Crown of the Continent
Research Learning Center

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Science in the Crown

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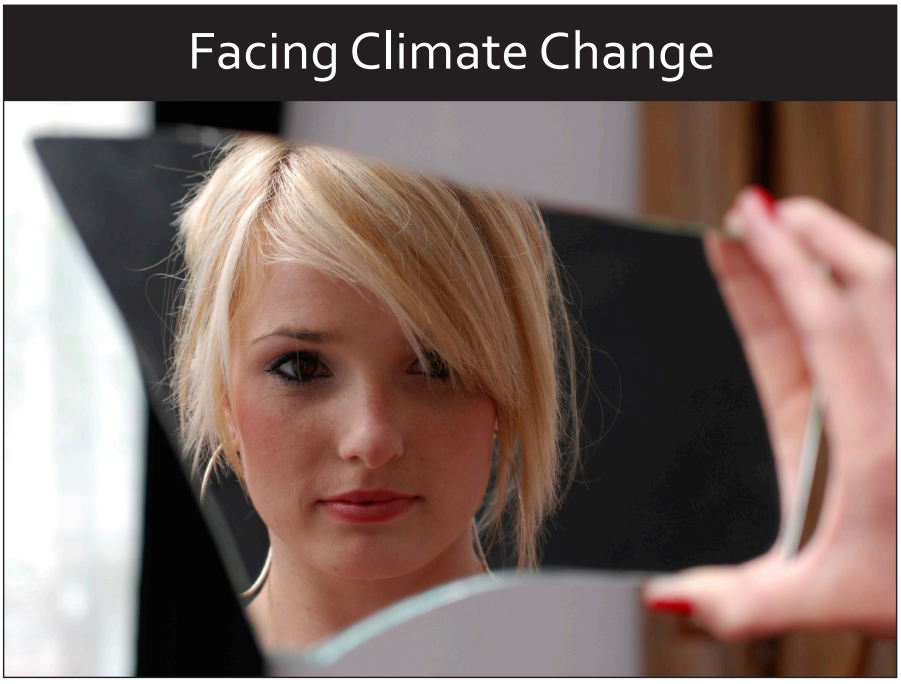
Facing Climate Change

By Melissa Sladek

Humans are not immune to loss. We deal with it throughout our lives. Some losses are manageable – moving to a new town, attending a new school, losing a promotion – while others, such as losing a loved one, are much more traumatic. And for many of us, painful loss is a long process that takes time and dedication before healing and acceptance takes place. I've been thinking about this in recent months because I am trying to piece together why climate change is such a difficult concept for people to not only understand, but accept.

A light bulb went on in my head after reading an article that compared the "five stages of grief" to climate change. It made sense to me that, similar to the "five stages of grief" (denial, anger, bargaining, depression, and acceptance), it's easier to deny climate change than face it, cope with the loss, and move forward. Perhaps it hit a chord with me because I can relate it to my own experience.



Facing climate change sometimes means facing ourselves.

I have often wanted to bury my head in the sand when it came to climate change. Sure, I would read and talk about it at work, but then I'd go home and push it out of my head. It seemed too daunting, too challenging; incomprehensible. But my current position as a science communicator in Glacier National Park, a park well-known for its melting glaciers, didn't let me ignore this difficult topic for long. Instead, it forced me to come up for air, shake myself off, and walk, step by step, forward.

For the last three years, I have pored over climate change research. I have met with climate change

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SCIENCE IN THE CROWN

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CCRLC is part of a network of research learning centers that the National Park Service established to promote research and scientific understanding.

www.crownscience.org

Director's Corner

By Tara Carolin

As I reflect on the Crown of the Continent Research Learning Center's accomplishments for the year, I realize much of our focus has been on our changing climate. For starters, more than a third of current scientific research and collection permits in Glacier National Park are linked to climate change. Scientists are studying the impacts of climate change on wildlife, aquatic communities, vegetation, fire ecology, and glacial recession. CCRLC-sponsored "Jerry O'Neal" scholars Cristina McKernan and Libby Pansing are studying climate impacts on wetland ecology and treeline whitebark pine communities, respectively. These projects have provided us with exciting opportunities to share recent research results.

Our science communication specialist, Melissa Sladek, partnered with Glacier's education specialist, Laura Law, and The Glacier Institute to facilitate our second Climate Change Teacher Workshop. See page 8 for more detail on how participating teachers have found creative ways to bring climate change science into their classrooms. The workshop also featured a public presentation by Dr. Steve Running, a leading climate change scientist from the University of Montana, about climate science and hope for the future. In addition, a number of this summer's brown bag presentations and talks at our tenth annual Waterton-Glacier Science and History Day discussed climate impacts on a variety of park resources.

Jami Belt led our Citizen Science Program, providing educational outreach to more than 250 individuals and engaging more than 150 students in collecting data on species of concern due to environmental changes. Our summer interns, Elizabeth Flesch and Taylor Hanson, did an outstanding job of helping us coordinate both citizen scientists and data, while gaining hands-on experience in the field of scientific public engagement (see p. 9). We also owe thanks to Sheree West for professionally managing our library and to Terry Peterson for assisting with, well… everything.

Melissa Sladek facilitated the completion of a field guide to Aquatic Invasive Species threatening the Crown of the Continent, a wildlife observation recording booklet, and resource briefs on several species of management concern. Thanks to talented assistance from Jim Giese, our science communication technician, our web site, www.crownscience.org, is ready for public browsing. We are also looking forward to sharing our first science film on harlequin duck research, currently under production.

As emerging research teaches us more about how the world around us is changing, CCRLC staff are invested in working with Glacier's Green Team to promote sustainability — the practice of making sure we can fulfill our social, economic, and environmental resource requirements not only for ourselves, but for future generations, within the park. As sustainable practices become more ingrained in our culture, we believe we can reflect a brighter future for upcoming generations in the Crown of the Continent.

Monitoring Amphibians in Glacier

By Jim Giese

Distant rumbles of thunder creep closer as Blake Hossack, a research zoologist with the U.S. Geological Survey (USGS), finishes inserting a microchip in the back of an adult boreal toad. Standing calf-deep in water, a nervous student looks west toward the thunder, and I imagine she is contemplating the wisdom of her current situation. She and other students from the Flathead Lake Biological Station have come to Glacier's Two Medicine area to learn about amphibians in the park. I joined them to learn about the status of amphibians and the role climate change may have on these cold-blooded creatures. I soon discover there is a lot to consider when dealing with amphibians.

Our main target is the boreal toad, but Hossack also expects we may catch Columbia spotted frogs and perhaps long-toed salamanders. Boreal toads are one of six species of amphibians known in Glacier, and are the only toad found in the park.

Besides being effective controllers of many insect "pests," amphibians are a food source for many mammals, birds, and fish. They are also regarded as excellent ecological indicators due to high sensitivity to slight changes in their environment. A decline or extinction of a population could represent responses to habitat fragmentation, ecosystem stress, disease, pollution from chemical inputs, or other human-caused activities.

Monitoring of amphibians in Glacier began in 2000, as part of the USGS's Amphibian Research and Monitoring Initiative (ARMI). Worldwide declines in amphibian populations prompted the creation of ARMI, a national effort to document trends of amphibian populations on federal lands and to conduct research on the causes of amphibian declines and malformations. Information collected by ARMI is then used by resource managers to protect amphibian populations.

Microchips, which contain unique identifying codes, are inserted into amphibians monitored in the study in order to estimate population size and individual survival rates. Estimating amphibian occupancy, or the probability that suitable habitat contains breeding populations, is done by collecting larval and adult amphibians using dip nets. A decline in occupancy could indicate a reduction in suitable habitat, a decrease in population, or a response to changes in climate. In Glacier, the boreal toad's occupancy rate is roughly 6% of the suitable

Above: A student from the Flathead Lake Biological Station searches for amphibians. Photo by Jim Giese.

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monitored sites, whereas the Columbia spotted frog has a higher occupancy rate of approximately 20–25%. Overall, the occupancy rate has remained steady during the study, although there have been shifts in which wetlands are being occupied.

Photo by Steve Corn, USGS

Boreal toads have a prominent white or yellowish line down the center of the back. They are currently listed as a Species of Concern in Montana.

As we gather gear and head into the cool, murky waters of the survey site, Hossack tells me that boreal toads were once common in this particular wetland. However, he and his staff are not finding toads in anywhere near the numbers they have in past years. In fact, he has instructed his crew to stop surveying for amphibians here. "It is one of those dilemmas: the smaller a population gets, the more time you need to devote to it. Yet at the same time, the amount of effort [required to collect such a small amount of data] is so high you eventually have to say, well, with a limited budget, you are better off doing something else."

Listed as a Species of Concern by the State of Montana, boreal toads were once more abundant in western Montana, as well as in other states throughout its range. The reason for their decline is uncertain, but disease, fragmentation and loss of habitat, and climate change are thought to be contributing factors.

During the drive to the Two Medicine area, I asked Hossack about climate change and its possible effects on amphibians in the park. He mentioned a recent study in which he researched how populations of the Rocky Mountain tailed frog, a frog found in cold streams of Glacier, might respond to long-term effects of climate change.

In previous studies, the consequence of a warming climate on a species with a specific temperature-range tolerance has been applied only to larger geographic areas. Hossack and his colleagues wondered if the same consequences could hold true for populations of the same species on a much smaller, localized geographic scale. They compared the survival rates of six different populations of Rocky Mountain tailed tadpole in Glacier to variations in late-summer temperatures. The results showed that the ability of individual populations to tolerate warming temperatures can indeed vary across a small geographic scale and is linked to the increased complexity of the local environment.

Additional questions need to be explored, such as how the frogs respond during different life stages and what role genetics may play. However, once these factors are identified, this information may lead to additional tools for resource managers in response to a warming climate. For example, there may be greater value in protecting populations of frogs known to tolerate a wider range of temperatures, as they might repopulate areas once inhabited by other, less-adaptable frog populations.

Back in the wetland, Hossack sweeps a dip net through the shallow water to collect larval forms of amphibians. Students follow his example and soon numerous tadpoles at differing stages of metamorphosis are collected in blue tote boxes.

Hossack pulls a Columbia spotted frog larva from the tote. About two inches long, the tadpole has a brownish-green coloring on its back and gold flecking scattered along the belly. A boreal toad tadpole is next, much smaller, less developed, and nearly jet black. Hossack explains that boreal toads breed later than Columbia spotted frogs. This prompts me to ask about the life cycle of boreal toads, since it is thought that some correlation exists between timing of breeding and success rate.

Hossack explains that adult boreal toads emerge in spring once snowmelt has cleared away from their burrows and daily temperatures remain above freezing. The timing of breeding depends on snowmelt and begins as early as May in lower elevations, but can be delayed to July or early August in higher elevations. Depending on a female's body condition, breeding may occur every 1–3 years. Eggs are deposited

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in long strings which are normally laid in shallow water. Development of egg and larva are temperature-dependent and development from hatching to metamorphosis can take up to 75 days in higher elevations. It is this temperature-dependency that might be affected by a changing climate and is one of the reasons Hossack is monitoring breeding populations.

A new concern for amphibians in Glacier, and one that Hossack is also monitoring, is the emergence of amphibian chytridiomycosis, otherwise known as chytrid. Chytrid is an infection of skin cells in amphibians, caused by the microscopic aquatic fungus, *Batrachochytrium dendrobatidis* (Bd). It is linked to widespread declines in amphibian populations throughout the world. Chytrid was first discovered in a boreal toad in Glacier's Two Medicine area in 2001. It is now detected in 30–50% of the wetlands sampled each year.

Although present, Hossack says chytrid does not appear to be causing problems within the park: "While it's infecting animals in our area, it does not seem to be causing population crashes. However, we can't rule out a link to slow declines, because that is much harder to tease apart from other sources of decline." In fact, all of his monitoring efforts are geared toward determining the cause of reduced amphibian populations, and, in particular for Glacier, the boreal toad. At this point, the reasons for the declines remain unclear, but Hossack is hopeful that this and other monitoring sites throughout Montana and the West will shed light on this worldwide phenomenon.

The thunder and heavy, dark skies now engulf us as Hossack finishes the final measurements of the last caught toad. The consideration of heading to another wetland is trumped as rain starts to pelt the surface of the wetland and raingear is pulled out of packs.

Our trek out of the soggy wetland in the now cold, steady rain does not dampen the enthusiasm of the students. The group discusses the toads and frogs seen today and the important role they play in a healthy ecosystem. The highlight of the field trip, though, seems to be the constant chirping by a male toad. One student from Kentucky, who is experiencing Glacier for the first time, wonders if he will ever get a chance to hear the toad's chirping again, referring, I assume, to whether he will return to Glacier. My hope is that he will get that chance—both to return to the park, and to hear the toads chirping when he does.

"Facing" continued from pg. 1

scientists. I have read oodles of documents and websites. I've even personally witnessed changes taking place in my own backyard. Along the way, waves of anger, disbelief, depression, and hopelessness have swept over me. And even though I accepted long ago that human-caused climate change is a fact, I couldn't fully look climate change square in the face and take action. That is, until recently.

I am no stranger to loss. I know its power, its strange grip over my daily life. Some days, staying in bed or hiding in a closet seemed a much better alternative than dealing with my life and facing the loss of my mother. But time passes, caring people share their stories, and life moves forward. Acceptance is hard, facing change is hard, but we are all capable of it. It is a beautiful human trait.

And, similar to my experience with personal loss, it has been supportive people throughout my community and within the National Park Service that have helped me face climate change and move forward. Collaborations, discussions, and motivation from others have spurred me to look climate change squarely in the face; to decide that just admitting climate change is happening is not enough. I finally feel empowered to say, "Yes, the climate is changing. Yes, humans are for the most part responsible. And yes, we can do something. *I can do something*."

"Yes, the climate is changing. Yes, humans are for the most part responsible. And yes, we can do something. ***I can do something.***"

This issue of Science in the Crown explores research on how climate change may be affecting amphibians and mountain goats, and highlights creative and innovative ways local educators are teaching climate change to their students. Read on, learn how others are taking action, and join me in facing climate change.

Mountain Goats: Indicators of a Changing Alpine

By Jami Belt

Visitors to Glacier National Park often reflect on the park's lush alpine meadows, rising, jagged peaks, and, of course, the scruffy, bearded icon of Glacier—the mountain goat. And although we see mountain goats in many alpine areas throughout Gacier, what do we really know about them and how they are doing within the park? Documented declines in native mountain goat populations in other parts of Montana, and a decade of declining counts at a well-used mineral lick in Glacier, prompted concern about Glacier's population as a whole.

The Crown of the Continent Research Learning Center, with support from the Glacier National Park Conservancy, responded by launching the High Country Citizen Science Project in 2008, a program that recruits and trains volunteers to help park managers gather baseline information about alpine species that may be vulnerable to climate change impacts. More than 150 local residents, visitors, and students volunteer each year, providing the boots-on-the-ground needed to monitor wildlife throughout the million acres that make up Glacier National Park. Traversing the high-elevation trails, these volunteers count mountain goats at 37 survey sites across the park. The purpose is to develop annual population estimates that help scientists to detect long-term changes in goat numbers. Braving the harsh conditions in mountain goat country, these volunteers have conducted over 1,200 goat surveys since the onset of the program.

The mountain goat is a species of the alpine, well adapted to blend into the white background of its home of rugged, snow-laden mountaintops. Current research indicates that alpine environments are expected to be hard-hit by climate change. Due to their dependence on these areas for survival, mountain goats may serve as an indicator of changes occurring in the alpine. But how might mountain goats be affected? Questions abound. Will nannies be able to adjust the timing of their birthing to take advantage of an earlier peak in seasonal forage? How might populations fare if snow no longer blankets the ground? Can goats continue to evade predators if upward-creeping treelines begin to surround their rocky outcrops? The answers to these questions are complex and far from certain, but published studies on mountain goats and other alpine ungulates have yielded many consistent patterns. This article will explore a few of these potential scenarios through the lens of mountain goat ecology.

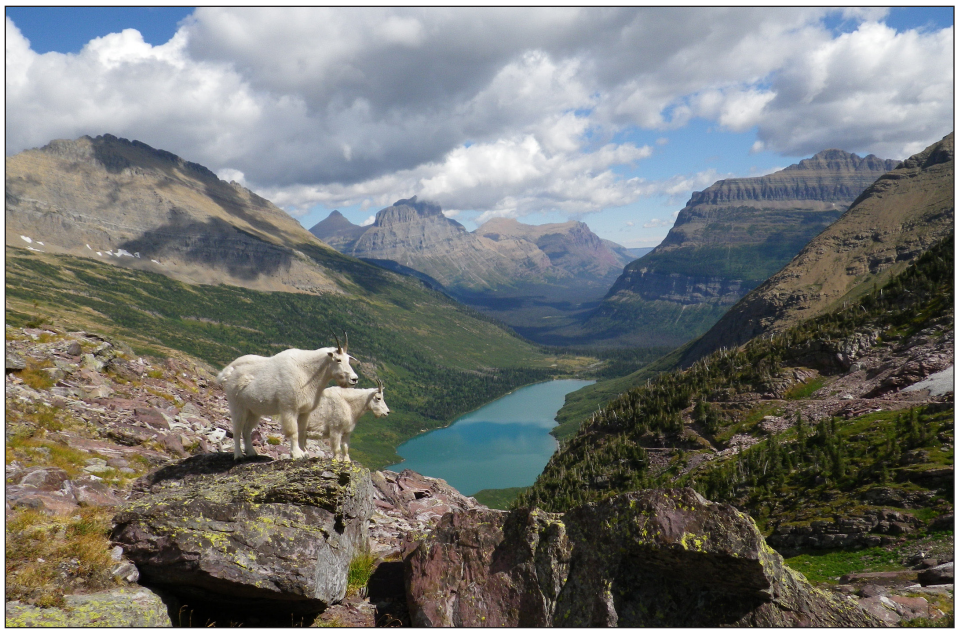


Photo by Len Kopec

Mountain goats roam throughout the alpine areas of Glacier National Park. But what do we really know about these scruffy, bearded kings of the alpine and how they will fare in a changing climate?

Could spring green-up and the timing of mountain goat births become out of synch?

An advance in the onset of the growing season by seven days has been documented since the 1960s (Walther et al. 2002). An earlier snowmelt may trigger an earlier onset of growth in plants— possibly a good thing for the mountain goats that rely on them as forage. But forage quality is at its highest in early spring, so a burst in plant growth earlier in the season may be mismatched with the timing of the birth of mountain goat kids. In addition, warmer temperatures and decreases in glacial runoff (important for the growth of alpine plants) may shorten the amount of time that mountain goats have access to forage. A study by Pettorelli and others (2007) showed that rapid changes in plant growth correlated with decreased growth in young mountain goats, but it is not yet clear how that may influence survival.

Will milder winters make life easier for mountain goats?

In 2001, the International Panel on Climate Change predicted a decrease in snowpack levels. Mountain goats tend to fair better during milder winters—especially the young, who exert incredible amounts of energy in deep snow years pawing through the snow to find their food. The oldest (age 9+), most dominant mountain goats are also more likely to survive winters when they spend less energy maneuvering through heavy snow, and can restore their energy reserves after the rut (White et al. 2011). While less snowpack would boost the population in the short term, it could lead to a feedback loop as population density creeps upward.

Such an effect was recorded during a forty-year trend monitoring study of alpine ibex, a close relative to mountain goats. During years with low snowpack levels, greater numbers of older ibex survived the winter, leading to higher population densities. A crowded ibex population, trying to make a living on limited resources, triggered delayed reproduction and a decrease in survival of kids and yearlings in the following years (Jacobsen et al. 2004). A lag effect of this sort can also occur in mountain goats where survival of adults to older ages masks a slowed rate of population growth for a few generations, followed by a population crash caused by lower numbers of kids being born.

Will increasing temperatures force mountain goats to move to higher elevations?

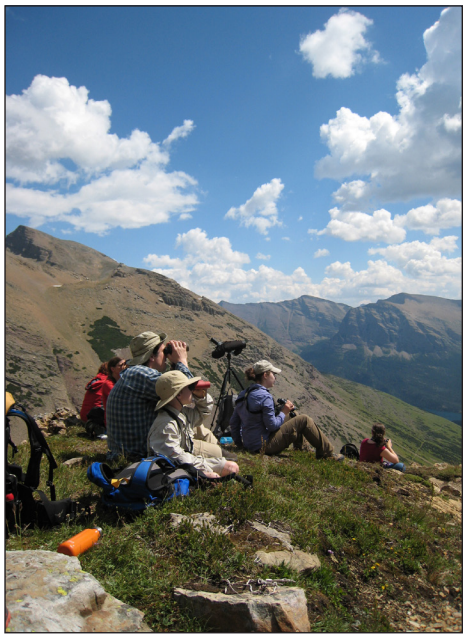
Facing increasing temperatures in the Italian Alps, alpine ibex have begun to spend more time foraging in the early morning, retreating to higher elevations to rest during the hotter part of the day (Aublet et al. 2009). Over the short term, mountain goats can also adapt in this way by increasing their foraging during the cooler parts of the day (Rideout 1977). But, a long-term increasing trend in average daily temperatures may ultimately reduce the amount of time when mountain goats can forage without overheating or may force mountain goats, and their ibex kin, to stay at higher elevations, where forage is less abundant.

Perhaps fortunately, upward shifts in elevation are also occurring in alpine plants and in treeline levels (Parmesan and Yohe 2003). This means alpine ungulates can follow their favorite forage plants up the mountain slopes where it is cooler. But it is possible that alpine ungulates and plants may eventually reach the tops of mountains and run out of places to seek higher, cooler ground. Meanwhile, potential competitors, such as bighorn sheep, may change their distributions to higher elevations as well (Hughes 2000), introducing competition for available forage. Upward-creeping treeline elevations could also provide more hiding places for predators, jeopardizing the safe haven of ledges, which mountain goats currently rely on for protection against predators.

I*n light of all these complex scenarios, where should managers focus their energy to safeguard Glacier's stronghold of mountain goats?*

A consistent theme among the studies reviewed is the need for long-term monitoring to track whether these changes are having an impact on mountain goat populations. However, counting mountain goats and tracking their distribution over Glacier's over one million acres each year is a daunting task. It often takes at least two to three mountain goat generations (3–10 years) to determine whether any pattern exists at all, or if changes in count are due to typical yearly fluctuation.

Herein lies the power of citizen science. Due to the relatively low cost of managing a large team of volunteers, our program can be conducted over a longer term than many traditional research projects, enabling us to continue looking for changes that occur over many generations of mountain goats. We are in our fifth full year of surveys and have achieved our initial goal of getting a baseline population estimate. In the coming months, we hope to bring some insight into current mountain goat population trends within Glacier by compiling our results and producing a five-year trend analysis. Stay tuned and thanks to all of our volunteers for making these results possible!



NPS Photo

Citizen scientists survey for mountain goats near Siyeh Pass.

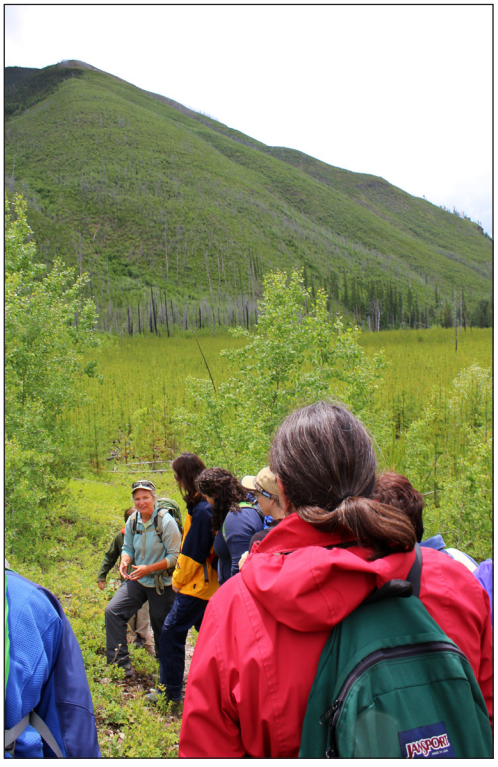
Literature cited on page 10.

Making a Difference

By Melissa Sladek

What do 18 teachers from across the country have in common? The ability to make a difference. That's what we discovered this summer at our 2013 Climate Change Teacher Workshop and, as lesson plans and project ideas began to flood our inboxes, in the months that followed. The workshop, funded through NPS project funding and made possible through a partnership between the Crown of the Continent Research Learning Center (CCRLC), Glacier National Park's Division of Interpretation and Partnerships, and the Glacier Institute, gave insight to climate change research and impacts happening in Glacier National Park and provided instruction and resources to teach the topic.

Learning from the highs and lows of our 2012 workshop, we once again offered informative and educational presentations from a variety of agency researchers as well as hit the trails with the park's education specialist to learn effective climate change teaching tools and curriculum. But this year, after realizing the value of time spent brainstorming with others teaching this difficult topic, we incorporated more time for teacher collaboration and hands-on activities. Our funding also allowed us to include a keynote speaker, climate change researcher and Nobel Peace Prize recipient Dr. Steve Running, from the University of Montana, to talk to the group about climate change science and impacts in western Montana.



NPS Photo

Workshop participants discover how climate change is affecting Glacier's forests.

Throughout the week, workshop participants discussed how to take the information, curriculum, and resources into their classrooms in order to create successful lesson plans on climate change science.

As our teachers shared with us their newly created climate change lesson plans in the months that followed, it became clear that our participants were not only successful, but also inspirational. One workshop attendee, Lisa Knezha, a media specialist from Alabama, incorporated climate change science and the impacts of sea-level rise on Alabama's coastal areas in her tenth-grade, volunteer, environmental service group. The group meets throughout the year and engages in service learning projects that help both their school and community to become more sustainable. Samantha Schoeberl, an eighth-grade science teacher from Colorado, created a climate change unit that gives students opportunities to learn about climate change issues in Colorado, measure their carbon footprint, and discover the benefits and disadvantages of using alternative energy.

Locally, an exciting collaborative project took off this fall as three of our participating teachers came together to create a yearlong energy-reduction competition between their respective schools. The goals of the project are threefold: to monitor and reduce energy usage at each of their middle schools, to increase students' understanding that their day-to-day actions have an effect on global climate, and to build community between these middle-school students.

The competition began in September, with a kick-off event in which participating students and teachers from all three schools introduced the challenge, got to know one another through team-building exercises, and brainstormed what they could do at their schools to minimize energy use. The kick-off even included a motivating and hilarious climate change song, composed by science teacher Randy Jakes and sung to the tune of Johnny Cash's "Folsom Prison Blues!" In addition to this project, each teacher is also incorporating a unit on climate change in his or her eighth-grade classroom.

These are but a few of the exciting service-learning projects and climate change lesson plans that our workshop participants have created. We applaud their motivation, creativity, and willingness to tackle this challenging topic. Their efforts truly are making a difference.

Intern Spotlight

By Elizabeth Flesch

Rocks crunch and damp thimbleberry leaves brush my arms as I accelerate up the trail along a rock face. I pause to catch my breath, taking a moment to glance down at Gunsight Lake, a deep-blue jewel nestled among magnificent mountains. To my left, ghostly white figures saunter across a sloped patch of vibrant green. I yank a pair of binoculars to my face, adjust the blurred image with a slight turn of the dial, and three mountain goats come into focus. I quickly set up my scope and tripod to begin a mountain goat survey at the Gunsight Pass survey site. Alas, just as I hunch over the scope and place my eye up to the lens, the goats move out of view.

NPS Photo

Intern Elizabeth Flesch poses in front of Iceberg Lake before conducting a citizen science mountain goat survey.

I am conducting this survey as part of Glacier National Park's Citizen Science Program, which uses trained volunteers to conduct surveys on wildlife species and invasive plants. This summer, I have had the privilege of serving as the coordinator of the High Country Citizen Science Project (HCCS), one of three projects run under the Citizen Science Program. The HCCS project uses volunteers to monitor Glacier's mountain goats, bighorn sheep, and pikas. My position has allowed me to conduct research on these alpine species, coordinate and train citizen scientists, and analyze data. In addition, it has given me a unique opportunity to learn first-hand how trained volunteers can assist in building scientific insight and environmental awareness.

The fact is, alpine animals are difficult to observe (even when we know they are present) and, as I know after hiking many miles in Glacier's high country, collecting biological data in the mountains is often difficult, not to mention time-consuming. I now realize the tremendous power of citizen science. While I spend seven hours hiking 17 miles and completing one survey, a trained volunteer could conduct another survey on the other side of the park. Or, on a good day, several surveys might be conducted in various locations throughout Glacier. As an aspiring wildlife biologist, I realize the value and practicality of using citizen scientists and hope to continue to involve citizen scientists in wildlife projects throughout my future career.

Beyond being practical, working with citizen scientists is fun! I have tremendously enjoyed helping volunteers of all ages spot a bighorn sheep and identify pika sign among talus. I believe that by training others about these species and how to observe them, we not only gain more data, but also foster a sense of stewardship and appreciation of the natural world. As our society works to address issues that may threaten these high-country species, a little more information and a few more informed people might make a significant difference.

Funding for Elizabeth's position was provided in part by the Glacier National Park Conservancy.

CCRLC Director Receives Regional Award

By Staff

This fall, the Crown of the Continent Research Learning Center (CCRLC) was proud to find out that Tara Carolin, the center's director since 2009, received the National Park Service Intermountain Region Director's Award for Professional Excellence in Natural Resource Research.

Tara's leadership has enabled the CCRLC to advance its mission in facilitating research, communicating research results, and promoting resource stewardship. Throughout her time here, she has been a leader in climate change research and communication, improving Glacier's sustainability efforts, and keeping popular and critical programs like the Glacier National Park Citizen Science Program afloat. She has also encouraged and assisted students in their research by offering fellowships, internships, and advice on research techniques.

Tara's career includes 22 years with the National Park Service. She has a master's degree in wildlife and range resources from Brigham Young University, with a strong background in native plants, and is currently in her seventeenth year of working at Glacier National Park. As a regional recipient of this award, Tara is eligible for the national award in this category.

The staff at the CCRLC wish her the best of luck and thank her for all of her dedication, patience, and guidance. We, of course, believe she is a winner in every sense of the word!

NPS Photo

Tara Carolin holds her NPS Intermountain Region Director's Award for Professional Excellence in Natural Resource Research.

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