When they do burn, climate scientists predict they will burn – like the Roaring Lion Fire – very hot and very fast.

There is a human element to wildfire in the age of climate change. People can start fires at times and places that nature would not start them. Four teenagers built a campfire four days before the Roaring Lion fire got out of control on a small bluff just off Roaring Lion Creek. They teenagers thought they had extinguished their fire, but they had not. A court case is now underway to determine whether they will be held accountable for the cost of fighting the fire. The blaze was only a few miles southwest of Hamilton. It claimed one life, 14 homes, about 50 outbuildings. It burned 7,130 acres and caused the evacuation of hundreds of people. Resources assigned to the fire included nine helicopters, 735 personnel. It cost $11 million to fight.

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The first step was to evacuate

July 31 started out like many other mornings for Bret Lewis, the district assistant fire management officer for the West Fork Ranger District on the Bitterroot National Forest: physical training and some training for the engine and crew. The conditions for that day were predicted to be hot and dry with strong winds out of the west. Everything that contributes to a large fire was in the place.

At 2:30 p.m., Lewis received a phone call from Bitterroot Dispatch asking him if he was willing to take over an emerging fire on the Darby Ranger District.
He accepted the assignment.

Lewis worked in a unified command. That means he was able to focus on the Hotshot crews, bulldozers and air support while a local fire chief focused on fire engines, protecting houses and residential evacuation.

After getting information from the dispatcher, Lewis gathered a little bit of gear and left for the Roaring Lion Fire. “I was told the fire was quickly exceeding the forest’s initial attack capability,” he said.

As Lewis made his way north, he came to the road junction with Highway 93 where he got his first good look at the fire. He noticed a dark column, which indicated a crown fire growing fast. It was also crossing the valley, indicating the fire was burning toward private property.
Over Lost Horse Hill, he could see the flaming front. The fire had come out of the south side of the Roaring Lion drainage and was starting to cross the face to the south. He could see flame lengths in excess of 200 feet in the air.

The flames burning to the south combined with the winds pushing the smoke column east across the valley. That told Lewis that they would see fire spotting to the south and to the east of the main fire front.

“Our first priority is the safety of the public and the fire fighters,” Lewis said. “From the fire behavior, I observed at this time, I knew we would not be able to attack directly with ground resources. The first mission was to ensure evacuations of the public were completed."
Anita Poe and Dave Campbell had been evacuated from their home before.

“Usually, when we were evacuated, we have time,” Poe said. “The last time we were evacuated, I was taking things out of here every day for a couple weeks; this time we left here half an hour after we saw that fire, not two weeks.”
It was three in the afternoon, but the sky looked like night as smoke blocked out the sun. It was gloomy.
The Incident Command Post had been established at the junction of Highway 93 and Roaring Lion Road.
Most people evacuated after being advised to do so and some were evacuating before they were contacted. A few made the decision to stay and defend their homes and property, and Campbell was one of them.

Poe had made a list of her priorities, including family photos and business records, but she didn’t have time to find her list. She said she looked out the window and just wanted to get out of there. She took two duffle bags, filling one with her clothes and one with Campbell’s. “That’s funny, I didn’t even grab my laptop,” she said. “I just grabbed stuff. I didn’t plan anything. Oh, we need some shoes. I threw shoes, shirts, here’s some pants. I threw some toiletries for me, but not for him and thinking we may not come back to this house ever.”

She called her son who lived in Washington. “I am evacuating and I don’t think we are coming back this time,” she told him.

The couple hadn’t done their taxes so she grabbed that file plus an artifact they called the “longitude and time chart,” which a great grandfather of Campbell’s had handwritten in 1893 showing what time it is in other parts of the world. The car filled up, and two dogs waited in the truck ready for her to come back and take them down to a friend’s house.

While Poe was driving down the road, she heard the fire’s sound, like the distant rumble of jet engines. “If this had been a normal fire, it wouldn’t look like this,” she remembers thinking. “This was a very unusual fire because it was human-set and it didn’t act like a natural fire. All I knew that day was that I’ve never seen anything like this and just half an hour (after fire started), I was watching trees being torn apart already over the hill. It was so fast.”

Campbell stayed behind, drawing on 40 years of experience with fires to protect his house. As soon as he spotted flames, he watered down his deck, the most flammable part of the house, and the roof. He wanted to make sure they were wet before the fire came. Then the power went out and his pump shut down. He had planned to stay home and water all the surroundings too. He

used 500 gallons of water from the hot tub in front of the house and watered down what area he could. By that time fire roared down to the edge of his meadow, Poe was calling, insisting over the phone that he leave.

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The public has a strong need to know

Penny Bertram is an assistant business manager at the U.S. Forest Service's Rocky Mountain Research Station and was also the public information officer on the Northern Rockies Type One Incident Management Team assigned to manage the Roaring Lion fire. She said that she went into that mission with some preconceived notions and prejudices about the community and its attitudes toward the agency. As a person who fights fires all over the country, she normally sees that that a percent of the community does not trust authority and does not want those outside agencies there. "It would get ugly. Every fire was ugly," she said.

But this time, she felt different. The community was notably friendly. Hamilton High School opened its doors for them so they could set up their camps.

For the first time, Bertram and her team live-streamed the public meeting on Facebook. Over a thousand people were at the meeting, and during the first 15 minutes. The video generated about 137,000 hits.

Bertram went outside and started greeting and talking to the people at that event. She was there to answer any questions or just listen to their stories. "All human dramas take place in the background of this public meeting," Bertram said.

She remembered an older man saying, "'You know, that's why we never buy on that side of the highway. It has burned forever.'"

The public's suspicion of the feds is always something she has to deal with too.

"Ravalli County has no zoning laws and that goes back to the attitude that nobody should tell me what I can do with my property," Bertram said.

For firefighter and public safety, and to protect evacuated residences, the Ravalli County Sheriff's Office employed a landowner permit system. "That system allowed property owners into the areas deemed safe enough by the Incident Management Team, but kept unauthorized persons from the empty structures," Sheriff Stephen Holton said.

During the fire, management teams took information and noted the location of those people who stayed on their properties. Lewis took a helicopter to look for anyone who might have been overlook in the evacuation notifications. He didn't find anyone in apparent danger.

That gave firefighters some comfort that they had reached everyone, but the possibility existed that they had missed someone.

"During the flight, I could see the fire had spotted into the sub-division. The fire was still burning too intensely for ground resources," Lewis said.

He decided to land and set the helicopter up to start dropping water around the structures. Before he took the flight, he had a conversation with the Forest Fire Management Officer and discussed what they thought would be the proper management level for this fire. They agreed

that a Type One incident management team should be ordered, but it couldn't take over till the evening of the next day. Lewis also ordered two bulldozers.

Lewis knew when the sun went down, they would have an opportunity to attack the fire. The fire behavior would be inhibited by cooler night time temperatures, higher humidity and less wind. After he landed, Lewis made his way back to incident command.

At this point, incident team members had completed evacuations and established roadblocks. They weren't able to operate their firefighting aircraft due to the high winds from the west and the erratic winds created by the fire itself.

This wasn't entirely unexpected, but still disappointing.

The helicopters continued to be used, and more were on order. When the hotshot crews arrived, Lewis' team put together a plan to build containment lines along the eastern flank when fire behavior allowed. "Our opportunity came when the sun began to disappear behind the mountains," he said.

The crews and dozers began to build fire line along the eastern flank through the sub-division. The Volunteer Fire Department began structure suppression and protection efforts, which continued through the night and into the next day.

At 8 a.m. on August 1, the day after the fire started, the fire management team transitioned to the Type One team.

During his time on the incident, Lewis had many interactions with the private land owners in the area.

"My heart went out to them," he said. "It was well into the next day before we could start informing them if their house or land had burned or not. I can only imagine the anxiety they felt not knowing."

Many people from the area offered to help those who were affected and supported the firefighters with food, drinks and other supplies during the fire. "That support was very much appreciated," he said.

Lewis says in his early years, this kind of job promised was good money and it was exhilarating, but now it's more about helping people and the environment, it's about camaraderie and little accomplishments. "I don't get a real sense of joy in what I do. With the good we try to do comes the bad," he said. "Many people have told me I did a good job, but it is difficult to reconcile that with what was lost."

It was several days into the fire before Ravalli fire managers and the count sheriff's department could physically get into one of the neighborhoods that had burned west of Judd Creek Hollow. The Ravalli County fire marshal and sheriff went in to examine damaged structures and investigate the situation after the first day of burning. Several homes had burned to the ground.

As they checked on homes, they became concerned that, despite assurances to the contrary, one resident was unaccounted for. The condition of his home and burned vehicles outside of it indicated the man, who lived alone in a relatively remote portion of the area, had likely died in the fire. The team began an investigation and sent a crew of firemen and sheriff's deputies to start searching for the man's remains. Part of that investigation involved contacting the U.S. Postal Service to see if mail had been delivered or picked up. "It fortunately turned out that the local postmaster personally knew who we were looking for, and had knowledge that the missing man was a volunteer at a youth summer camp and was out of the county," said Sheriff Holton. Their worst fear, in this case, was avoided.

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Climate science helps understand fire

In 1988, fires charred almost 800,000 acres in Yellowstone National Park, some 280 miles from Roaring Lion. The nation watched, horrified, as more than 25,000 people worked to protect the park. Steve Running, a regents' professor of ecology at the University of Montana's College of Forestry and Conservation, says those fires serve as a benchmark for when a new era of wildfire started.

"In the public's mind, nobody paid much attention to wildfire until Yellowstone '88," Running said.

Some people think that the forest service is capable of stopping all fires, and that it's just lazy or doesn't have enough money or enough helicopters to do the job, Running said. "They don't seem to realize that these big wildfires under these extreme conditions are absolutely unstoppable." He said, adding that he often reminds people that nobody expects NOAA to stop hurricanes at the Florida beach; they just know inherently hurricanes are so much bigger than anything humanity can do.

But they do not seem to have the same idea when it comes to wildfire.

It wasn't until 10 years ago that scientists connected climate change with an increase in the intensity of wildfires. It started with Anthony Westering's 2006 paper in Science Magazine. The study found that climate change was causing an earlier spring warming and increasing Western U.S. wildfire activity.

Running was a reviewer of that paper while working on the International Panel of Climate Change report. He said he was so excited by the paper that he mentioned it in his review that as an IPCC author who was trying to write a report; this was the first paper he had seen connecting climate change and wildfire. "Of course, when the science editors saw that (review), they went nuts and put it in the cover of the magazine," he said.

As a Montanan, Running realized the report put science behind what he anecdotally knew. Explorers Lewis and Clark couldn't get over Lolo Pass on June 22, 1805, because there were still 20 feet of snow drifts. Now, "My God, Lolo Pass melts free now in May," Running said. The knowledge that these high-elevation forests can burn now in ways they haven't before hit him especially hard.

Because the snowpack melts earlier, the higher elevations are drying out in a way that they never used to, he said.

“When I was a kid, you couldn’t go hiking above about 6,000 feet until July, because it took that long for snow to melt and consequently you never had high sub-alpine wildfires,” Running said.

“What we are seeing now are these sub-alpine forests occasionally, on these dry summers, getting dry enough to burn, and these are the fires that ecosystems haven’t burned for hundreds of years. They don’t have a normal, natural fire dynamic that the low-elevation ponderosa pine has always had.”

A long trend analysis of wildfires is hard to do because there are not sufficient data, he added. Scientists can effectively look about 30 years, but looking back 50 years is not easy because of weak data.

“Basic things -- like how many days the fire burned, how many acres burned, what severity -- that nowadays we measure, back then, in the ‘60s and ‘70s, they didn’t bother,” Running said. “They figured that their job was to get the things out and go home and have a cold beer.”

Back in the 1970s, almost all that weather stations recorded were temperature and precipitation. There was no measurement of humidity, wind speed or solar radiation, all of which are crucial factors for environmental studies, including wildfires. With recent advances in data and modeling, researchers are able to do more complex modeling to study the environment.

Roaring Lion’s intensity in keeping with climate science predictions

Although wildfires are common in the Bitterroot range, the Roaring Lion fire was noteworthy for its intensity and the speed with which it grew.

It’s the kind of fire predicted by the modeling work of fire ecologist Matt Jolly and a team of researchers at the Rocky Mountain Fire, Fuel and Smoke Science Program in Missoula.

Jolly’s team published a key report in 2015 that examined climate-induced variations in global wildfire dangers over a 35-year span. The study found that wildfire season length increased by 18.7 percent due to more rain-free days and hotter temperatures.

Each wildfire activity is driven by three key factors: fuels, sources of ignition and weather. The Roaring Lion Fire had all three. Legal entanglements had prevented logging in the area that the forest service had proposed as a fire management strategy, so the area held plenty of wood to burn. The wood in the forest contained very little moisture. And the weather was exceptionally hot, with winds blowing down the canyon.

“We saw strong trends toward increasing fire weather season lengths across the area where the Roaring Lion fire occurred,” Jolly said in an email.

Jolly's study found that weather is the most variable factor, and climate change has created weather conditions that are perfectly conducive to fire: Higher temperatures, lower humidity, fewer days with rainfall and higher surface wind speeds. "We observed significant increases in maximum temperature, decreased minimum relative humidities and stronger winds over that area during our study period, suggesting that the area has experienced some pronounced climatic changes over the last ~ 4 decades," Jolly wrote.

Jolly's team combined three global climate data sets from five continents with fire danger indeces from the United States, Canada and Australia and looked at the length of fire seasons and the amount of land area vulnerable to ignition.

They found that the fire season is longer and drier, and that the change is global. "Climate change has led to fire seasons that are now on average 78 days longer than in 1970." This increase in fire season length was most apparent in certain regions -- including the western United States.

"We expect conditions to worsen in the future if these climatic changes continue," Jolly said in an email.

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The wildfire paradox

The 2015 fire season had been quiet, which meant there was an abundance of vegetation. A lot of brush had become fuel for a fire in the woods.

Ponderosa pine trees and mixed conifers dominate the lower elevations burned by the Roaring Lion fire. Many of these areas used to burn every 10 years, and these frequent burns kept the fuel load down. But these ecosystems have changed recently, and it is possible that fires like the Roaring Lion would have been rare prior to a firefighting strategy that tried to remove all fire from the landscape.

"By thinking the fires are bad, by attempting to suppress them because we are afraid of them or afraid of them for what they do, we basically make the next fire worse," said Mark Finney, a research forester from the Missoula's U.S. Forest Service Lab. This is called the wildfire paradox: The harder you try to remove wildfire, the worse it gets. "It's like struggling in quicksand. If you try to swim out of it and try to struggle against it, the faster you sink. That's kind of where we are right now."

Fire behavior includes how fire spreads, how long it burns, how much it burns and the physical characteristics of every fire. The temperature of all fires is the same: 1,000 degrees. So, the temperature doesn't matter, the amount of the energy that releases and how fast that fire moves, those things matter.

The Roaring Lion fire was interesting because it grew quickly and spread fast. What fire researchers usually do is to investigate where the fire started, what kind of fuel conditions were out there, what the forest structure is like, how much moisture was in it, what the wind speed and pattern was. In general, they try to understand how it spread the way it did, which takes a lot of effort.

Fire in general is just like a candle flame. It consists of combustion, heat transfer and ignition. These three main factors affect each other and work a circle.

For Finney, the Roaring Lion fire was not a major fire. “It was a major (fire) for people who were in it, and whose houses burned,” Finney said. “It wasn’t a large fire. It went on for one day, and that was it. It happened too quickly.” But he believes the fire had some unique characteristics that made it unusually destructive in the area it burned.

He compared the Roaring Lion fire with a fire month earlier called the Observation Fire, exactly to the south of the Roaring Lion fire. The Observation Fire was on the ridge, and fire managers tried hard to suppress it. Finney believes that if the fire managers had not suppressed that fire, it would have burned down the mountain into the area that was burned by the Roaring Lion fire. “What I am saying is by removing fire today, you make the next one worse,” he said.

In the American mindset, there is this notion that wilderness areas were completely wild before the Europeans arrived. “That’s not true. There were millions and millions of Native Americans here, living in this environment and manipulating it. There is no such a thing as wilderness,” Finney said.

The problem is people have the same misconception about fire, too. They believe that the wilderness areas are perfect and pristine unless the managers touched them, and where they did touch them, they screwed them up. “That’s a complete fairy tale,” Finney said. With this way of thinking, mangers can’t manage this area by doing prescribed burning, cutting and thinning, which is not sustainable.
“People think you could put a fence around (wilderness) and preserve it. Perfect: You can preserve it for a wildfire to burn,” Finney said. “It’s a disappointing realization that most people don’t understand that their attempt to preserve things and to save them are actually destroying them.”

Ecosystems are dynamic entities and subject to change, and fire is going to be part of it. “We have to accept that reality. There are no alternative facts in this case, there are only biophysics facts and they occur whether we want them to occur or not,” Finney said.

There is good evidence that fuel management activity such as thinning and prescribed burning is effective at changing future wildfires in this type of ecosystem. It is likely that if that area had been thinned, as the Forest Service planned, the Roaring Lion would have been less intense. By looking at the fire effects on both private land that had been thinned around Roaring Lion and natural forest where it has not, the fire intensity was more obvious in the natural forest. “If thinning and prescribed burning would have taken place prior to that, that fire would have been much different,” Finney said.

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Singed and lonely

From the beginning of the wildfire, Dave Campbell knew he and his wife's home and outbuildings were relatively safe, because he knew what defensible space meant. “The reason

why our houses are here and some others are not, is because we are paying attention to the fuel around it and the risk around it," he said.

Some of the people who did not lose their homes have not come back, and the Campbell family feels pretty alone up there.

Their home is an island with a fringe of green grass surrounded by a sea of scorched black forest floor.

"The human story for me is just devastating," Poe said. "I was so attached to this place, and I have trouble recovering from what we lost."

Poe compares this loss to amputation. "You get used to only having one arm, but you sure miss the other one."

Campbell and Poe's house didn't burn. They lost one outbuilding that contained nine boats, five bicycles, 11 pairs of skies, tractors, antiques, all their camping gear and the most important thing: old family photos and scrape books.

Poe feels the loss of serenity intensely. "We have the house, but we lost a lot of value," she said. "It was just a perfect little universe we had and it is not there anymore. Those trees that died in this fire that were 300 years old. You can't put your arms around them, and they have been through fire after fire but they didn't make it on this one. It's been really a long, long difficult recovery for me."