CROWN OF THE CONTINENT

THE UNIVERSITY OF MONTANA

MAGAZINE

SPRING 2009

THE UNIVERSITY OF MONTANA CROWN OF THE CONTINENT INITIATIVE

THE UNIVERSITY OF MONTANA
CROWN OF THE CONTINENT
INITIATIVE
Department of Geography –
Old Journalism Building
The University of Montana,
Missoula, Montana 59812

Faculty and students from many University of Montana departments contribute to the Crown of the Continent Initiative's overall efforts, including this publication.

Published by The University of Montana Press.

THE UNIVERSITY OF MONTANA PRESS

CONTENTS

ISSUE I — SPRING 2009

CROWN OF THE CONTINENT MAGAZINE

Cover photo by Susie Graetz

Contact us at: UMCROWN@umontana.edu

INTRODUCTION

In 1901 when George Bird Grinnell coined the phrase "The Crown of the Continent," little did he know that those lofty words, employed to gather support for his efforts to create Glacier National Park, would some day come to represent a far greater expanse of soaring alpine country in two nations. Glacier National Park, with its approximately one million acres, is now, almost one hundred years after its official establishment, just one of several jewels in this very large, pristine, trans-boundary ecosystem that encompasses nearly 13 million acres.

Today's Crown of the Continent, to which this E-Magazine and the new UM initiative bearing that name are dedicated, is a mesmerizing, outrageously beautiful, diverse, and both scientifically and historically important piece of geography that extends some 250 miles from north to south along the Continental Divide. It holds legendary landscapes, including those within the boundaries of the Waterton-Glacier International Peace Park, as well as perhaps the grandest wilderness country of all –"The Bob," that is, the contiguous Bob Marshall, Scapegoat, and Great Bear Wilderness Areas, and other grand landscapes on both sides of the U.S.-Canadian border.

In the realm of time and space—it is difficult to separate history and geography—this special place in the Rocky Mountains of Northern Montana and the southern parts of both British Columbia and Alberta can boast of a relatively recent, perhaps, but excitingly colorful past. Before the Europeans came in search of fur and then gold and other natural resources, this swath of land was part homeland and part transit territory for numerous indigenous peoples north and south, east and west. They are still a part of this place, and it is certainly still a part of who they are. When the Europeans (and after the Lewis and Clark Expedition, Americans) came to this spectacular country in search of wealth, space, and natural resources, they settled sparsely and mostly in a few valleys and along the periphery of what we have come to regard as this Crown of the Continent. Consequently, much of this place, this "ecosystem," is still intact and relatively undisturbed; much of it is legally protected.

This E-Magazine, of which this is but the first issue (we intend to publish at least two per year), is produced to help shed light on and bring information, stories, and photos from and about this incredible Crown. The University's Crown Initiative is interested in the various kinds of research being carried out here by scientists and scholars of all stripes from around the world; in the many educational activities and opportunities that are available through all kinds of official institutions as well as volunteer citizen groups; and in working collaboratively with its large and rapidly growing number of partners throughout the region who share these interests and want to participate in making information about the Crown available to the general public in a variety of accessible forms. One of those forms, with contributions from a wide range of people and organizations, is this E-Magazine. We intend to bring to you—researchers and scholars who study this place; officials who manage and make policy that affects this place and everyone and everything related to it; and the general public from near and far that is rightly fascinated by and concerned about its history and health—a wide range of articles, essays, scientific findings, stories, anecdotes, lots of visual representations, bibliographies, and tips on where to find even more information about all aspects of this place: our (collectively) Crown of the Continent.

It is also our plan to bring this E-Magazine, and other newsletter-type publications, to you free of charge, although as is the lot of most non-profit organizations, we certainly won't reject any donations, large and small, that you might consider sending our way to support this effort and other activities of the University of Montana's Crown Initiative as well as related activities of our collaborating partners. You may send such donations to the University of Montana Foundation, Brantley Hall, Missoula, Montana, 59812, USA, with a notation of "Crown of the Continent Initiative" on your checks.

We are all very excited about this initiative and the collaborations already started with our partners. Our recent symposium on the Crown, held in Kalispell in February, was a great success, and our numerous meetings and conversations with scientists, scholars, students, public officials, and representatives of our partner organizations have made us here at UM feel extremely optimistic about the future of this initiative. You are invited to read more about current activities as well as plans for the next months in the closing pages of this issue. As you do so, however, please keep in mind that this is all a "work-in-progress," and we would very much like to hear your thoughts, suggestions, criticisms, concerns, and ideas. You may contact us at our e-mail address: UMCROWN@umontana.edu. Thanks for your interest and support, and if you know of other individuals or groups you think would like to receive this E-Magazine and hear more about the Crown Initiative, please let us know that as well.

Rick Graetz and Jerry Fetz, Co-Directors
The University of Montana Crown of the Continent Initiative
Department of Geography, The University of Montana

—We would be pleased to have your assistance —

Donations large and small—$5, $10, $25 or more—are needed as we grow our efforts to bring you "The Crown" in a variety of ways and formats: Symposia, such as the one we recently held in Kalispell, book projects, newsletters, regular issues of this E-Magazine, etc. Your contributions will also enable us to get students out "into the field" in Crown areas, offer courses for them and the general public, support student research projects, and provide you and other interested parties with accessible and high-quality information about our wonderful and fascinating Crown. Donations are tax-deductible and should be sent to:

The University of Montana Foundation, P.O. Box 7159, Missoula, MT 59807

Please make checks payable to the UM Foundation with a notation to be directed to the "Crown of the Continent initiative." You also may donate online at https://safe.onlinemontana.com/onlinemontana/fundraiser/?s=6070. Select your desired gift amount, designate it to the College of Arts & Sciences and note that your gift should go to the "Crown of the Continent Initiative" on the "Additional Comments/Instructions Regarding Your Gift" page. Thank you.

PRESIDENT'S MESSAGE

President George Dennison and Provost Royce Engstrom of The University of Montana ride a trail above the Blackfoot Valley and the southern perimeter of the The Crown of the Continent.

This electronic magazine will afford to participants in this very special project, and those interested, a window into the ongoing developments. As promised by those who have pushed us to the stage, we do not intend to have a bureaucratic structure or erect barriers curtailing participation. In the information age with the advent of the Internet, it seems entirely appropriate to use this vehicle to include as many participants and observers as possible.

But why such a project? Why the name? Those familiar with the region of the country recognize immediately the dependence of the remainder of North America on what happens here. At the center stands Triple Divide Peak, and from that center the waters run west, east, north, and ultimately south. Failure to understand and protect this valuable ecological landscape will result in devastating consequences down stream. Hopefully we have learned from what has occurred elsewhere in the world, notably in China, when we fail to act as good stewards. The oncoming effects of climate change also illustrate vividly – in the Crown of the Continent as elsewhere – why we must act now.

Good management requires good science and a full understanding of the interrelationships that apply. As has become readily apparent, the challenges do not lend themselves to solutions derived solely from good science. Those most versed in the causes and consequences of climate change remind us that the work we must do requires the engagement of humanists, social scientists, policy experts, journalists, public servants, and, most importantly, average citizens.

This project and this magazine aims to bring together all who will contribute toward developing solutions to the challenges before us that demand the engagement of citizen and expert alike for success. We welcome you to this critical work.

George M. Dennison, President
The University of Montana

I am a resident, you almost might say a product of the Rocky Mountain Front, "the front," as we have come to call it.

It is a strip of land just east of the Continental Divide and includes an edge of the plains, the higher bench lands, the foothills and then the great jagged wall of the mountains.

At the age of 89, living on the front, I have come to feel a part of what has gone before, kin to dinosaur and buffalo and departed Indians that lived here. When I step out of doors and hear a small crunch underfoot I sometimes suspect I may be treading on the dusted bones of duckbill or bison or red man killed in the hunt.

I look to the north and the south, where the foothills rise, east to the great jagged roll of the high plains and west to mountains and my vision site of Ear Mountain and good medicine lies all around.

A.B. GUTHRIE, JR.

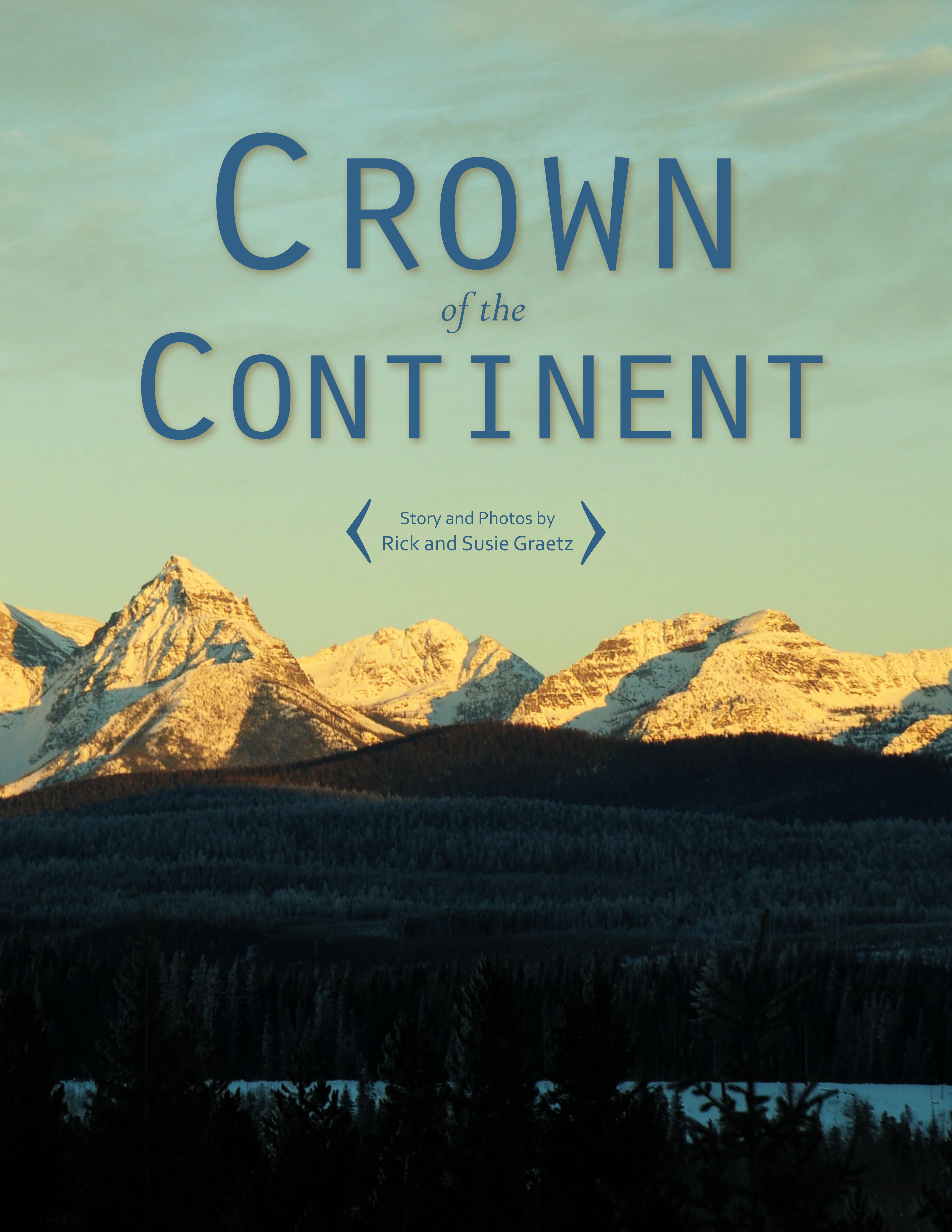
from *Montana: A Photographic Celebration, Vol. 3*

A.B. "Bud" Guthrie, Jr. was a Pulitzer Prize-winning author. Of his many books and screenplays, he is perhaps best known for his book *The Big Sky*. Photo by Rick and Susie Graetz.


"… the Blackfeet referred to the compilation of jagged,
soaring edifices as the 'Backbone of the World'…"

Crown of the Continent

Story and Photos by
Rick and Susie Graetz



Much earlier in time, control of the hunting lands of what would one day become Montana east of the mountains rotated through various tribes. But it was the acquisition first of horses, and then of guns, that allowed the Blackfeet Nation to rule the prairie the bison roamed, especially within the area in the shadow of today's Rocky Mountain Front.

With the arrival of white Europeans, the Blackfeet were pushed into the neighborhood they occupy today—the Blackfeet Reservation—hard up against the eastern flanks of Glacier Nation Park. Corralled in a distinctly smaller landscape, the natives ventured into the high country to hunt, fish and establish vision-quest sites. In awe of what they saw, the Blackfeet referred to the compilation of jagged, soaring edifices as the "Backbone of the World."

Searching for adventure, James Willard Schultz, an educated easterner and accomplished author, migrated to Montana's high plains in 1876 and eventually came to live with the Blackfeet Indians. He took a wife from the Piegan band of the Blackfeet and, despite being a white man, Schultz melded in so well that the Piegan name "Apikuni," meaning "Far-off White Robe," was bestowed upon him. Time spent hunting and exploring the mountainous terrain that rose abruptly west of the Indians' encampments inspired him to write about

Mount Reynolds – Logan Pass Area, Glacier National Park

his adventures and the beauty he witnessed, making him perhaps the first person to chronicle the magnificence of these western lands.

In 1885, Schultz sent an article titled “To the Chief Mountain” to *Forest and Stream Magazine*, the forerunner to the current *Field & Stream*. The editor at the time was George Bird Grinnell, a Yale graduate educated in wildlife and forestry whom *The New York Times* referred to as the “father of the modern conservation movement” at the time of his death in 1938. Grinnell had spent many years studying the natural history of the nation’s western regions and understood well the Native Americans and animals of the Northern Great Plains. Impressed with what Schultz penned, Grinnell boarded a train to Helena and then rode the mail stagecoach to Fort Benton, where he met the author. From there, the two journeyed by wagon to the Blackfeet villages.

Grinnell’s mission was to see the topography Schultz had vividly described. Initially, they camped somewhere in the vicinity of today’s

Bison herds make a comeback on Glacier National Park's east slope – Blackfeet Reservation.

Triple Divide Mountain and then trekked to the now highly photographed St. Mary Lake, which Grinnell called "Walled in Lakes." From there, the duo traveled into the Swiftcurrent region and climbed to a glacier just below Mt. Gould and the Continental Divide; the glacier now bears Grinnell's name.

This naturalist was so enchanted with the entire landscape that he returned again and again for the next 41 years.

During the early 1900s, Grinnell and other notable folks began seriously lobbying for protection of the Crown through national park status. Their efforts were bolstered and prompted by previous discussions to preserve this collection of alpine majesty. As far back as 1883, John Van Orsdale, an army officer on duty in the Browning area and the Blackfeet Reservation, suggested the establishment of a national park for the region of today's Glacier National Park.

In 1901, Grinnell heightened the campaign to enlighten the American public about the great natural features that the area possessed; he christened the land "The Crown of the Continent."

Finally, in 1907, legislation was introduced. Residents of Kalispell vehemently opposed the action, fearing the loss of logging and hunting lands and believing there was nothing up there that folks would want to see. It took three attempts before a bill finally passed, and, in May of 1910, President Howard Taft signed a decree creating Glacier National Park.

Sometime in 1895, land contiguous to Glacier just across the Canadian border was reserved for Canada's Waterton Lakes National Park. Now, an even greater collection of vast mountains sculptured by ice, water and wind was in public ownership. The area received lofty recognition in 1932 when the two parks were joined together as an International Peace Park.

Today, the original area of Grinnell's "Crown" and the Blackfeet's "Backbone of the World" has been expanded to include a large and vastly important ecosystem that extends well beyond the confines of Glacier National Park. An estimated 13,000,000 acres make up this two-nation environment.

Today, the original area of Grinnell's 'Crown' …has been expanded to include an important ecosystem that extends well beyond the confines of Glacier. An estimated 13 million acres make up this two-nation ecosystem.

Following the crest of the Rocky Mountains, the Continental Divide is the defining landmark of the Crown. A precise strand, it gives order to every drop of moisture that reaches it. All waters descending on the west slopes find their way to the Pacific Ocean. Snowmelt or rainfall on the east side of the Divide works its way through the Missouri and Mississippi rivers to the Atlantic.

If you are traveling directly north to south, the top tier of the Crown of the Continent commences in the headwater terrain of the Elk River and Mt. Jaffe on the Continental Divide, north of Sparwood, British Columbia and Crowsnest Pass. The pass allows Canada's Hwy 3 to cross the Rockies and the Continental Divide between two Crown communities—Fernie, British Columbia to the west and Pincher Creek, Alberta to the east.

Descending southward from Crowsnest Pass, the Continental Divide follows the apex of Canada's Waterton Lakes National Park, busting out into Montana's Glacier National Park and then on through the Bob Marshall Wilderness country to Rogers Pass. For the uninitiated, "The Bob" consists of the contiguous Great Bear, Bob Marshall and Scapegoat wilderness areas as well as de facto wildlands that surround the federally designated wilderness. Gathered together, this landscape occupies about 2.5 million acres.

When delineating the exterior boundaries of the Crown, we begin with the eastern perimeter, where the rolling, wave-like prairie lands of Alberta and Montana surge toward a collision with the reefs, walls and peaks of the Canadian and American Rocky Mountain Front.

The southern frontier follows Montana Hwy 200 from Bowman's Corner—the crossing of Hwy 287 and Hwy 200—over Rogers Pass, the Continental Divide and on through the Blackfoot River Valley. At the junction where the Blackfoot River meets the Clearwater River flowing south out of the Swan Valley, the border makes a sharp right-hand turn and begins moving north with the Clearwater. It continues westward along the southern edge of the fast-rising Mission Mountains and the Jocko Divide into the Flathead Reservation lands.

Mount Harding, center, and to the right McDonald Peak, the Mission Mountains, near Ronan.

From here, the western limit takes in the Mission Valley and Flathead Lake and extends north to the west slopes of the Whitefish Range and the Tobacco Valley. North of Eureka, Montana, Canada takes over again and ushers the western rim through the Kootenay (Kootenai in Montana) River Valley and then northward to the area of the Columbia Lake and Canal Flats in British Columbia.

This glorious gathering of trans-boundary topographic pieces represents a microcosm of what the American and Canadian west once was. Glacier-carved peaks—some of their north faces still embedded with remnant glaciers—, vast forests rising to the upper reaches of mountains, wandering river valleys, steep canyons, gushing creeks, flowered meadows and a wild population that represents nearly all of the major and minor critters of the Rockies together form what many researchers consider to be the largest intact and most pristine ecosystem in North America.

In the approximately 200-mile stretch as the bald eagle flies between the Crowsnest and Rogers passes, only one year-round road—Marias Pass, route of US Hwy 2—traverses the geography of the Crown. In Glacier National Park, the Going-To-The-Sun Road climbs over the Divide through Logan Pass; however, with the exception of the summer months, heavy snowfall, enormous drifts and avalanches seal this route for up to nine months of the year.

Geologically, much of the Crown's topography, especially east of the Divide, is a result of tremendous chaos within the earth's crust nearly 75 million years ago. Slabs, considerably more than a mile thick, of pre-Cambrian limestone,

sandstone, mudstone and shale—about 1.5 billion years old and thus some of the oldest rocks on the planet—were thrust skyward to the east, which caused them to ride over much younger rocks and created a series of wave formations that are termed "overthrust" in geo-speak.

South of Glacier Park to Rogers Pass, the overthrust formations reveal themselves in a series of conspicuous north/south oriented cliffs and ridges; they are steep faced on the east and slope in a more gentle fashion to the west. Caves and rough rock surfaces—a result of Madison and Meagher pale gray limestone (calcium carbonate, $CaCO3$), a mineral form of calcite that is extremely susceptible to erosion from the acidity of rainwater and snowmelt—are common to this section of the Rocky Mountain Front and well into the Bob Marshall.

Above Marias Pass, the Glacier and Waterton Lakes area is a single slab of uplifted rock. After the configuration moved into place, glaciation and rivers began the arduous task of sculpting cirques and valleys. It is interesting to note that the rocks in the two national parks are far more richly hued than their relatives in the Bob Marshall and the Rocky Mountain Front to the south.

Here, the streams and creeks are filled with the exceedingly hard, red and green mudstone and the burgundy and teal argillite that give the water its unique, colorful appearance.

Glaciers acted out their magic not only in Glacier and Waterton, but they also designed nearly every other piece of the Crown's geographic puzzle.

Continental ice sheets buffed the prairie hills and valleys, leaving behind glacial till that enriched the soils of the area.

In the Kootenay and Flathead valleys, where the ice was once upward of 3,000 feet thick, numerous advances of ice scraped out the bottomlands that are now known geographically as the Rocky Mountain Trench. A yawning depression left behind by an enormous ice mass that lingered long after the main level of glacial ice melted became home to Flathead Lake.

The glaciers that moved south about 15,000 years ago overran the northern two-thirds of the Mission Mountains, gouging deep scratches—"striations" in geo-speak—in the bedrock. Previous ice ages brought rivers of ice to the far end of the Mission Valley and were partly responsible for the many pothole lakes that dot the area.

Historically, the land of the Crown reaches well back in time. Much of what played out is lost in the mists of surmise, but through legends and stories that have been passed on, it is possible to grasp a bit of a fascinating story.

Along its eastern flank, where the northern plains abruptly end, the Great North Trail, a route once followed by ancient peoples after they crossed the Bering Sea land bridge from Asia, is still visible in places; we can only imagine how old it is and who passed by.

In more recent times, countless thousands of bison drifting below and along the Crown's mountain wall were hunted by the great indigenous nations.

Right: Camas was a valuable plant to the Native Americans.

Opposite: Lake McDonald in late summer, Glacier National Park.

Jealousy and guardianship over the hunting grounds forced much inter-tribal warfare within the Crown. Tribes from west of the Continental Divide—the Kootenai, Salish, Pend'Oreille, Nez Perce, Shoshone and others—threaded their way through Glacier, the Bob Marshall country and the Blackfoot Valley to hunt the big beasts of the prairie; they called the journey "Going-to-Buffalo" and were often attacked by the more powerful Blackfeet.

Unlike today's backpacking trails, which follow river bottoms and switchback up passes, natives crossing the Continental Divide through the Bob Marshall and Glacier followed the natural terrain. Signs of their travels are found high above the canyons and valleys, as this is where game was found. It was only on the sunrise edges of the mountains that they eventually descended from passes to reach the lower country to the east.

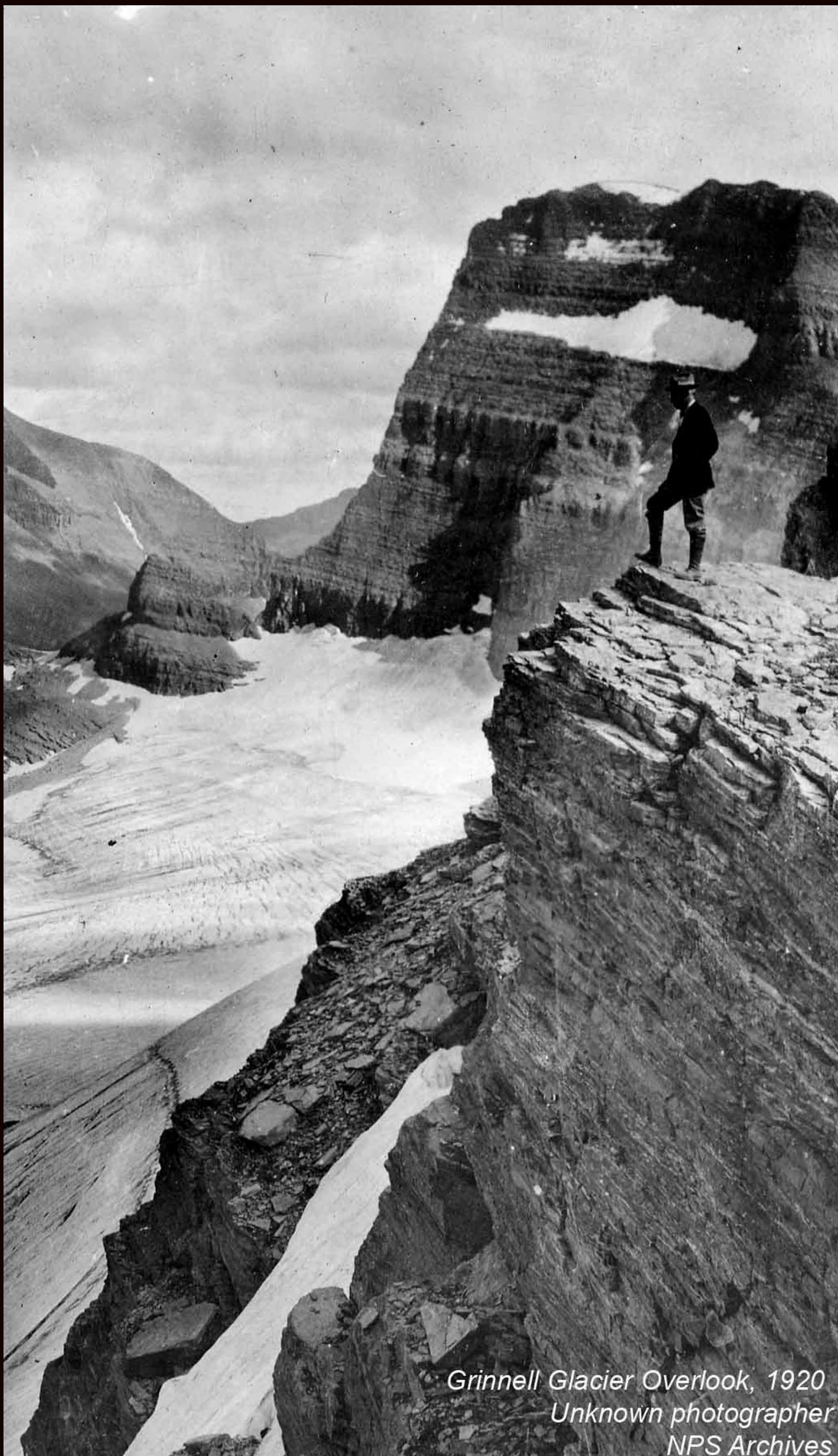
In time, white trappers searching for beaver followed the Indians into the mountainous wilderness, but they did their camping in the bottomlands.

When the legendary conservationist and Forest Service leader Bob Marshall passed on in November of 1939, a move was made to create a wilderness in his honor. Three primitive areas established by the Forest Service in the 1930s—the Big River (the Middle Fork of the Flathead), the Sun River, and the South Fork (of the Flathead)—were combined in August of 1940, and with this, the Bob Marshall Wilderness came into being. In more recent years, the Scapegoat Wilderness and the Great Bear Wilderness were added to the complex.

We could continue describing all of the distinct regions of this magnificent corner of North America, the "Crown of the Continent," but let it suffice that other pieces of splendid Crown landscapes—the Kootenay country, the Elk River, the Rocky Mountain Front, the Blackfoot Valley, the Swan Range and Valley, the Mission Mountains, Flathead Lake, the North Fork of the Flathead and the Mountains of Glacier and Waterton, to name a few—are gems in the Crown that have their own unique tales and, in due time, will gain center stage. Future issues of The University of Montana's Crown of the Continent Magazine will explore in depth each piece of this great bit of Canadian and American geography!

Chronicles of "the Bob" are fascinating and colorful. Part of its lore is a "sense of place" that a hiker once said reminded him of the "hush of a cathedral." Moving through these wildlands, one is often treading not only on old trails that the first travelers marked, but also on those blazed by mountain men and early-day forest rangers.

CLIMATECHA



Grinnell Glacier Overlook, 1920
Unknown photographer
NPS Archives

ANGE

A photographic investigation

‹ by Daniel Fagre ›

Grinnell Glacier Overlook
Sept. 9, 2008
Chris Miller photo, USGS

ACROSS THE GLOBE, mountains have had more than their share of the climate changes that have been so evident in the last several decades. Major glaciers have entirely disappeared from the Andes, the Himalayas have lost a third of their snow, and 99% of the glaciers in Alaska are retreating. Particularly at upper elevations, average annual temperatures in mountains have increased between two and three times the global average. At the same time that there has been recognition that mountains are sensitive to climate change, the dependence of humans on mountain resources, especially water, has become ever clearer. Mountains provide 50% of the water humans use globally and 85% of the water that the relatively arid western United States depends on. Thus, how mountain ecosystems continue to respond to climate change will have direct impacts on human populations.

In 1990, the U.S. Congress passed the Global Change Research Act, directing federal agencies to examine how climate change potentially could affect natural resources of the nation. The National Park System was chosen to be a key player in the U.S. Global Change Research Program because national parks tend to be relatively pristine, making it easier to detect early or subtle changes attributable to climate change. The underlying dynamics of ecosystems also can be investigated more effectively with the nearly intact ecosystems found in many national parks. Against this backdrop, the U.S. Geological Survey has been monitoring and investigating the changes in mountain ecosystems related to ongoing climate change since 1991. In the Crown of the Continent, these efforts have primarily focused on Glacier National Park and have involved numerous collaborators from other federal agencies and universities.

CLIMATE RECORDS AND HISTORIC PHOT

99 OF GLACIER RECESSION AND THI

KM² OF ICE COVERED GLACIER PARK

WITHIN 40 YEARS, OVERALL GLACIER CO

LESS THAN 16 KM² IS

Mountain ecosystems are very complex because of the strong gradients caused by elevation and the spatial variability caused by mountain topography. As every mountain hiker knows, the climate differs greatly as you ascend, go over a pass, or go around a slope to a different aspect. Consequently, plant and animal distributions change quickly over short distances, and there are interactions with the changing climate that complicate the picture. Determining which responses are attributable to a changing climate rather than the inherently dynamic qualities of mountain ecosystems is a daunting challenge.

Monitoring small, alpine glaciers provides an elegant solution to this problem. These glaciers, distributed throughout Glacier National Park, are influenced almost completely by temperature and precipitation. When it is colder and snowier, they accumulate more snow, which eventually forms ice, and the glacier grows. When it is warmer and drier, less snow accumulates and the glaciers shrink. Because it takes several years for the glaciers to reflect changes, one or two exceptionally warm or cold years are averaged out, and the size of the glacier reflects what is happening on the scale of decades. Therefore, changes in the size of glaciers indicate longer-term trends in climate.

The history and potential future of glaciers in Glacier National Park clearly suggest that major mountain ecosystem changes are a reality. Glaciers were present within current park boundaries as early as 7,000 years ago but may have survived an earlier warm period as well, which would make them much older. Tracking past climatic changes over thousands of years, these relatively small glaciers varied in size through time but gradually grew and reached their largest sizes around 1850. Physical evidence left by the glaciers (e.g., end moraines) indicates that there were an estimated 150 glaciers and large perennial snow/ice fields. Tree-ring based climate records and historic photographs indicate the initiation of glacier recession and thinning between 1860 and 1880. Between 1917 and 1941, the coupling of hot, dry summers with substantial decreases in winter snowpack (~30% of normal) produced dramatic recession rates as high as 100 meters per year.

These periodic droughts have occurred on top of a long-term trend of a 1.6 °C increase in annual temperature since 1900. Many smaller glaciers disappeared during this period. Based on 1966 aerial photographs, the first comprehensive map of the region's glaciers was published by the U.S. Geological Survey in 1968. Only 37 glaciers were named, out of a total of 84 perennial snow-and-ice bodies that survived from earlier in the century. It's likely that at least some of the other 47 snow-and-ice bodies may have qualified as glaciers. For instance, Glacier National Park documents from the 1970s list "about 50" glaciers. In a 2002 publication, Carl Key, Richard Menicke and I estimated that 99 km^2 of ice covered Glacier Park in 1850 but only 26 km^2 remained by 1968.

OGRAPHS INDICATE THE INITIATION
NNING BETWEEN 1860 AND 1880.
IN 1850. BY 1968, 26 KM^2 REMAINED.
OVERAGE WAS REDUCED TO 17 KM^2.
LEFT.

In late September 1998, aerial photographs were acquired of all GNP glaciers. The glacier area measurements from these photographs were made by Michele Manly and were the first for all glaciers since 1966. The overall glacier coverage for Glacier Park was reduced to 17 km^2. Using criteria of a 0.1 km2 minimum area, and/or visual evidence of crevasses in the ice surface indicative of downslope movement, only 27 glaciers existed of the original 150. Other former glaciers appeared to have shrunk to the point of being miniscule and stagnant ice masses. Between 1993 and 1998, glaciers ranging in size from 0.15–1.72 km^2 became 8–50% smaller. The relative rate of shrinkage was greatest for the smaller glaciers. Red Eagle Glacier, for example, was reduced to half its size between 1993 and 1998 and no longer meets the 0.1 km^2 criterion for being considered a glacier.

Using Global Positioning System (GPS) technology, a survey of the glacier margin was completed for Grinnell Glacier in 2001 and showed a loss of 0.17 km2, or 19% reduced area, from 1993 to 2001. The margin survey of Grinnell was repeated in 2004 and a further loss of 0.4 km^2, or 5.6% reduced area, had occurred in three years. An additional 9% reduction occurred by 2006. Grinnell Glacier will be measured again in 2009 and will definitely be smaller yet again. We've witnessed several places where ice has collapsed into the lake, leaving icebergs that almost cover Upper Grinnell Lake.

Many watersheds of Glacier Park no longer contain glaciers, and glacial coverage in any of the remaining watersheds does not exceed 3%. Furthermore, glaciers have thinned by hundreds of meters and, like Grinnell Glacier, may have less than 10% of the ice volume that existed when George Bird Grinnell first explored GNP in 1887. Park area covered by ice and permanent snow was reduced from 99 km^2 in 1850 to less than 16 km^2 by 2005, and there are only 25 glaciers that meet our size and other criteria. New aerial photography is scheduled to be acquired in 2009, and a new estimate of the remaining ice and permanent snow areas will be made next winter.

Field measurements of other glaciers have been completed in the last few years, including Swiftcurrent, Chaney and Boulder, and these show that the loss of glaciers continues. Sperry Glacier—a glacier potentially more reflective of climatic change because it lacks a glacial lake such as the one at the base of Grinnell Glacier—was chosen as an index glacier for annual surveys and other measurements in a collaboration with Joel Harper and Blasé Reardon at the University of Montana. Sperry Glacier shrank from 0.89 km^2 in 2003 to 0.86 km^2 in 2005, according to precision GPS surveys of the margins at the end of the summer melt season. This represents a 3.6% loss in two years. Sperry Glacier will be monitored for mass balance, movement and ice depth in addition to its area. A climate station and automated camera have been installed, and GPS surveys of its margins and other features will continue annually.

Blasé Reardon

The terminus of Chaney Glacier, shown in 1911 and 2005.

TO BETTER UNDERSTAND THE CONNECTION between changing climate and shrinking glaciers, all available data were used to build a computer-based projection of glacier dynamics now and into the future. With colleague Myrna Hall, this projection focused on the Blackfoot-Jackson Glacier Basin of Glacier National Park, where ice cover had decreased from 21.6 km^2 in 1850 to 7.4 km^2. Using the temperature records from nearby weather stations, the climatic causes of glacier retreat in the Blackfoot-Jackson Basin were analyzed, the melt rate (change in glacier area/decade) was determined, and the topographic influences on the spatial pattern of melt were examined. Analysis of glacial area extent per decade from 1850 to 1979 versus a variety of climatic drivers reveals that annual precipitation and summer mean temperature together explain 92% of the loss over time. Using this information, potential future glacier behavior under both a "climate as usual" and a "global warming" scenario was predicted per decade until 2100.

These images of changing glaciers and landscapes were displayed for each climate scenario as an animated time series and indicated that all glaciers in the basin will disappear by the year 2030 if current trends of increasing temperatures continue under the "global warming" scenario. Even if no further warming occurs, the glaciers were predicted to be all but gone by 2100. The results were confirmed by several other computer models that also estimate that all glaciers will be gone between 2030 and 2050 at current warming rates in the northern U.S. Rocky Mountains. If the largest glaciers in Glacier Park will be gone by 2030, it is likely that the smaller glaciers will likely be gone as well.

More recent measurements of the Blackfoot-Jackson Glaciers indicate that the area in 1998 (2.94 km^2) was substantially less than the computer model predicted for 2000 (3.89 km^2) and was only slightly greater than the area predicted for 2010 (2.44 km^2). This indicated that the glaciers were being reduced to specific areas nearly 10 years earlier than predicted. Myrna Hall compared the predicted temperature increase used in the model for 1990–2007 against the actual temperature increase in Glacier Park for the same period. The actual increase was twice as much as the model predicted. Precipitation was variable but did not have a net increase. This leaves the temperature increase as the cause of accelerated glacier retreat. It also means that the model was too conservative in predicting the demise of glaciers by 2030. Without a significant reversal in the upward trend in temperatures, the glaciers will continue to disappear, perhaps as early as 2020.

Results from the study can be seen at: http://nrmsc.usgs.gov/research/glacier_model.htm
See the entire time lapse photo collection at: http://nrmsc.usgs.gov/repeatphoto.htm

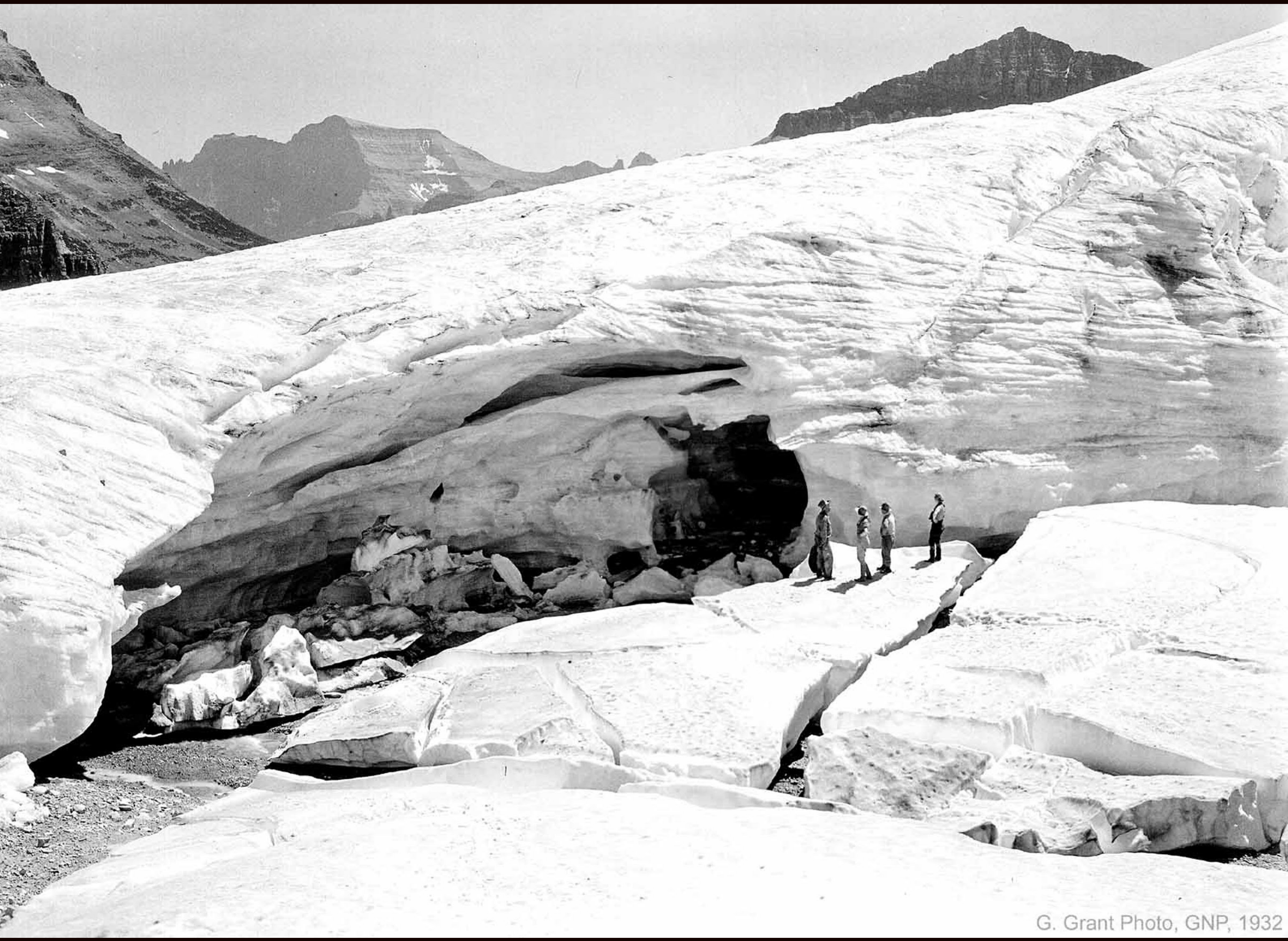
WITHOUT A SIGNIFICANT REVERSAL IN THE UPWARD TREND IN TEMPERATURES, GLACIERS WILL CONTINUE TO DISAPPEAR, PERHAPS COMPLETELY BY 2020.

IN 1997, MY STAFF AND I initiated the Repeat Photography Project with photographs repeated from historic images of the Grinnell and Boulder glaciers in Glacier National Park. The images revealed dramatic glacial recession and became, for many people, some of the first visual representations of the effects of climate change. Since then, repeat photography has proved to be a critically important tool for documenting and analyzing the retreat and disappearance of glaciers at Glacier Park. Of equal importance has been its function as a compelling communication medium for educating the public and policymakers about the dramatic transformation of the park over the last century of warming temperatures. Because humans are predisposed toward visual information, photographic evidence often trumps other types of data in convincing people that fundamental changes have occurred.

The earliest photographs taken of the area that was destined to become Glacier Park date from 1861, when a joint U.S.-British survey expedition was marking the boundary between the U.S. and Canada along the 49th parallel. These photographs were taken by the British surveyors and are of poor resolution, but they document a cold and stark landscape. Photographs do exist of Dr. Lyman Sperry and his team on Sperry Glacier in 1887 and by G.B. Grinnell at various times in the 1890s on Grinnell and other glaciers. However, the earliest photograph deemed useful for documenting glacier retreat is from 1900 by W.C. Alden, which shows a panoramic view of Grinnell Glacier.

Repeat photography in Glacier Park has been used to effectively show other types of environmental change in mountains. Alpine treeline changes, geomorphological events, the aftermath and long-term recovery from wildland fire, and changes in grasslands have all been documented with repeat photography. Beginning in 1997, a systematic search was made of the archives at Glacier Park and elsewhere to locate appropriate historic photographs of glaciers. To date, photographs have come from sources as diverse as personal collections to the National Park archives in Washington, D.C.

Photographs and negatives are digitally scanned, and copies are taken into the field to locate the photo site where the historic photograph was taken. A modern photograph is taken (i.e. repeated), and photo pairs are that focus on the glacier in that landscape are digitally created. Some of the photo sites have required multi-day hikes to relocate, and glaciers' photographs must be taken late in the summer when snow has melted enough to reveal the ice and extent of the glacier. Fair weather, good air quality and the absence of late-season forest fires are also required. Thus, there is a narrow window of opportunity to repeat photographs each year. At this time, 44 photo points, or camera stations, overlooking 19 glaciers have been located where repeat photographs can be taken.



Early park visitors in 1932 made the long trek to see Boulder Glacier in the northwest corner of Glacier National Park. Just over 50 years after the original image was recorded, rapid glacial retreat has eliminated the ice, and vegetation has become established at the glacier's forefront, and by 1988, only glacial rubble and streams remained.

Jerry De Santo (1988 photo)

DRAMATIC CHANGES HAVE TAKEN PLACE over various time periods. I previously reported that 13 of 17 glaciers showed obvious reductions in size when comparing historic to repeated images. However, from 2005 to 2007, even glaciers that seemed to resist retreat, such as the Gem and Sexton glaciers, have begun retreating.

The paired photographs of the Boulder Glacier ice cave are significant from both a cultural and natural-resource perspective. The 1932 image illustrates the attraction that early tourists to Glacier Park had for glaciers as charismatic geological phenomena. The tourists are part of a guided horse-packing trip to the Glacier Park backcountry, and the furry chaps of the guide are visible on the figure closest to the ice cave. A mere 56 years later, all of the ice is gone, and vegetation has become established in the forefield of the glacier. This repeat photograph garnered the most media attention in 1997 and provided the impetus for establishing our current project.

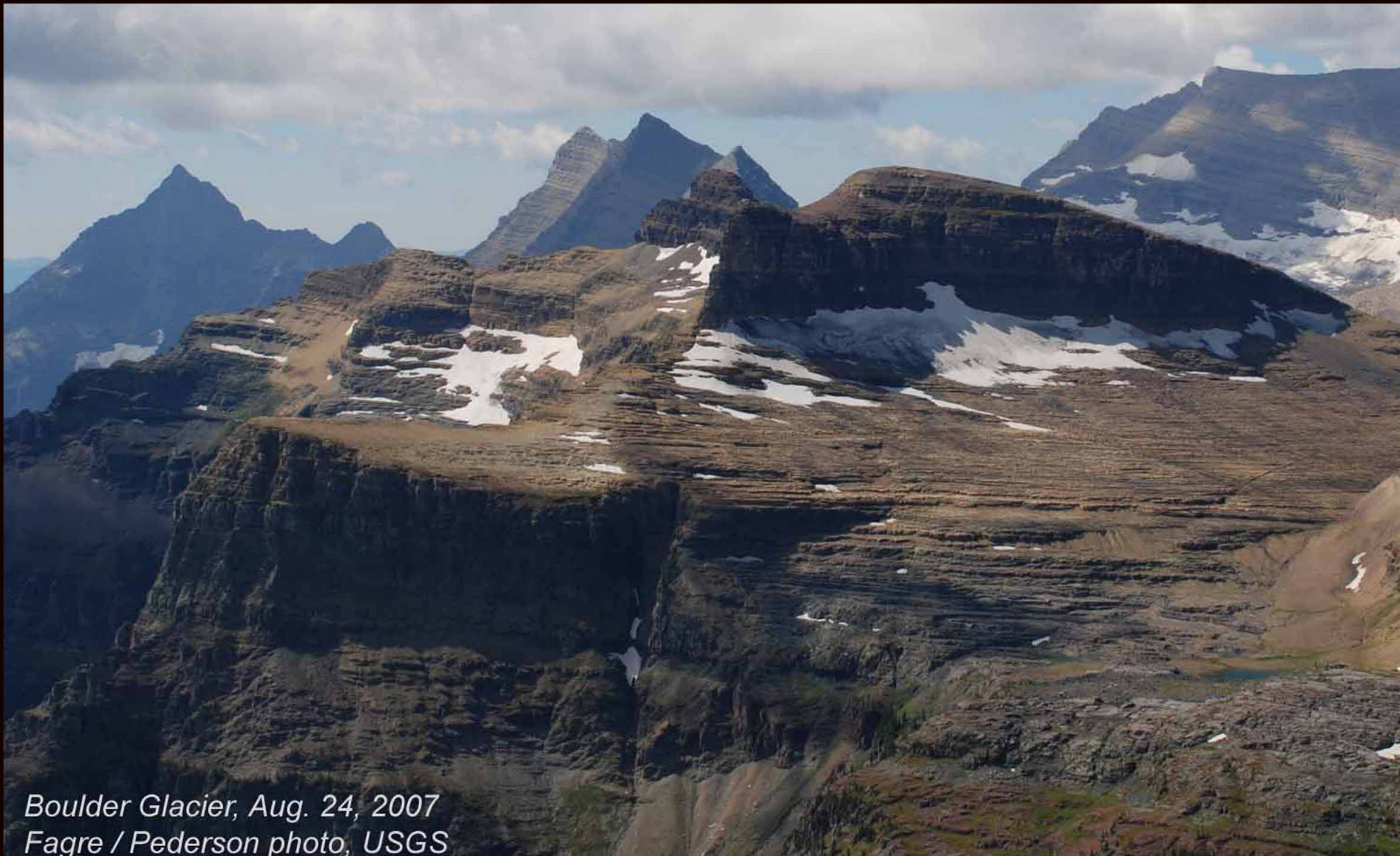
Shepard Glacier, Alden photo, USGS, 1913

The thick, crevassed ice flows of historic Shepard Glacier, captured here in 1913, diminished to less than 0.1 km2 in area by 2005. According to the criteria set by the USGS Repeat Photography Project, Shepard Glacier is now considered to be too small to be defined as a glacier.

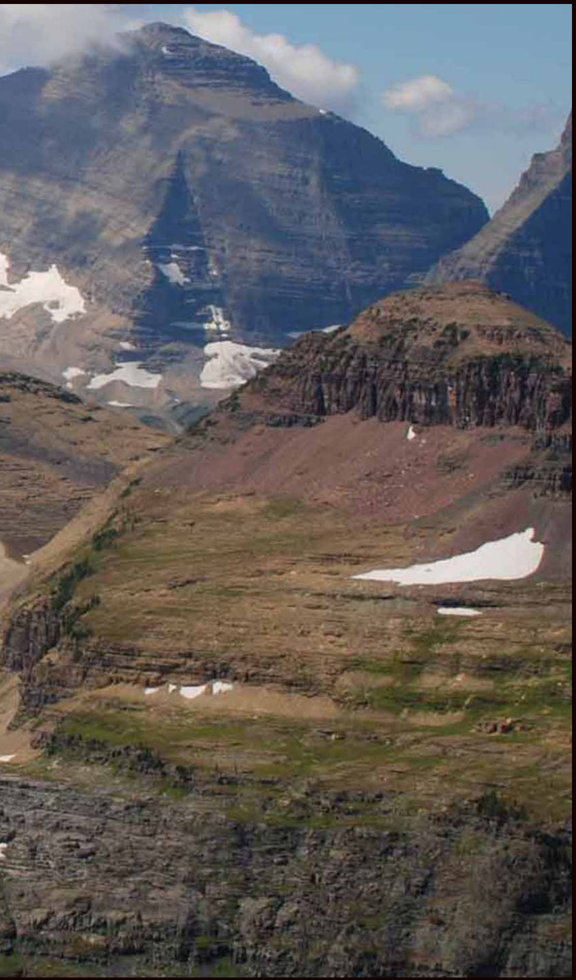
Blasé Reardon

SHEPARD GLACIER CLEARLY ILLUSTRATES that glaciers have complex boundaries and features in these mountain environments. In 1913, the upper glacier portion in the wide cirque has crevassing indicative of fairly thick ice. The glacier flows down to the bench, where ice previously broke off the glacier front and fell to the valley below. By 2005, however, only a remnant of debris-covered ice (darkly streaked) remains in the upper left part of the cirque, and bedrock is showing elsewhere. Shepard Glacier is less than 0.1 km2 in area in 2005 and is thus considered by some scientists to be too small to be defined as a glacier. The modern photograph underscores this point compellingly.

Boulder Glacier, circa 1910
Morton Elrod photo, courtesy of GNP Archives



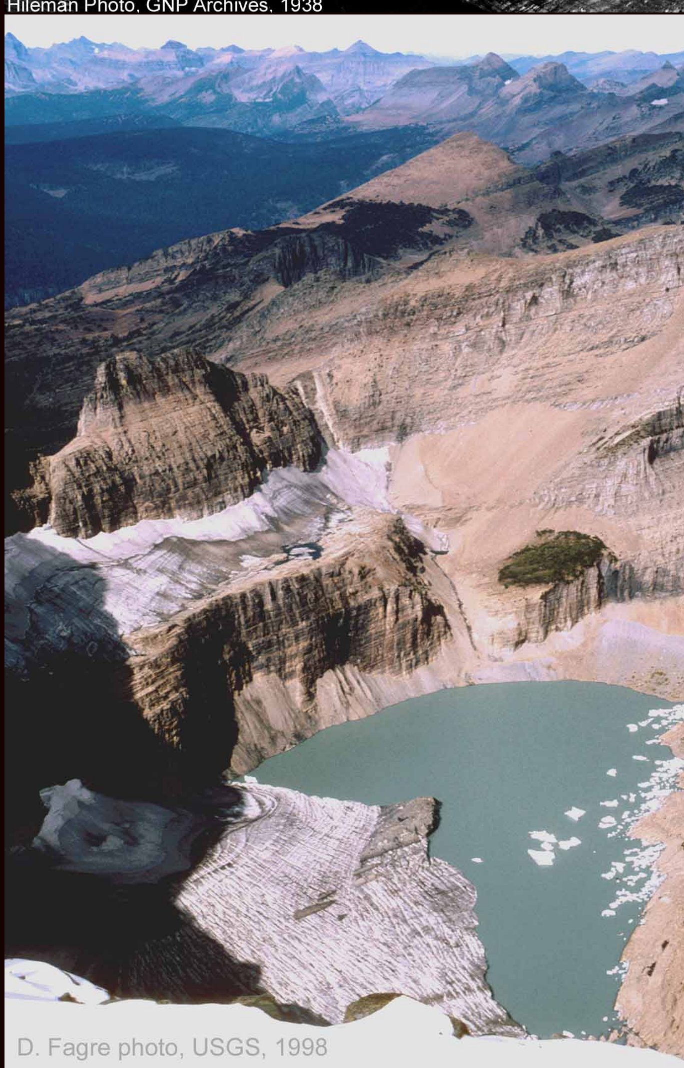
Boulder Glacier, Aug. 24, 2007
Fagre / Pederson photo, USGS



THE PAIRED PHOTOGRAPHS OF BOULDER GLACIER on Boulder Pass in the northwest corner of Glacier Park show the virtual disappearance of all ice where a substantial glacier existed around 1910. In the 1910 photograph, the glacier actually extends to the right over Boulder Pass, and a lobe flows down toward the next drainage. Matching this photograph required several hundred meters of climbing to a ridge—a feat we were glad to do with a relatively lightweight camera instead of the heavy, cumbersome gear that Elrod carried to his camera station.


Hileman Photo, GNP Archives, 1938


C. Key photo, USGS, 1981


D. Fagre photo, USGS, 1998


Grinnell Glacier from Mt. Gould
Karen Holzer photo, Sept. 11, 2006, USGS

THE SERIES OF PHOTOGRAPHS from the summit of Mt. Gould looking down on Grinnell Glacier are somewhat unique for glaciers in the Northern Rocky Mountains because they show the reduction in ice height from 1938, when ice filled the cirque, to the melting of the glacier into the glacial lake at its foot. The height of the cliff behind the lake is nearly 150 meters. Prior to 1938, the ice-surface elevation was high enough to connect with the upper band of ice, now known as Salamander Glacier. This series also illustrates the forward movement of the glacier into the lake. A dark, triangular rock pile can be seen in the middle of the ice in 1981, and by 1998, it has moved to the front margin of the glacier (the dark diamond shape protruding into the lake). It, and much of the glacier front, disappeared by 2006.

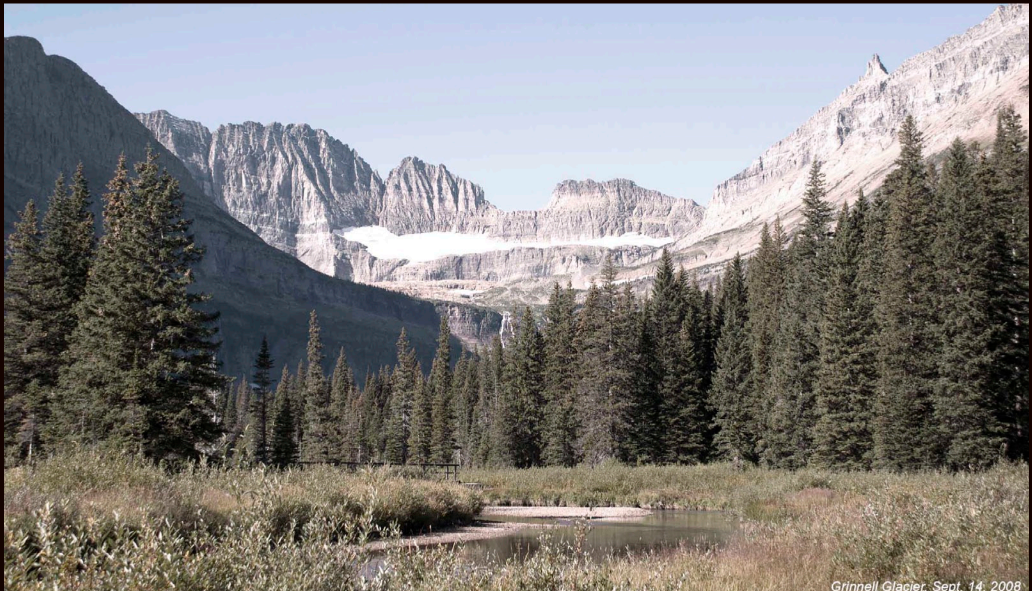
A website for viewing the collection of repeat photographs and for downloading the images was launched in March 2006 in response to the overwhelming number of requests received (http://nrmsc.usgs.gov/repeatphoto.htm). This website has a number of features that are designed to make the use of the imagery as convenient as possible. There has been extensive use of the website. Users have spanned the globe and included places such as North Korea and Qatar. Users from Japan and Germany have been the most frequent visitors after U.S. users. By user type, the U.S. government has recorded the most use, but commercial use (hits from dot-com domains) are a close second. There has been active use by dot-edu domains as well. A user form is included in the instructions and guidelines can be found at the repeat photography website, but filling out the form is voluntary.

However, from the forms returned, we know that the repeat photographs have been used in numerous media outlets (e.g., TV or various websites), print media (e.g., ranging from *Time* magazine to *RV Quarterly* and *Airstream Life*), books (from those on debate to the insurance industry), educational curricula and lesson plans (from Russia to Brazil), scientific websites (including the Hadley Centre for Climate Research in the U.K.), and numerous other publications. In addition, links to our website have been created at hundreds of other websites, and the repeat photographs have been reposted on numerous other websites. All of these examples underscore the power of repeat photography in providing a compelling message to the public.

After several years, the glacier photographs were increasingly used not only for scientific documentation and education but also as inspiration for artists. The photographs found additional purpose, filled an unanticipated demand, and have clearly resonated with audiences of diverse interests and backgrounds. Thus, the genesis for an exhibit at the Hockaday Museum of Art was born—to offer historic and modern photographs of glaciers in Glacier National Park as visually compelling landscape art and equally compelling documentation of landscape change. With a major effort from colleague Lisa McKeon and help from the museum director and staff, this exhibit opened on January 29, 2009, and runs through April 10, 2009. Information can be obtained at: http://www.hockadaymuseum.org/exhibit.htm.

We hope you will examine these photographs in both their scientific and artistic contexts—either at the USGS website for repeat photos or in person at the Hockaday Museum of Art—and that you will appreciate the bridge between art and science as two highly complementary views of our dynamic mountain landscapes.

Opposite: This oblique view of Grinnell Glacier not only shows the decrease in the glacier's area, but also the obvious reduction in the depth of the glacier along the cirque wall, where the original ice surface elevation was high enough to connect with the upper band of ice. The photos date from 1938, 1981 (Carl Key), 1998 (Dan Fagre) and 2006 (Karen Holzer).



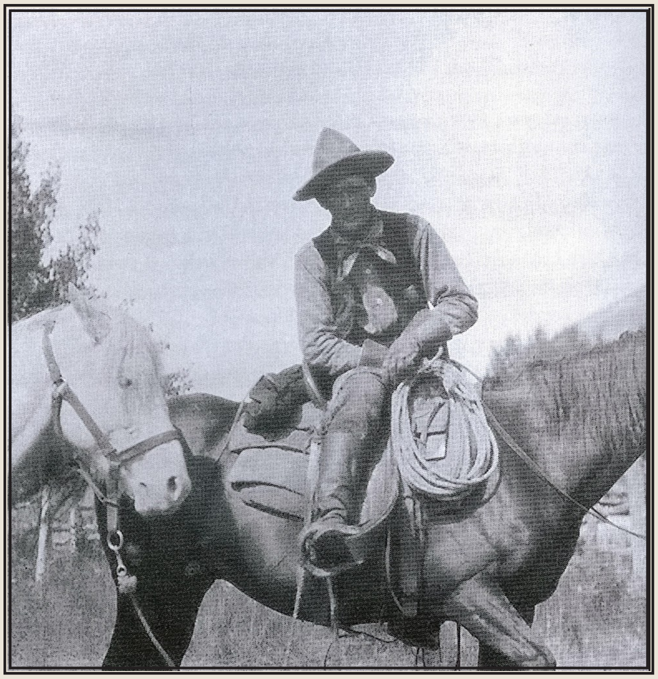
2008 (Lisa McKeon)

1887 Courtesy of Glacier
National Park Archives

120 YEARS

ALTHOUGH SHRINKING GLACIERS are the most visible signals of mountain ecosystem change, there are numerous other, if more subtle, changes taking place. Increased growth at upper elevation forests has resulted in subalpine meadows becoming smaller and trees extending higher into alpine tundra. Expanding tree populations have complex consequences for alpine wildlife, as open habitats are reduced but fuel continuity for forest fires and snow retention are increased. These and other changes are explored in a recently published book on the Crown of the Continent titled S*ustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem* (RFF Press, 2007). This book has 39 authors who address the breadth and complexity of the Crown of the Continent mountain landscape in 19 chapters. The project is merely a beginning; however, this electronic magazine and the Crown of the Continent Initiative are further pathways by which we can learn about and better appreciate this special part of the planet.

Clyde Fickes



Clyde Fickes in 1947 (U.S. Forest Service)

This piece is excerpted from a report Clyde Fickes wrote in May 1944. It appeared in Volume 1: Early Days In The Forest Service. His words are unedited and appear as he penned them. Fickes retired from the Forest Service in 1947. He died on Dec. 29, 1987, at age 103, from an accident on the dance floor.

Mountain Front

An Early-Day Ranger's Story

I applied for work on the old Lewis & Clark National Forest in the spring of 1907. Appointed a Forest Guard on July 1st at $60 per month and supplying two horses, and myself I was assigned to a survey party on the Swan River. On July 23rd and 24th I took the Forest Ranger examination at Kalispell and was directed to go to the Hannan Gulch Ranger Station on the North Fork of the Sun River. It has always been my impression that I was not considered a very promising candidate for ranger by Acting Supervisor A.C. McCain, so he figured, "I'll give this kid an assignment that he won't want to accept, or else he will never get to Sun River and we will be well rid of him."

They gave me a badge, a Use Book, and a Green Book and told me "When you get to Hannan, you can take charge of the Sun River District." That's how I became a orest ranger in 1907.

Well, I fooled McCain. I had discussed with Ranger Jack Clack the possible routes to follow. He had suggested the best route for that time of year was to go up "Big River", the Middle Fork of the Flathead, follow the railroad until I reached the east side, and then south across country, until I reached Sun River.

Leaving Kalispell on July 26th, with saddle and packhorses, I swam the South Fork (of the Flathead), which was high, and camped the first night at the old Fitzpatrick homestead about where the present highway bridge is located.

Most of the trail followed the tote road used in building the railroad back in the '90s, and there were places where the trail lay between the iron rails, which made travel by horse a little hazardous at times, as one never knew when a train would want to use the tracks. That second night on the trail, I camped about 3 or 4 miles east of Belton (West Glacier) on the old tote road grade near some cabins where there was good grass for the horses. The next day, I made it to Essex and camped for the night with Ranger Dick Bradley and his family.

In the morning the horses and I forded the "Big River" and even though the current was rather fast, we made it to the other side all right without much difficulty and proceeded up Bear Creek. Camped at the Phil Gypher place at his invitation, as there was good horse feed, and we were tired.

From Bear Creek we rode to the Lubec Ranger Station. Flies were real bad, giving the horses no rest, and I stayed over the next day to catch our breath. This was July 31, 1907. The problem now was to get across the Blackfeet Indian Reservation without having to go to Browning for a pass, therefore saving myself 2 days time. I camped at Wolf Plume's place on the Little Badger that night. I had worked on the cow roundup on the Reservation the year before and knew these Indians. They were camped on Wolf Plume's personal allotment putting up the hay. There were 5 or 6 tepees of them.

A couple of years before that, the Government had built for Chief Wolf Plume a two-room log cabin and partially furnished it, and it had never been used-even one night. The old man took me over and showed me the cabin and told me to camp in it for the night. I thanked the Chief and he said to me "You got pass?" I shook my head. He grinned, shook his head, and left me to make camp. There was a new six-hole Majestic stove in the cabin, and it had never had a fire in it. I didn't disturb its virginity!

I finally pulled into the little town of Dupuyer late that next night. We were tired; it had been a long, hot day. A manger full of hay looked good to my horses. I went looking for a steak for myself.

Late the next afternoon we arrived at Ranger Linc Hoy's ranch on Blackleaf Creek, spent the night and in the morning headed to the Godwin Ranch at the forks of Deep Creek. The horses had a good roll and spent the night in knee-deep grass.

Left Godwin Ranch about 9:30 A.M. and arrived at last at the Hannan Gulch Ranger Station at about 2:30 P.M. It was quite a climb down into the Sun River Canyon on a narrow winding trail, across bare slide areas made by deer and elk on slopes as steep as 60 degrees and more.

According to my diary, I had traveled some 190 miles in 10 days to reach my post of duty.

Hannan Ranger station in 1907. (U.S. Forest Service)

At Hannan, I found Assistant Ranger Henry Waldref in charge. He was an old-timer who had been appointed to patrol the forests and watch for forest fires for 6 months each year. He had a mining claim near Lincoln, and his 6 months' wages from the Forest Service were his winter's grubstake. Henry was camped in a tent along the creek, and I joined him there. To him the job was just a summer's outing. He had been in the hills for years; and I sure picked up a lot of handy ideas from him about life in the mountains and living off the back of a packhorse that have been useful to me all my life.

At that time, the Sun River Ranger District, with headquarters at the Hannan Gulch Ranger Station, included all of what is now called the Sun River drainage, (then called the North Fork), the Deep Creek drainage to the north and the Willow and Ford Creek drainages to the south. At that time, the stream running through the town of Augusta was known as the South Fork of the Sun River. What is now known as the South Fork of the Sun River was then known as the South Fork of the North Fork, and we also had the West Fork of the South Fork of the North Fork of the Sun River.

The Sun River country comprises some very interesting, not to say spectacular, topography. The river comes out of the mountains in a due east and west course some 8 or 9 miles and breaks through a series of five sawtooth-like reefs, ranging in elevation from 6,000 to 8,000 feet, with the river at 4,500 feet. The reefs are perpendicular on the east face and at a 45 to 60 degree angle on the west. Looks just like a row of sawteeth. At the junction of the North and South Forks, the river runs due north and south for some 45 to 50 miles and forms a beautiful valley with many open parks and side streams which head up against the Continental Divide on the west, part of which is known as the Chinese Wall, as spectacular a piece of country as you will see anywhere.

Natives of the area are brown, black and grizzly bear; blacktailed deer; elk; moose; mountain sheep and goat; and the usual run of mountain small fry. Cattle grazing was permitted on all the Sun River Ranger District except the West Fork of the South Fork and Pretty Prairie, which was reserved for winter elk feed. In May 1908, I counted and estimated that 500 to 600 elk wintered on the West Fork licks and vicinity. That was about all the elk in that area at that time.

The business of the district, which included all the forest from Deep Creek on the north to Ford Creek on the south, included 10 or 12 grazing permits for cattle on the upper North Fork, Beaver Creek, Woods Creek, Ford and Willow Creeks and along the boundary south of the North Fork. Also there were a few free use permits for wood on Willow Creek. A typical entry in my diary for August 13th reads: "Rode up Beaver Creek road to Willow Creek, crossed over to Ford Creek and then rode NE to Witmer's ranch. Range along Beaver Creek getting short. Posted 4 fire warnings on Beaver Creek. No fires. 8 to 5."

On September 30th, notice was received from Supervisor Page S. Bunker of Kalispell that a ranger meeting would be held at the mouth of White River on the South Fork of the Flathead River from October 14th to 18th inclusive. The supervisor had just returned from a six months detail to the Washington office and I guess he wanted to find out if his rangers could get around in the mountains satisfactorily. Eustace A. Woods, who was the ranger on the old Dearborn District and on occasion known as "Useless" to his close friends, was in town the same time I was and we agreed that, in company with four others, we would assemble at the mouth of the West Fork of the South Fork on the North Fork of the Sun River and trail over the Continental Divide together. Only one of the group had been over the route with a hunting party and was to be the guide. I call it a "route" advisedly, because there was no such thing as a located trail except along the main river. The appointed day of our meeting for departure was October 8th, but due to circumstances I could not get there.

On the morning of October 9th, Linc Hay, the ranger from Teton District and I left Hannan and camped at the beaver dams on the West Fork. The others had not waited for us so it was a case of finding our own trail over the divide. My diary for October 10th reads, "moved up West Fork Trail, camped on top of the divide under the cliffs. Jumped about five miles of logs. Bum trail. " The next day we pulled down to the mouth of White River to be the first arrivals at the meeting site. Woods and the others had stopped to try to get some elk meat, but failed to do so.

All in all, nearly 20 rangers and guides gathered here to meet with Supervisor Bunker and Inspector D.C. Harrison from Washington D.C. Like all its successors, the ranger meeting on White River was mostly talk. We also did a Ranger Station survey under the direction of Inspector Harrison and on the third day, all moved down the river to Black Bear where a new cabin was being built for the ranger headquarters.

Snow was beginning to cover the high country so those from the east side—some nine of us—pulled out for home. No one wanted to buck the logs on the West Fork, so we went up to the Danaher Ranch and crossed through Scapegoat Pass and some 16 or 18 inches of snow.

On November 6th I received a notice from the Civil Service Commission that I had passed the ranger examination and was eligible for appointment. On July 1, I had been appointed a forest guard at $720 per annum, promoted to $900 on August 1, appointed an assistant forest ranger on November 11 at $900 and on January 1, 1908, promoted to deputy forest ranger at $1,000.

The Hannan Ranger Station consisted of an old log cabin, 16x20, and dirt roof, a 14x16 hewn-log cabin with box corners, a log barn, corral, hay meadow and pasture —all taken from a former homesteader or squatter named Jim Hannan, who allegedly operated a station on the old Oregon-Montana horse rustling trail. The story is that Jim also liked beef steaks and occasionally butchered a steer, regardless of whose brand it might bear. Seems like the neighboring ranchers, led by one of the largest cow owners in the Sun River country, surrounded Jim in his old cabin and convinced him with a few "Winchester salutes" that it would be advisable to do a Iittle dickering if he wanted to continue life's journey. Bullet holes were still evident when I occupied the cabin. Old Jim agreed to leave the country and not come back. Shortly after that, maybe 2 or 3 years later, the Government pre- empted it for use of us Forest Rangers.

For a Ranger Station, no more isolated or lonesome spot could have been found. Visitors were practically unheard of for months at a time. The nearest neighbor was Johnny Mortimer who homesteaded in the gulch named for him. Johnny was a recluse and a bachelor. He never went to town. He had complete surveillance of all approaches. If he was not in the mood and a visitor approached, he would simply fade away into the rocky cliffs behind the cabin and would not come out until the visitor left. Whenever I was going to Augusta, I would let him know. He would give me a list of anything he needed, and I always picked up any mail for him. Several old-time friends paid him periodic visits. Sometimes one of them would stay all night at the cabin, but Johnny would not come in.

About the most convenient facility connected with the Sun River District was the built-in bathtub with hot and cold running medicated water. There was a warm, almost hot, mineral spring at the forks of the North and South Fork. Over the years users of the spring had dug out a sizable pool. There was a cave where the water came out. I took advantage of this convenience whenever possible. I was told by some of the old-timers that in the '90s, in the late summer and early fall, a hundred or more folks from as far down as Great Falls would be camped at the springs. It was a beautiful spot until the Reclamation outfit ruined it with Gibson dam. In the fall of 1907 I helped build a beautiful two- room log cabin on the flat just below the spring. When Gibson Dam was built, the cabin was moved up to Arsenic Creek and burned in the 1919 fire. Incidentally, there was a double log cabin on Arsenic Creek known as the Choteau or Medicine Cabin, built by some Choteau men and used as a hunting camp in the fall. It was a convenient stopping place for all of us travelers.

What about the forest fires? Well, there just weren't any. I do not recall that we had any lightning to speak of all that summer, and it was plenty hot at times. Also, there were not very many people roaming around in the hills.

When I left Kalispell, my equipment consisted of a regular stock saddle with a blanket and bridle and a sawbuck packsaddle with a blanket and saddle pad, a pair of canvas alforjas (pack bags), a halter, and a lead rope for the packhorse. Camp equipment, consisting of two long- handled fry pans, three tin plates, coffee pot, table knives, forks and spoons, a hunting knife in scabbard, a .32 Special 1894 Winchester rifle with leather scabbard, my camp bed, and extra clothes, a yellow Fish brand slicker (raincoat to you) and a canvas pack cover 7x7.

My food supply consisted of a slab of Winchester bacon, 10 pounds flour, can of baking powder, salt, sugar, canned tomatoes, corn, string beans and milk-three of each. This stuff made a packhorse's load about 180 pounds. It was packed in the alforjas, which made two side packs for the packhorses, and the bed folded into a top pack with the canvas pack over it-rain and dust proof. Then I threw a diamond hitch (the one-man diamond which Jack Clack showed me) over the canvas cover, and we were ready to travel. The saddle horse carried the rifle in a leather scabbard, which hung from the saddle horn, my slicker, and me, which spent in travel with this kind of an outfit. Each individual used his own variation according to personal ideas and desires.

Cooking was done over an open fire, and you soon became accustomed to a regular routine of setting up camp. First, the horses were turned out to graze. Maybe you hobbled them or picketed one and turned the others loose to graze. Then you rustled some dry wood, selected a place downwind for your campfire, and got the fire started. Then you set up camp. Most of us carried a 7x9 tent with 18-inch sidewalls; this was pitched in a convenient dry place. The bedroll was spread over fir boughs, if you were inclined to luxury. By that time, the fire had burned down to a good bed of coals (only tenderfeet attempt to cook over a blazing fire). You ate, washed dishes, smoked a pipe or two or a cigarette, took a good look at the horses and probably, just before bedding down, decided for various reasons—poor feed, stormy weather prospects —to catch the horses and tie them up for the night. For various reasons, known only to a horse, they will take off during the night; and you have a long walk to find them. Sometimes you don't find them for 3 or 4 days; that's hard on the legs, not to mention your temper. In the morning you start a fire, check the horses, fix breakfast, pack up, bring in the horses, saddle up, and you are on your way.

In those early days you probably spent an hour or two cutting logs out of the trail or just clearing the way to get through to where you wanted to go. That was the way you lived in the field, as it is sometimes referred to. Old Henry Waldref had a homemade sheetiron folding stove that he packed with him. On a cold wet night, it would make a 7x9 tent almost luxurious living. Oh yes, most of us packed a sourdough can with us at all times. Couldn't live without it!

So went the life of a forest ranger in 1907-08.

the FLATHEAD LAKE BIOLOGICAL STATION

Story and Photos by Jack Stanford

Located on the east shore of the big lake, the Flathead Lake Biological Station (FLBS) of The University of Montana plays a key role in the Crown of the Continent ecosystem by conducting scientific research on processes that influence natural and cultural interactions. Scientists at FLBS have provided a clear understanding of how the alpine, mountain and river valley landscapes are ecologically interconnected in natural and cultural contexts. Detailed records show how organisms respond to human influences, including climate change, and how human economies and lifestyles are tied to the natural goods and services of the ecosystem.

HISTORY: *"the leading freshwater field research statio*

Professor Morton Elrod and The University of Montana established the FLBS in 1899. Elrod envisioned a base of operations for college education and research in the pristine environs of Flathead Lake and Glacier National Park. He and other visionaries of the time (Grinnell, Pinchot) knew that human well-being was dependent on a scientific understanding of the natural and cultural attributes and processes of regional ecosystems. Moreover, Elrod recognized the immense educational value of the landscape that he and his colleagues called the "Crown of the Continent."

The first summer classes using the Crown of the Continent ecosystem (CCE) as the classroom were held at the newly founded Yellow Bay campus in 1901. Young people from around the nation studied with UM and visiting professors in the lake environs near the station and took horse-packing trips deep into the mountains. Professor Elrod helped create Glacier National Park and was the park's first official naturalist. In addition to the big lake, the park soon became the focal point for summer students.

FLBS graduate classes focus on limnology (water science), remote sensing and modeling of ecosystem processes, and conservation of ecosystem goods and services.

n in the world"

Elrod's vision inspired the expansion of FLBS into a world-class field station during the 1980s and 1990s. The station was designated a "Center of Excellence" by the UM Board of Regents in 1986. The new program integrated research and education and enhanced outreach such as routine monitoring and reporting of water quality to local NGOs and agencies; these are key functions that have identified FLBS for well over 100 years. At the FLBS Centennial Celebration in 1999, the world-renowned scientist Professor Charles Goldman of the University of California-Davis stated that FLBS has become "the leading freshwater field research facility in the world."

Since 2000, the FLBS has expanded the scope of work to include terrestrial and climate issues in a systems ecology context. Today, FLBS is an important technology center for Montana, as it produces skilled scientists for local, state and national positions; creates jobs in-house; and pumps over $5 million per year into the local economy via expenditures derived from the many competitive research awards won by FLBS faculty.

Research: *"complex linkages"*

The most important functions of FLBS are basic and applied ecological research as well as the dissemination of the results and implications of our research to society. This work encompasses many aspects of ecology but emphasizes ways to sustain the natural goods and services provided by freshwater ecosystems. We recognize that fresh water is vital to human health, economies and overall quality of life. We also recognize that cumulative impacts of human activities compromise the ecological structure and function of the watershed ecosystems from which our freshwater supplies are drawn.

The FLBS strives to advance an understanding of the complex linkages between atmospheric, terrestrial, aquatic and human components of watershed ecosystems in a natural-cultural context. This requires a "genes to ecosystems" approach, and the research faculty that has been developed at FLBS over the last two decades and is therefore purposefully interdisciplinary, formally integrating the biological and physical aspects of ecology with economic and cultural influences on ecosystem processes.

Currently, seven PhD-holding faculty members work together at FLBS. These professors have divergent, but complementary, skills, experience and personal research interests, ranging from microbial ecology to ecosystem processes and modeling—hence the reference to the FLBS program as "systems ecology." The work of the faculty at the Biological Station is supported by a talented staff with skills that complement the FLBS mission and add considerably to our research capability. In July 2008, 54 scientists and graduate students were employed in full- or part-time positions.

The research takes FLBS scientists throughout the CCE and on around the world to watershed ecosystems in South America, Europe, Scandinavia and the Russian Far East. For example, the Gordon and Betty Moore Foundation (San Francisco, CA) has committed over $10 million to FLBS during 2003–2010 for research to examine structure, function and conservation of the most pristine salmon rivers of the northern Pacific Rim. This research, in close cooperation with the Wild Salmon Center (Portland, OR), encompasses the Salmonid Rivers Observatory Network (SaRON) and is designed to yield important new insights and actions to proactively assist the preservation of intact salmon river ecosystems, restore degraded systems and revise and improve the management of wild salmon as a natural resource. SaRON operates field camps in Argentina, Alaska, British Columbia and Kamchatka; FLBS staff scientists run the research operations in these camps. The Sa-

UM graduate students run tests in Glacier National Park. What a "boring" place to study.

RON initiative is interactive with a NSF-EPSCoR program in Large River Ecosystems that was funded in 2007; FLBS faculty member Dr. Richard Hauer was recently appointed Director of the UM-EPSCoR program.

Our cooperative work with the Numerical Terradynamic Simulation Group (NTSG) at UM and the Jet Propulsion Lab (JPL) at the California Institute of Technology is raising the bar daily on understanding of climate change processes by modeling data from an array of sensors on earth-observing satellites and on-the-ground monitoring sites. FLBS associate research professor John Kimball is a principal modeler for the Soil Moisture Active-Passive mission of the National Atmospheric and Space Administration for 2010 that will underpin global analyses of river runoff in relation to climate warming.

Thus, FLBS research results and implications are contained in over 200 scientific papers that may be viewed on our website, along with faculty bios and descriptions of ongoing research projects. Results and implications of the work have been widely covered by national and international media—most recently in Chile, where FLBS scientists are helping evaluate influences of several mega-dams planned for Patagonian rivers.

Alpine ecology class in Glacier National Park.

ACADEMICS: *"hands-on, in-the-field"*

Summer Academic Session for Undergraduates

While FLBS has become a world-class research center, another FLBS trademark is teaching ecology in a hands-on, in-the-field fashion. The annual summer academic program at FLBS throughout its 100+-year history has offered novel, field-based classes for undergraduate and graduate students with a focus on field-based study and observation. The session typically runs from mid-June to early August. The FLBS courses are high-content and tough, emphasizing research design, analysis and reporting (written and verbal), plus practical application. Enrollment is limited to 13 students per class, and therefore, student-professor contact is at least 50% higher than typically occurs in the usual university lecture-lab courses.

Our objective is to produce leadership-oriented graduates with a robust, field-based understanding of principles and tools that must be applied for the conservation of ecosystem goods and services for sustained human well-being worldwide.

The FLBS Graduate Program: Systems Ecology

Advising MS and PhD students and funding their work through research assistantships on grants/contracts is a primary duty of university science faculty. FLBS faculty routinely recruit top graduate students from around the country to participate in novel studies associated with the many FLBS research projects in the CCE and around the world.

FLBS faculty teach highly technical graduate courses—which are available to campus-based students through Internet conferencing and weekend field trips to Flathead Lake and the CCE—to enable them to use the sophisticated instrumentation and remote sensing tools used in the FLBS labs and field sites. These graduate classes focus on the complex details of limnology (water science); remote sensing and modeling of ecosystem processes; and conservation of ecosystem goods and services in the CCE and adjacent areas—notably the Greater Yellowstone and Greater Frank Church Wilderness ecoregions.

Outreach: *"consensus building"*

The Biological Station is an ideal place for focused workshops, owing to its setting on the shoreline of Flathead Lake and the modern FLBS facilities for small groups working over several-day periods. We have hosted many scientific workshops and forums that produced scientific papers of international importance. Each year, a variety of workshops and short courses sponsored by agencies and NGOs are held at FLBS. These are designed to inform citizens, teachers and professionals about tools and approaches for solving contemporary ecological problems.

The main method for disseminating research results is through peer-reviewed scientific papers and books and presentations at professional conferences nationally and around the world. However, we recognize the practical importance of presenting research results to local government agencies and the public. FLBS science strives to be politically neutral, but the faculty and staff do not shy away from controversial issues if FLBS studies, data or informed judgments may assist in issue resolution. FLBS scientists are routinely asked to provide research data and experience to public officials and to NGOs, such as the Flathead Lakers and Flathead Basin Commission. The goal is to use FLBS science as the basis for consensus building in environmental problem solving.

The Biological Station is proactively participating in the Crown Initiative begun in 2008 to formally link Glacier National Park and The University of Montana in education and research for the purpose of conserving the CCE. The FLBS will provide information about the Crown via the FLBS website at www.umt.edu/flbs, workshops, science field tours and general-interest classes. An electronic visitor center at FLBS has recently been funded to allow the linkage of FLBS to other Crown activities.

How FLBS has helped protect and add value to the Crown ecosystem

- Provided key testimony of scientific studies describing biodiversity of the Crown as rationale for designation of Glacier National Park as a world heritage site.
- Provided data and interpretations about water quality in Flathead Lake based on continuous measurements since 1977 that guided basin-wide strategies for minimizing air and water pollution.
- Provided primary analyses that led to provision of permanent federal reserve water rights for the virgin flows of the North and Middle Forks of the Flathead River that preclude any dams or significant water extractions in perpetuity to protect regional biodiversity and water quality of Glacier National Park.
- Provided detailed information and consultation since 1980 to agencies of the Flathead Basin Commission to prevent strip mining of coal and other landscape disturbances in the Canadian North Fork of the Flathead River that would harm the natural integrity of Glacier National Park and Flathead Lake.
- Provided public information based on years of research to help resolve a wide array of environmental issues, including the harmful effects of urban sprawl and gravel mining on the sensitive flood plains of the Flathead River, local and long distance air pollution and food-web changes in Flathead and other CCE lakes.

A Winter Morning

On the Rocky Mountain Front

No matter the season, the Rocky Mountain Front—where the swell of the prairie ends abruptly against the wall of the Northern Rockies—presents a grand sight. In the depths of winter, though, the early morning hours just might show off its radiance best.

In mid-February a few years back, we were making our way in the dark to one of the front's landmarks, Sawtooth Reef, the serrated, towering limestone overthrust that guards the Sun River Canyon. Frigid temperatures made us question our mission, but a brilliant night sky had promised an unobstructed sunrise. As a pre-dawn rising wind whipped a small ground blizzard across the iced landscape, the sky dropped its cloak of darkness, and the subzero air was cleared of any haze. We had arrived on time for the performance.

At first, a pale pink and red hue bathed the snow and bare rocks on the upper reaches of Sawtooth Mountain. This initial kindling started a fire-like display. A brilliant orange and red flame took over, spread into a nearly neon pink, intensified, and held. We hoped these unreal colors, so beautiful yet difficult to describe, would be preserved in our photos.

As the "fire" spread to the lower ground, the sky extinguished the stars, the scene took on a more balanced perspective, and this bit of prairie and mountains was displayed in an unearthly spectacle. The winter sun seems to allow that rich first illumination to last a bit longer than in warmer months.

Gradually, the stronger light of the sun took over, chasing the pinks from the landscape and leaving a brilliant diamond sparkle to the snow, highlighting the rough, jagged ridge of Sawtooth against a fierce blue sky. We gave the occurrence a standing ovation!

—Rick and Susie Graetz

Sawtooth Reef, Rick and Susie Graetz

All photography by Rick and Susie Graetz

Above: The Belly River country near the U.S.-Canadian border. Taken in Alberta.
Previous page: Prince of Wales Hotel, Waterton Lakes National Park, Canada.

Sawtooth Reef on the Rocky Mountain Front, west of Augusta.

A rainbow arcs over Lake McDonald, Glacier National Park, after an autumn storm.

Above Left: The Mission Valley between Ronan and St. Ignatius.

Above Right: The North Fork of the Flathead Valley, looking toward the peaks of Glacier Naitonal Park.

Bottom Left: A regal bald eagle.