

The Glacier Lakes Ecosystem Experiments Site

1. INTRODUCTION

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Background Information

Wilderness ecosystems in the United States are federally mandated and set aside by the Wilderness Act. They are managed to minimize human impact using methods that leave these systems, to the extent possible, in their natural state uninfluenced by manipulation or disruption by humans. Management often involves controlling or minimizing visual impact by enforcing strict use rules such as no roads, motorized or mechanized equipment, structures, or harvesting. In addition to human-caused impacts, natural and anthropogenic environmental stresses affect the rates and magnitudes of natural dynamic processes in natural ecosystems. These stresses can have a large effect on ecosystem structure and function. The Clean Air Act designates federally mandated wildernesses and National Parks as Class I areas to be protected from deterioration from air pollutants. Data are not available to quantify and distinguish between natural and anthropogenic factors that cause changes in wilderness ecosystems.

Wilderness managers are faced with making decisions concerning effects of atmospheric pollutants on Class I wilderness ecosystems. The permitting process for siting a new point-source of pollutants requires an assessment of the potential effects of such a facility on Class I areas. Little data are available to determine the effects of atmospheric deposition on these ecosystems. Background collection of deposition data in these areas is just beginning, and effects of this deposition are largely unknown. In addition, changes in the structure and function of these ecosystems induced by long-term climate change cannot be quantified without baseline data concerning current environmental status of sensitive systems. Prudent management of wilderness ecosystems requires a basic knowledge of the present environmental and biological condition of these systems and an understanding of the basic processes influencing change in these systems.

Research to provide answers to the question of environmental impact of atmospheric deposition or climate change in wilderness sites requires an integrated ecosystem approach involving the study of meteorology, geology, soils, hydrology, limnology, plant ecology, plant physiology, and snow chemistry and physics. These disciplines must be integrated to determine interaction and movement of pollutants, chemicals, or gases among different components of the ecosystem. Research will

require measurement of inputs and outputs between tightly defined components of the overall ecosystem, with these components defined as small (e.g., a square meter) terrestrial or soil plots, small sections of a stream, a lake, a small subcatchment, a watershed encompassing a lake, or a group of lakes and their watersheds. Atmospheric and ecosystem processes, and interactions between abiotic and biotic portions of these research units need to be studied, with an important component of these studies being estimation of nutrient budgets. Process-based models will be constructed to integrate individual studies into a system-level understanding of ecosystem processes that can be used to predict the response of the system to potential changes in physical or chemical environment. Long-term baseline monitoring data are important for model development, and detailed process-level studies will provide information for validating the model predictions.

Research involving extensive monitoring and manipulations is not possible in federally mandated wilderness areas, which impose strict limits on means of transport and prohibit installations causing visual impact. The Glacier Lakes Ecosystem Experiments Site (GLEES) has been established in an area that is wilderness-like, but not a federally mandated wilderness, where the research described here can be conducted to provide baseline and experimental data for alpine and subalpine ecosystems. GLEES was selected to represent Class I wilderness areas that might be exposed to atmospheric deposition. It is located on National Forest land and has been managed to preserve its natural state. GLEES is easily accessible all year, yet has received limited human use or impact. GLEES provides a site with habitat similar to wilderness areas in the West but without the restrictions of the statutory designation of a Class I area. These unique characteristics provide an excellent site for extensive alpine and subalpine ecosystem research activity.

GLEES is characteristic of high-elevation alpine/subalpine wilderness sites having massive winter snowpack, harsh climate for terrestrial vegetation, exposed and slow-weathering bedrock, shallow immature soils having low base saturation, and lakes with extremely low acid neutralizing capacity. The deep snowpack typical of these areas accumulates sulfates and nitrates. The aquatic systems are highly sensitive to deposition, since spring snowmelt can bring a pulse of chemicals delivered rapidly to the system. The low inherent buffering capacity of alpine lakes and streams can make them

especially sensitive to this chemical pulse, which can result in drastic changes in the biotic complex of these systems.

Ecosystems exposed to the conditions typical of these sites experience short growing seasons, high winds, cool temperatures with summer frosts, low nutrient supply from soil, and drought conditions after snowmelt. Such environmentally stressed systems are likely to be most sensitive to additional stress from atmospheric pollutants. Global climate change caused by increased atmospheric CO₂ may cause changes in environmental conditions in wilderness ecosystems. In high-elevation ecosystems, dramatic vegetation responses are possible as a result of climate change. For example, the transition zone between alpine and subalpine will likely rise in elevation with a warmer climate. GLEES represents a unique opportunity to study such phenomena, with alpine/forest and terrestrial/aquatic features being dominant at the site.

Site Location

GLEES is an area of approximately 575 ha located at 3200 to 3500 m elevation in the Snowy Range on the Medicine Bow National Forest, 55 km west of Laramie, Wyoming, and 15 km NW of Centennial, Wyoming, at 41°22'30" latitude and 106°15'30" longitude (figs. 1.1–1.3). The upper portion of GLEES contains three small lakes located in glacial cirque basins: Lost Lake (6.7 ha, fig. 1.4), West Glacier Lake (3.3 ha, figs. 1.5–1.7), and East Glacier Lake (2.9 ha, figs. 1.6–1.8), with their corresponding watersheds of 51.4, 60.7, and 28.7 ha. Also included in GLEES are about 110 ha north of the East Glacier, West Glacier, and Lost Lakes watersheds on the Glacier Peak ridge; and 110 ha south of the three watersheds, north of Telephone Lakes and the road on the north side of Brooklyn Lake. An additional area of approximately 200 ha extends southeast of the East Glacier Lake watershed, east of the Brooklyn Lake road, to just east of Little Brooklyn Lake. This area includes subalpine forest not present in the upper GLEES. Only the

upper GLEES area of East Glacier and West Glacier and Lost Lakes watersheds has been characterized for this report. Except for this introductory chapter, the material presented in this manuscript, unless otherwise noted, refers only to the East Glacier, West Glacier, and Lost Lake watersheds. This is where much of the research and monitoring is conducted. Additional information on the remaining areas of GLEES will be compiled later.

East and West Glacier Lakes are located in the S 1/4 of Section 3, and Lost Lake is in the NW 1/4 of Section 9, T16N R79W, 6th P.M. The site is located on the Sand Lake, Centennial, Medicine Bow Peak, and Morgan Quadrangles, WY USGS 7 1/2 Minute Series Topographic Maps. The site is north and east of Brooklyn Lake, and it can be reached by driving north from State Highway 130 on the Forest Service Brooklyn Lake Road, FDR 317, which exits Highway 130 at the Mountain Meadows Resort (figs. 1.2, 1.3). A trailhead to the GLEES lakes is located at the north end of the Brooklyn Lake Campground.

Site Management and Access

GLEES is in the Laramie Ranger District of the Medicine Bow National Forest. Laramie Ranger District Headquarters is located at Laramie, Wyoming, but a Visitors Center located about 1.5 km NW of Centennial is open during the summer to provide information to Laramie District users. Current management of GLEES and the surrounding area is primarily for recreation use, with off-trail use of motorized vehicles restricted to snow machines. Primary summer use is for fishing and day hiking, but infrequent overnight camping is also evident. GLEES is in an area of the Laramie Ranger District that has been removed from mining claims; but the area still contains many active, though unworked, mining claims. Grazing has recently been removed in the upper portion of GLEES.

GLEES has no roads within the study area but is accessible from Forest Service Road FDR 317 on the southwest portion of the site in the summer. The site can be accessed by snowmobile in the winter and is about 5 km from the Highway 130 winter closure turnaround point at Green Rock Picnic Area (fig. 1.2). The south edge of East Glacier Lake is about a 15-minute hike from the Brooklyn Lake road at the Brooklyn Lake Campground, while Lost Lake is a 20-minute hike west of West Glacier Lake. A trail enters Lost Lake from the west, just northwest of the Lost Lake outlet, and is used primarily by fishermen and hikers. Numerous smaller trails exist within the site, but most site users are fishermen or hikers who confine themselves to the main trails or stay near the lake edges. Most visitors remain in the area of East and West Glacier Lakes. East and West Glacier Lakes are at lower elevations than Lost Lake and are the most easily accessible. Lost Lake is farthest from the road and is closest to the edge of the glacial cirque. Avalanche hazard inhibits access to both Lost Lake and West Glacier Lake in the winter.

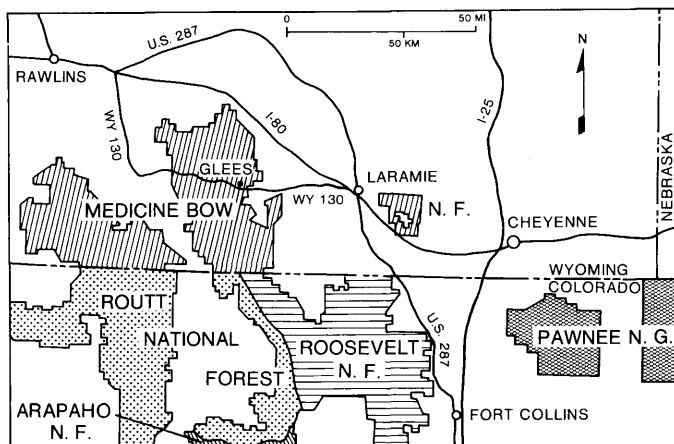


Figure 1.1.—General location of GLEES, in Medicine Bow National Forest, southeastern Wyoming.

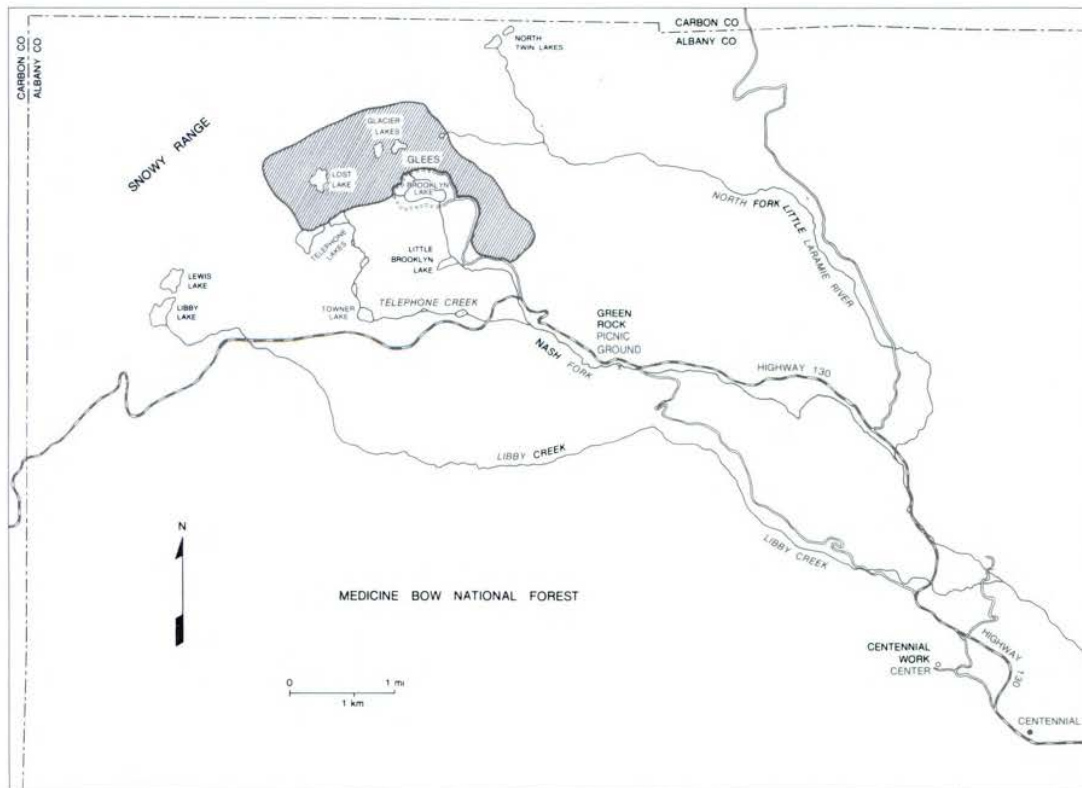


Figure 1.2.—Local area map of GLEES, showing location of Centennial, Centennial Work Center, Green Rock Picnic Ground (winter highway turnaround), and area lakes and streams.

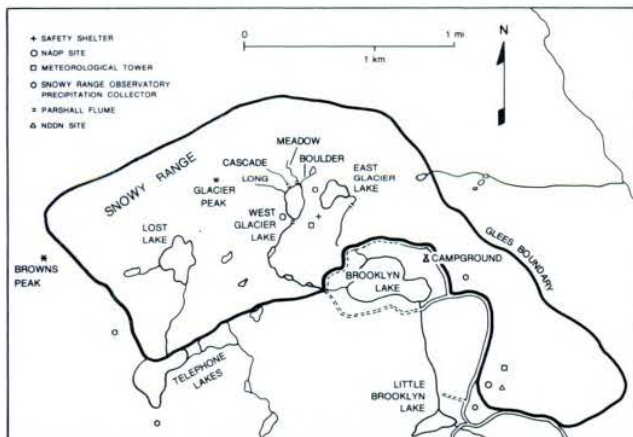


Figure 1.3.—Site location of research installations at GLEES. Inlet and outlet streams of the lakes are also shown.

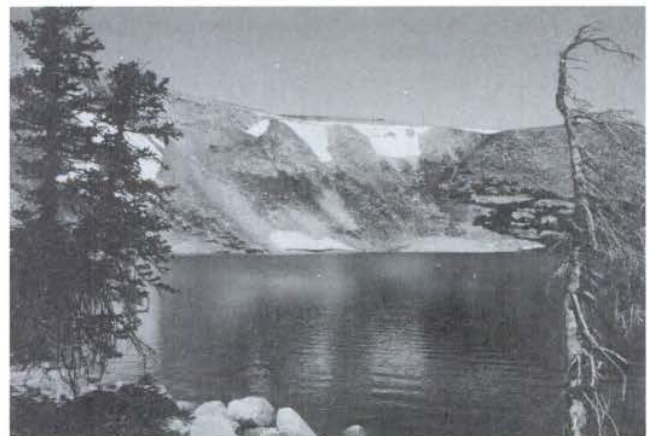


Figure 1.4.—Lost Lake, taken from the south, near the outlet. Note the snowfields near the top of the cirque, and the avalanche debris at the base of the cirque at the north shore of the lake.



Figure 1.5.—West Glacier Lake, from the ridge between East and West Glacier Lakes, looking NW.



Figure 1.7.—West Glacier Lake (front) and East Glacier Lake (background), taken from the west of West Glacier Lake.



Figure 1.6.—West Glacier Lake (right) and East Glacier Lake (left) from the base of the snowfield feeding Meadow Creek. Meadow Creek is to the left of the tree-covered ridge running toward the lake in the lower center of the photo; Cascade Creek is to the right of that ridge. Long Creek enters West Glacier Lake from the right of the photo, through the scree field at the bottom right corner of the lake. Boulder Creek enters through the scree field at the lower left corner of West Glacier Lake. Brooklyn Lake can be seen above the right side of East Glacier Lake.



Figure 1.8.—East Glacier Lake from the eastern edge of the watershed. Note the snowfields at the top of the glacial cirque in the West Glacier Lake watershed. Melt from the smaller snowfield to the right flows into Meadow Creek. This snowfield melts out most years. Melt from the larger, permanent snowfield to the left flows into Cascade Creek.

Landscape Habitats

GLEES is in the subalpine forest/alpine ecotone. Vegetation at the site is characteristic alpine and subalpine taxa. Engelmann spruce and subalpine fir forests dominate at the lower portions of the site (fig. 1.9). These two species form krummholz stands at the higher elevations (fig. 1.10), where willows are also common in drainage or other wet areas. This area is also interspersed with meadow vegetation or cushion plants, depending upon soil development and moisture availability. The higher elevations become increasingly barren and have a covering of small cushion plants characteristic of alpine flora. A considerable portion of the watershed is

not vegetated, consisting primarily of scree, rock outcrop, water, and/or snowfields. A description of 12 landscape habitats at the Lost, East Glacier, and West Glacier watersheds is presented in Chapter 2.

Vegetation

Plant communities at GLEES are distributed across a mosaic of habitat types that are influenced by complex, discontinuous stress gradients of wind distribution, snow cover duration, and microtopographic factors. The plant associations are separated by different species complexes and by dominant life forms. GLEES vegetation is characteristic of central and southern Rocky Mountain subalpine forests, subalpine wetlands, and alpine tundra. No endemics have been identified at

GLEES. The floristics of Lost Lake and East and West Glacier Lakes watersheds are described in Chapter 3. A herbarium collection of plant species at GLEES is maintained in cooperation with the University of Wyoming Rocky Mountain Herbarium in Laramie.

There have been vegetation disturbances at GLEES—primarily sheep grazing and recreational use by hikers, fishermen, and horses. Impact of these disturbances is considered minor. Most of the recreational use and impact is confined to the trails around the lakes, evidenced by compaction and sparseness of vegetation typical of trails. The alpine meadows surrounding GLEES have been used for permit sheep grazing since the late 1800's. In recent years, grazing at the immediate GLEES site has been infrequent and of short duration, primarily because of the sparse browse available and roughness of the terrain. Since 1990, grazing has been prohibited at the upper, steeper portions of the GLEES site. There are also numerous mining claims in the area, but the area has been recently withdrawn from new mining claims. Only three exotic species (dandelion, dark goose-foot, and many flowered woodrush) have been identified at GLEES, and abundance of these is very low. The small number of introduced species is perhaps due to the low impact of human activity at the site.



Figure 1.9.—Typical terrain and vegetation at GLEES. Note rocky nature of terrain and wind-deformed trees (*Abies lasiocarpa*).



Figure 1.10.—View of the permanent snowfield at the top of the glacial cirque at GLEES. Photo was taken at a location west of West Glacier Lake. Note the extensive area of exposed bedrock, wind-deformed trees in the center of the photo, and krummholz at the base of the snowfield.

Ninety permanent plots have been established in East and West Glacier Lakes watersheds for vegetation analyses. About 60 plots have been established in the lower GLEES area east of Brooklyn Lake. The vegetation of this general region of the Snowy Range, within 10 km of GLEES, has also been extensively studied by Billings and his colleagues (Billings and Bliss 1959) during the past 30 years. Many of the pioneering studies in alpine ecology and ecophysiology were conducted in the alpine areas of the Medicine Bow Mountains.

Geology and Soils

The major portion of GLEES is located on the steeply sloping SE-facing side of a SW to NE quartzite ridge whose main features are the Medicine Bow Peak and Browns Peak west of the study area (fig. 1.11). The site has developed from recent glaciation, with glacial cirque basins on the south side of the main ridge forming the upper reach of each of three watersheds. An alpine lake is the dominant feature of each watershed. A permanent snowfield exists at the top of the West Glacier Lake cirque. Bedrock at the site is primarily Medicine Bow Peak quartzite. Soils are minimally developed, formed over uniform quartzite bedrock that is crossed by weatherable mafic intrusions of amphibolite. Glacial till is present in the lower elevation areas of the watersheds. Exposed bedrock, talus slopes, or scree are evident in large areas of the site. More detail concerning geology at GLEES is presented in Chapter 4, and descriptive soils information is in Chapter 5.

Aquatics

The aquatic environment at GLEES is dominated by the snowpack and hydrological processes. Lakes have low buffering capacity and are impacted by a spring

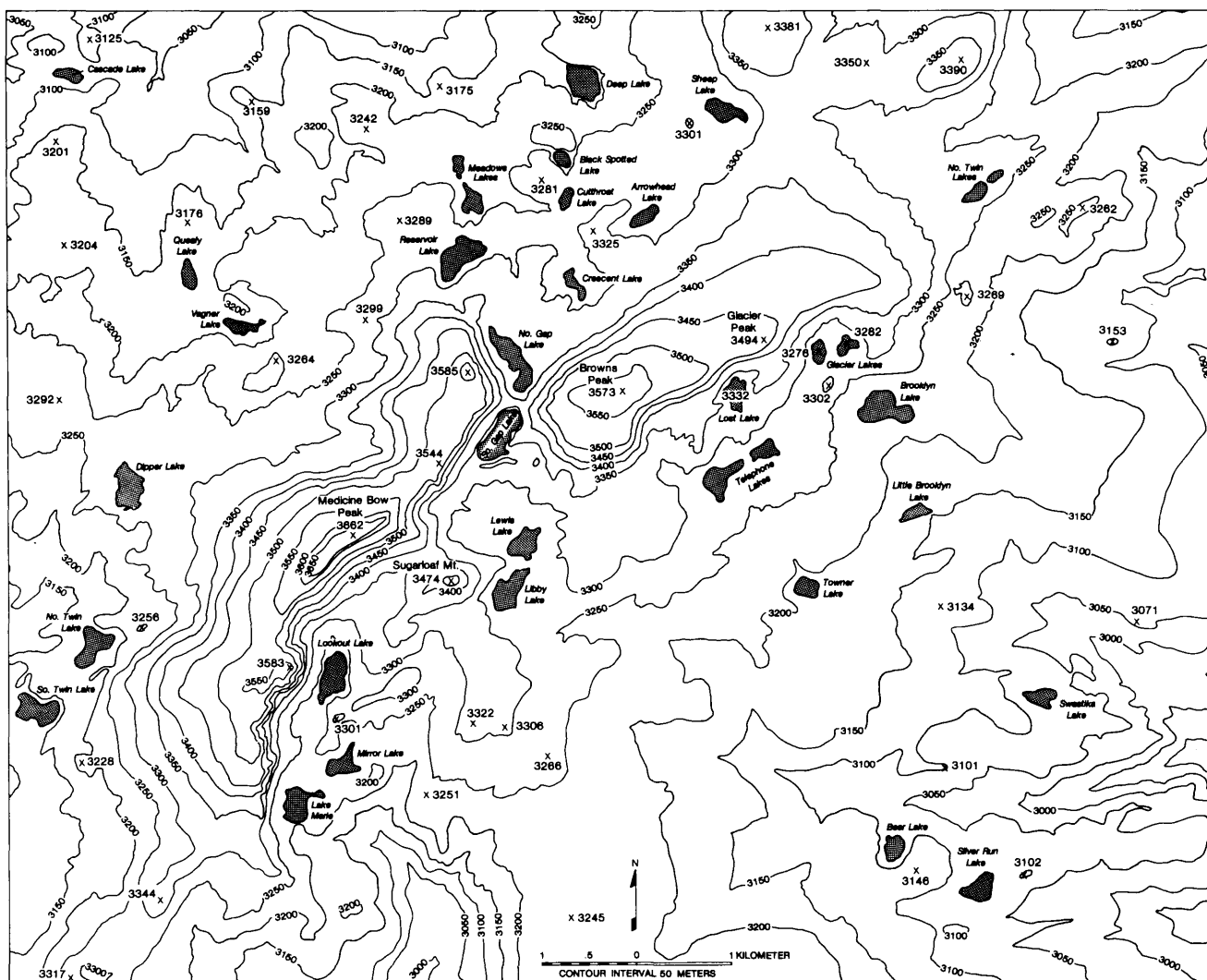


Figure 1.11.—Topographic map of GLEES and surrounding area, showing SW to NE Snowy Range Medicine Bow quartzite ridge, with upper GLEES (Lost Lake and Glacier Lakes watersheds) in glacial cirque basins south of the ridge.

acidic pulse at initial snowmelt. Input of this pulse is influenced by hydrological pathways into the lakes and streams. A preliminary examination of the physical, chemical, and biological aspects of the aquatic systems at GLEES is detailed in Chapter 6.

Meteorology and Air Quality

Long-term weather data have been collected near the site as a part of the Snowy Range Observatory operated by the Wyoming Water Research Center. Information from this database indicates mean minimum and maximum temperatures near the GLEES watershed ranging from lows of -23°C to highs of -1°C in winter, and lows of -7°C to highs of 21°C in summer. Precipitation is highly variable, with most in the form of snow. Snow cover frequently exists from late October until July. Measured precipitation averages 89 cm west of Lost Lake, 107 cm between East and West Glacier Lakes, and 125 cm near the East Glacier Lake outlet at Brooklyn

Lake. Air quality data is collected as wet deposition, dry deposition, and ozone from the National Atmospheric Deposition Program (NADP) and National Dry Deposition Network (NDDN) monitoring sites at GLEES.

Wind speed and direction, air and soil temperature, solar radiation, and precipitation data have been collected since 1987 from a 15 m meteorological tower near West Glacier Lake and from a 30 m meteorological tower east of Little Brooklyn Lake. Wind speed, on exposed locations of the watershed, can average above 34 km/hr and is high year round. Winds are primarily westerly at the surface, with northerly winds coming over the ridge of the glacial cirque resulting in a large snow cornice above West Glacier Lake. These two wind patterns converge at the eastern edge of the East Glacier watershed. Mean maximum snow accumulation is about 2 m depth at GLEES. Annual precipitation is about 100 cm of H_2O . Summaries of preliminary data on meteorological conditions at GLEES are presented in Chapter 7, and initial information on air quality at GLEES is summarized in Chapter 8.

Topography and General Hydrology

GLEES is located at high elevation in steep, rocky terrain (fig. 1.12). A 2-meter resolution topographic map of the upper GLEES is presented in figure 1.13. The highest elevation in the site is 3494 m at the top of the NW to SW quartzite ridge. A ridge from this point runs south to divide the Lost Lake and West Glacier Lake watersheds, each having a glacial cirque at the top of the basin just south of the ridgetop. Lost Lake, at 3332 m el-

elevation, is directly at the base of a well-defined, steep, unstable, cirque basin. A small pond, Scott Lake, at 3360 m on the west edge of the watershed near the top of the ridge drains into Lost Lake. A small drainage enters Lost Lake from the NE, fed from a snowfield that melts out in late summer. This drainage supports willow thickets near the lake, indicating moist soils. A small snowfield persists through the summer in some years on the talus slope above Lost Lake. A small, perched pond with no outflow after snowmelt is located on the ridge between



Figure 1.12.—Aerial photo of Lost Lake, East Glacier Lake, and West Glacier Lake watersheds, 1:4800 scale. Lost Lake is to the left, and West and East Glacier Lakes are on the right. The Medicine Bow Ridge with snowfields runs along the top of the photo (also shown in figure 1.11). Note the steep terrain and sparse vegetation. Aerial photo was taken August 19, 1988. (See Appendix F.)

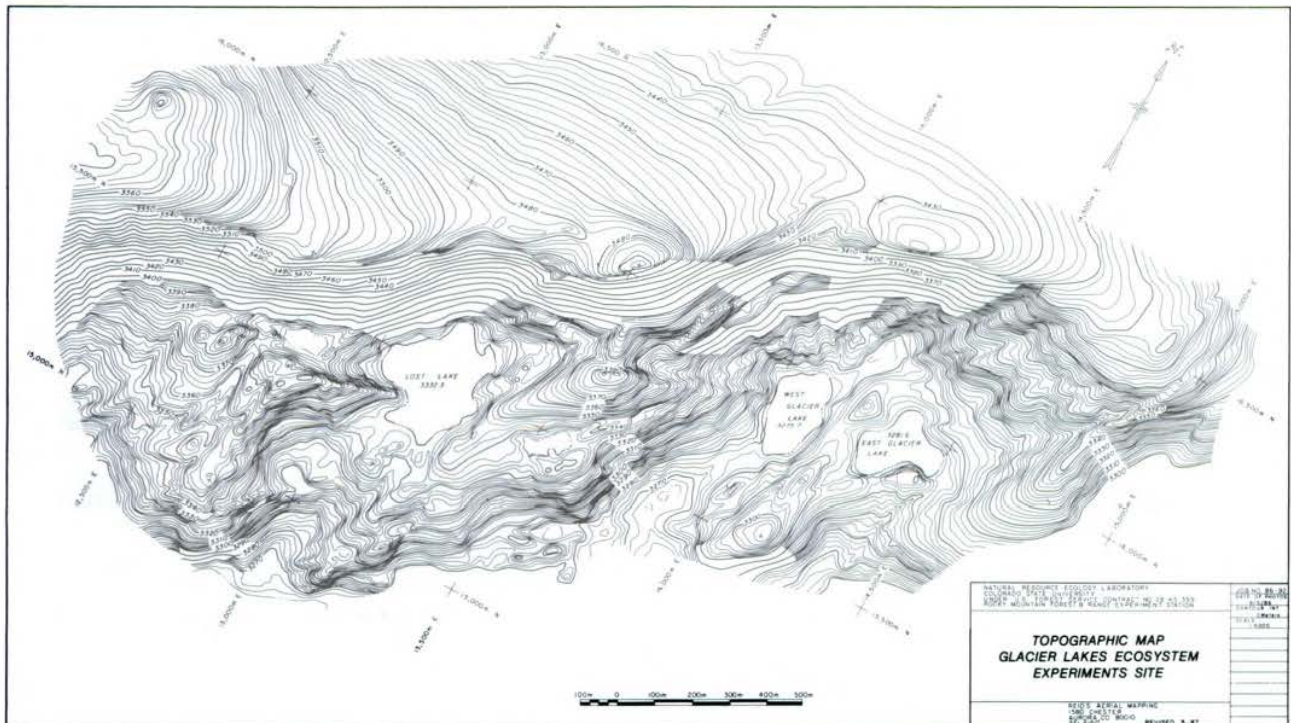


Figure 1.13.—Topographic map of GLEES, with 2-meter contour interval.

Lost and West Glacier Lakes watersheds. This pond has no fish and supports a rare crustacean, the fairy shrimp *Brachinecta paludosa*. Another small, shallow pond is located SE of the East Glacier Lake watershed. The lower portion of GLEES is on a relatively flat NW to SE ridge and contains deeper soils supporting spruce/fir forest.

East and West Glacier Lakes (figs. 1.6, 1.7) are similar in size, depth, and elevation. East Glacier Lake is slightly farther from the base of the steep portion of the quartzite ridge. East Glacier Lake, at 3282 m elevation, is 100–150 m east of West Glacier Lake, at 3276 m elevation. A low, windswept ridge running north to south separates the two watersheds. Four well-defined snowmelt drainages flow into the north end of West Glacier Lake (figs. 1.3, 1.5). Boulder Creek flows NE to SW from two drainage basins that merge to form a shallow pond, Boulder Pond, at the NE corner of West Glacier Lake. The pond outlet flows through scree about 100 m before entering the NE corner of West Glacier Lake. Cascade Creek and Meadow Creek are fed from the permanent snowfield (fig. 1.10) in a glacial cirque at the top of the watershed; however, only a small amount of Meadow Creek flow comes from the permanent snowfield late in the melt season. Smaller snowfields feeding Meadow Creek melt out most years. Meadow Creek enters the north side of West Glacier Lake (east of Cascade Creek) after flowing through a wet meadow. Cascade Creek feeds through a steep, rocky drainage channel to enter the north side of West Glacier Lake. Long Creek flows through rocky areas NW of West Glacier Lake, but it enters scree and becomes undefined about 100 m from the lake shore. Long Creek is fed by a snowfield that melts out most years by late summer. West Glacier Lake outlet stream drains to the SW through scree, wet meadow, and willow thickets. Several small ponds are located along the outlet.

East Glacier Lake has no perennial streams, and many intermittent streams are not well-defined. Almost all of the East Glacier Lake drainage basin lies to the east of the lake. Much of the East Glacier inlet area consists of wet meadow and springs near the lake. At the upper reaches of the watershed, snowmelt channels into NE- to SW-flowing drainage basins that become undefined as they reach the lake. Large areas of wet meadow and willow thicket on the east edge of East Glacier Lake indicate areas of moist soil, suggesting surface and subsurface flow into the lake in the absence of defined streambeds. Large areas of surface flow are evident in this area during snowmelt. There are no permanent snowfields in the East Glacier Lake watershed, and flow into the lake stops soon after snowmelt. East Glacier outlet initially flows east through scree from the southeast corner of the lake. The stream emerges in a well-defined channel about 200 m from the outlet. Outflow ceases in late summer.

Overall, there is a large diversity of types of streams at GLEES, including well-defined rocky streambeds, well-channelized streambeds through meadows, and poorly defined streambeds through rocky terrain or through meadows. All three GLEES lakes have extremely low acid neutralizing capacity. The hydrology of GLEES

is extremely complex because of the irregular topography, the large amount of unconsolidated surface materials and fractured nature of the bedrock, the variability of channelized flow to the lakes, and the relatively undeveloped soils. Chapter 9 presents an initial estimate of hydrologic flows at GLEES.

Snow

A major portion of precipitation at GLEES is in the form of snow. Snow cover generally persists at the site from November through June, with some snow patches persisting into August or September. A permanent snowfield supplies meltwater to West Glacier Lake until winter freeze. Snowmelt at GLEES dominates stream and lake chemistry except where water flows through mafic areas or meadows. Snow input to GLEES is examined in Chapter 10.

Research Installations and Programs

Long-term databases and research installations used to collect the data are listed in table 1.1. Major research facilities installed at GLEES include Parshall flumes on four streams, a wet deposition collector and associated Belfort rain gage, a dry deposition collector, a 15 m meteorological tower, a 30 m meteorological tower, a Wyoming Shielded Belfort precipitation collector, and a safety shelter (fig. 1.3).

East and West Glacier Lakes have been gaged with Parshall flumes on their outlets. Two inlet streams on West Glacier Lake (Meadow and Cascade Creeks) have also been gaged. Flow from Cascade Creek, fed from the permanent snowfield, and flow from the West Glacier Lake outlet continue until winter, and resume at snowmelt in the spring. Long Creek, Boulder Creek, and the East Glacier outlet maintain flow from initial snowmelt until soon after the snowfields are gone. Meadow Creek is fed from the permanent snowfield early in the season, but slows to a trickle as the snowfield recedes in late summer and fall. The East Glacier outlet Parshall flume is located at the end of the scree field about 100 m from the SE corner of the lake. The West Glacier inlet and outlet Parshall flumes are at the lake shore.

Meteorological data have been collected near GLEES since the late 1960's as a part of the Snowy Range Observatory (SRO) network, operated by the University of Wyoming. As a part of this network, in 1976 a precipitation collector with a Wyoming Rain Shield was installed on the ridge between East and West Glacier Lakes. In 1987, a solar-powered 10 m meteorological tower was installed on a knoll about 100 m SE of West Glacier Lake (fig. 1.14). Temperature, relative humidity, wind speed and direction, precipitation, wetness duration, soil temperature, and solar radiation are recorded at this site. An NADP wet precipitation collector is located near the SW shore of West Glacier Lake. A 30 m meteorological tower with 220V power is located east of Little Brooklyn Lake. Temperature, humidity, wind speed and di-

Table 1.1.—Long-term databases at GLEES and associated research installation sites.

Location	Measurements
Meteorological data	
Meteorological towers	Wind speed, wind direction, relative humidity, air temperature, soil temperature, precipitation, pyranometer radiation
NADP site	Precipitation, snow, radiation, pan evaporation, wind speed, wind direction (Jun - Oct), snow depth, snow temp, snow wetness (Nov - Jun)
SRO site	Precipitation
Air quality data	
NDDN site	Ozone, dry deposition chemistry
NADP site	Wet deposition chemistry
Hydrological data	
Lysimeters	Snow, soil chemistry
Lakes and streams	Flow, water chemistry—East Glacier Lake outlet, West Glacier Lake outlet, Meadow Creek, Cascade Creek Water chemistry—East Glacier Lake, West Glacier Lake, Lost Lake, Scott Creek, Scott Lake, Boulder Creek, Long Creek, pond between Lost Lake and West Glacier Lake
Snowcore survey	Depth, density, chemistry (East & West Glacier Lake watersheds)
Snowpits	Chemistry, depth, layering
Biological data	
Vegetation	Permanent plots Abundance data for all vascular flora Checklist of vascular plants Collection of voucher specimens for all vascular flora
Aquatics	Phytoplankton, zooplankton, periphyton Checklist of phytoplankton

rection, solar radiation, particulate concentration, sulfur and nitrogen species concentration, and ozone concentrations are recorded at the Brooklyn tower site.

A NADP wet deposition collector, established in 1986, is located on the SW shore of West Glacier Lake for measurement of wet deposition. Information from this site is available from the NADP network database. A NDDN station was established in February 1989 near the Medicine Bow National Forest Centennial Ranger District Work Center. The NDDN station is part of a network of dry deposition monitoring stations established by the U.S. Environmental Protection Agency. The NDDN station was moved to the Little Brooklyn Lake meteorological tower site in 1990. Ozone and dry deposition information from this site is available from the NDDN network database.

There are no laboratory or boarding facilities at GLEES, but the site is less than a 1-hour drive from Laramie. Limited motel space is available at Centennial, or with advanced arrangement at resorts within 3 km from the site. A National Forest campground is located at the NW corner of Brooklyn Lake directly adja-



Figure 1.14.—Meteorological tower at GLEES, located SW of East Glacier Lake.

cent to the GLEES. The Rocky Mountain Forest and Range Experiment Station has established a field laboratory and provides limited housing for their staff and research cooperators at the Centennial Ranger District Work Center less than 20 km from the site. Since weather conditions can change rapidly in the area, a temporary emergency shelter is located SW of East Glacier Lake for use by researchers who might be caught in the watershed during inclement weather, or for those in need of emergency first aid equipment.

Research at GLEES is coordinated by a GLEES Research Committee, chaired by a scientist from the Rocky Mountain Forest and Range Experiment Station, and includes scientists from the University of Wyoming and the Medicine Bow National Forest. Research proposals are evaluated by the GLEES Research Committee for scientific merit and for conflicts with area use or other research. Operational aspects of research approved by the Medicine Bow National Forest are coordinated by the Rocky Mountain Forest and Range Experiment Station, Research Work Unit 4452, located at station headquarters in Fort Collins, Colorado.

Measurements of magnitude of input of wet and dry deposition of cations and anions are being made at GLEES. All GLEES meteorological, biogeochemical, and vegetation data are archived in a PARADOX database at the Rocky Mountain Station. In addition to establishing a database on atmospheric deposition in sensitive alpine ecosystems, field studies will be conducted in controlled experiments to measure terrestrial and aquatic response to physical and chemical changes in the atmosphere.

Summary

This document provides a description of the upper GLEES study area and preliminary data on the biological, physical, and chemical environment at the site. Initial descriptions of vegetation, geology, soils, aquatics,

meteorology, air quality, and snow for the Lost Lake, East Glacier Lake, and West Glacier Lake watersheds are presented. Detailed checklists of plant species (appendices A and B), macroinvertebrates (appendix C), and soil descriptions (appendices D and E) for these areas are also included. Baseline grid orthophotographs for precise research site location in winter and summer are provided (appendix F). Detailed topographic, vegetation, geology, and soils maps are included in the appropriate chapters.

Reference

Billings, W.D.; Bliss, L.C. 1959. An alpine snowbank environment and its effects on vegetation, plant development, and productivity. *Ecology*. 40(3): 388–397.