MONTANA
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Two grizzly bear studies : moth feeding ecology and male reproductive biology

by Donnell Dee White, Jr

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Biological Sciences
Montana State University
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Abstract:
ABSTRACT Grizzly bears (Ursus arctos horribilis) consume adult army cutworm moths (Euxoa auxiliaris) from late June through mid-September on high elevation talus slopes in Glacier National Park (GNP), Montana. To better understand the importance of cutworm moths to grizzly bears in GNP, I identified the sex and age classes and minimum number of grizzly bears foraging at moth aggregation study sites, documented the timing and use patterns of grizzly bears foraging in these areas, quantified the effects of mountain climber presence on the behavior of foraging grizzly bears, determined temporal abundance patterns of moths at aggregation study sites throughout the summer, and determined body mass, total body moisture, total lipid, gross energy, and total nitrogen of moths collected throughout the summer. A minimum of 36 grizzly bears were observed 106 times feeding at 6 of 9 known army cutworm moth aggregation sites in GNP, from late-June through mid-September, 1992-1995. No bears were observed on moth sites in 1993. Bears fed on moth aggregations disproportionately more at elevations >2561 m, on slopes between 31 -45°, and on southwest-facing aspects. Lone adult and subadult grizzly bears appear to be underrepresented and overrepresented at the sites, respectively. Seasonal body weight and seasonal whole-body percentages of total moisture, total nitrogen, total lipid, and gross energy, varied linearly as a function of time. Grizzly bears foraging at moth aggregation sites are sensitive to disturbance from mountain climbers. Because alternative high-quality, late summer foods may not be available, human disturbance should be minimized at moth aggregation sites.

I also evaluated testicular growth and seminiferous tubule development, and age of sexual maturity in 20 male grizzly bears killed in Montana and Wyoming between 1978 and 1992. Seminiferous tubule diameter did riot differ among the regions of each testicle sampled. Testicle mass was related linearly to age. Seminiferous tubule diameter was related non-linearly to age. Mean testicle mass, volume, and seminiferous tubule diameter were smaller in immature bears than in mature bears. Based upon the presence or absence of spermatozoa in the lumen of the seminiferous tubules, sexual maturity in grizzly bears from the continental United States is attained at approximately 5.5 years of age.

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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PREFACE

The grizzly bear (*Ursus arctos horribilis*) in the contiguous United States once ranged from approximately the 100th meridian westward to California and south into Texas and Mexico (Storer and Tevis, 1955). The development of unfavorable environmental conditions in the wake of westward expansion and human development caused a rapid distributional recession (Lewis, 1961; Guilday, 1968). Between 1800 and 1975, grizzly bear populations in the contiguous United States receded from estimates of over 50,000 to less than 1,000 bears (U.S. Fish and Wildlife Service, 1993). Livestock depredation control, habitat deterioration, protection of human life and property, commercial trapping, and sport hunting were leading causes (Stebler, 1972; Martinka, 1976; Brown, 1985).

Currently, grizzly bears occur in less than 2% of their former range south of Canada (U.S. Fish and Wildlife Service 1993). Occupied grizzly bear habitat is largely confined to 5 or 6 areas known to contain either self-perpetuating or remnant populations of bears. These areas include portions of 4 states--Wyoming, Montana, Idaho, and Washington. Grizzly bears may still occur in Colorado, although confirmed sightings have not occurred since 1979 (U.S. Fish and Wildlife Service 1993).

The decreasing numbers and habitat of grizzly bears resulted in the grizzly being listed as threatened under the Endangered Species Act on 28 July 1975. It is important to continue grizzly bear and habitat research to ensure adequate scientific knowledge on which to base conservation and management decisions (U.S. Fish and Wildlife Service 1993).

In an effort to extend our understanding of grizzly bear biology and ecology, I have conducted 2 separate studies focusing on grizzly bear foraging ecology and male reproduction. Therefore, this dissertation is organized into 2 parts. Part A deals with grizzly bear use of high elevation moth aggregation sites in Glacier National Park, Montana, and part B deals with testicular histology of male grizzly bears in Montana and Wyoming.

These studies, like all studies, are not the sole work of their author. I would like to express my appreciation to Michael Kruger, Michelle Richards, Brian Killingsworth, Kimberly Medley, Jeremy Cannon, Piney Hardiman, and Jennifer Grossenbacher for their hard work and assistance in the rugged and remote backcountry of Glacier National Park. Their dedication and spirit of cooperation made the Glacier Park project possible. It was a delight to be in the field with each of them. I also thank Kirk Barnette, Jack Barringer, Bob Brastrup, Dr. Donald Heaney, Darrel Krum, John Maatta, Marko Manoukian, John Maki, Dave Phillips, and Judee Wargo, Montana State University-Bozeman County Agriculture Extension Agents, for collecting army cutworm moths for me in the autumn.

I have benefited both professionally and personally from the opinions, expert advice, and friendship of my major professor Dr. Harold Picton. I also appreciate Dr. James Berardinelli for his willingness to teach me histological techniques and analysis.

I thank my Graduate Committee members, Drs. Lynn Irby, Tom McMahon, Bill Kemp, Gordon Brittan, and Pete Burfening for their willingness to sit on my Graduate Committee and for their time in critically evaluating my dissertation.

I am indebted to Katherine Kendall for asking me to study grizzly bears in Glacier National Park and for entrusting me with this exceptional project. I also thank Matthew Reid for his encouragement and for securing initial funding.

Sincere thanks are extended to Peter Busch, President of the Peter W. Busch Family Foundation, for his friendship and for funding both the Glacier Park and reproductive biology projects. The National Park Service, Glacier National Park, the National Biological Service, the Montana Department of Fish, Wildlife and Parks, and the Mountain Research Center, Montana State University-Bozeman provided additional funding and support; I thank each of them.

Above all, I wish to thank my wife, Nancy. As in my other projects, she participated in every aspect of the work to such an extent that in some ways the results are almost as much hers as mine. She was someone with whom I could discuss concerns, she was also a buffer for disappointments. When at times we had to be apart, my joy in the work diminished and I knew then how much she is the focus of my life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Grizzly bears (*Ursus arctos horribilis*) consume adult army cutworm moths (*Euxoa auxiliaris*) from late June through mid-September on high elevation talus slopes in Glacier National Park (GNP), Montana. To better understand the importance of cutworm moths to grizzly bears in GNP, I identified the sex and age classes and minimum number of grizzly bears foraging at moth aggregation study sites, documented the timing and use patterns of grizzly bears foraging in these areas, quantified the effects of mountain climber presence on the behavior of foraging grizzly bears, determined temporal abundance patterns of moths at aggregation study sites throughout the summer, and determined body mass, total body moisture, total lipid, gross energy, and total nitrogen of moths collected throughout the summer. A minimum of 36 grizzly bears were observed 106 times feeding at 6 of 9 known army cutworm moth aggregation sites in GNP, from late-June through mid-September, 1992-1995. No bears were observed on moth sites in 1993. Bears fed on moth aggregations disproportionately more at elevations >2561 m, on slopes between 31 - 45°, and on southwest-facing aspects. Lone adult and subadult grizzly bears appear to be underrepresented and overrepresented at the sites, respectively. Seasonal body weight and seasonal whole-body percentages of total moisture, total nitrogen, total lipid, and gross energy, varied linearly as a function of time. Grizzly bears foraging at moth aggregation sites are sensitive to disturbance from mountain climbers. Because alternative high-quality, late summer foods may not be available, human disturbance should be minimized at moth aggregation sites.

I also evaluated testicular growth and seminiferous tubule development, and age of sexual maturity in 20 male grizzly bears killed in Montana and Wyoming between 1978 and 1992. Seminiferous tubule diameter did not differ among the regions of each testicle sampled. Testicle mass was related linearly to age. Seminiferous tubule diameter was related non-linearly to age. Mean testicle mass, volume, and seminiferous tubule diameter were smaller in immature bears than in mature bears. Based upon the presence or absence of spermatozoa in the lumen of the seminiferous tubules, sexual maturity in grizzly bears from the continental United States is attained at approximately 5.5 years of age.

PART A

GRIZZLY BEAR USE OF HIGH ELEVATION MOTH AGGREGATION SITES IN GLACIER NATIONAL PARK, MONTANA

Introduction

Grizzly bears (*Ursus arctos horribilis*) feeding on insect aggregations excavated from alpine talus slopes have been documented in several areas in the northern Rocky Mountains: the Mission Mountains (Chapman 1954, Chapman et al. 1955, Servheen 1983, Klaver et al. 1986), Scapegoat Wilderness (Sumner and Craighead 1973, Craighead et al. 1982), and mountains of the Rocky Mountain East Front (Aune and Kasworm 1989), Montana; and in the Absaroka Mountains, Wyoming (Mattson et al. 1991, French et al. 1994, O'Brien and Lindzey 1994). Grizzly bears consume army cutworm moths (*Euxoa auxiliaris*) (Lepidoptera: Noctuidae) and ladybird beetles (*Coccinnella* and *Hippodamia* spp.) (Coleoptera: Coccinellidae) in the Mission Mountains and army cutworm moths in the Scapegoat Wilderness, Rocky Mountain East Front, and Absaroka Mountains. Additionally, Ustinov (1965) has recorded bears eating aggregations of caddis flies (Trichoptera) along the shores of Lake Baikal, Russia, and Gurney (1953) observed bears feeding on fossil grasshoppers (Orthoptera) melted out of glaciers.

Anecdotal accounts of grizzly bears frequenting high elevation (>2000 m) talus slopes in Glacier National Park (GNP), Montana, are common in Park records. The first recorded report of bears observed above timberline in GNP was made by climbers on Mt. Cleveland (3190 m) in 1933. These climbers found "signs of a grizzly within 1000 feet of the summit" and the climbers considered this "the most remarkable thing in the whole trip." Though the climbers were the Chief Naturalist of GNP and a seasonal staff member, they had no plausible explanation for what the bear was doing at that elevation. Moth remains were confirmed in bear feces (scats) collected from several of GNP's tallest mountain peaks in the early to mid-1980's (Katherine C. Kendall, unpub. data).

From 1989 - 1991, 5 radiotelemetered grizzly bears spent several weeks feeding on army cutworm moths at 2100 - 2800 m elevation on mountains along the east side of GNP. These bears initiated feeding on moths as early as the third week of June and continued until mid to late August or early September (Daniel Carney, U.S. Fish and Wildlife Service, Browning, Montana, unpub. data).

In this study, I investigated grizzly bear use of army cutworm moths on high elevation talus slopes in GNP. Prior to my investigation, information on grizzly bear use of army cutworm moths was limited to 4 studies; 3 in the Greater Yellowstone Ecosystem (Mattson et al. 1991; French et al. 1994; O'Brien and Lindzey 1994) and 1 in the Mission Mountains, Montana (Klaver et al. 1986).

My goals were to determine the significance of high elevation army cutworm moth aggregations to the grizzly bear population in Glacier National Park and to quantify what physical, biological, and social parameters influence grizzly bear use of these areas. To meet these goals I pursued 5 specific objectives: (1) to identify the sex and age classes and minimum number of grizzly bears foraging at moth aggregation study sites, (2) to document the timing and use patterns of grizzly bears foraging in these areas, (3) to determine temporal abundance patterns of moths at aggregation study sites throughout the summer, (4) to determine total moisture, total nitrogen, total lipid, gross energy, and body mass of moths collected throughout the summer and early autumn, and (5) to quantify the effects of mountain climber presence on the behavior of foraging grizzly bears.

Life History Of The Army Cutworm Moth

The army cutworm moth is distributed throughout the semiarid region of the Great Plains, extending as far east as Kansas, south to southern New Mexico, west to California, and north to central Alberta (Fig. 1). Since 1929, the army cutworm has been reported in all states west of the Mississippi River except Louisiana (Burton et al. 1980). The army cutworm moth is also widespread throughout Alberta and is commonly abundant as far north as the Peace River District (Strickland 1942, Burton et al. 1980).

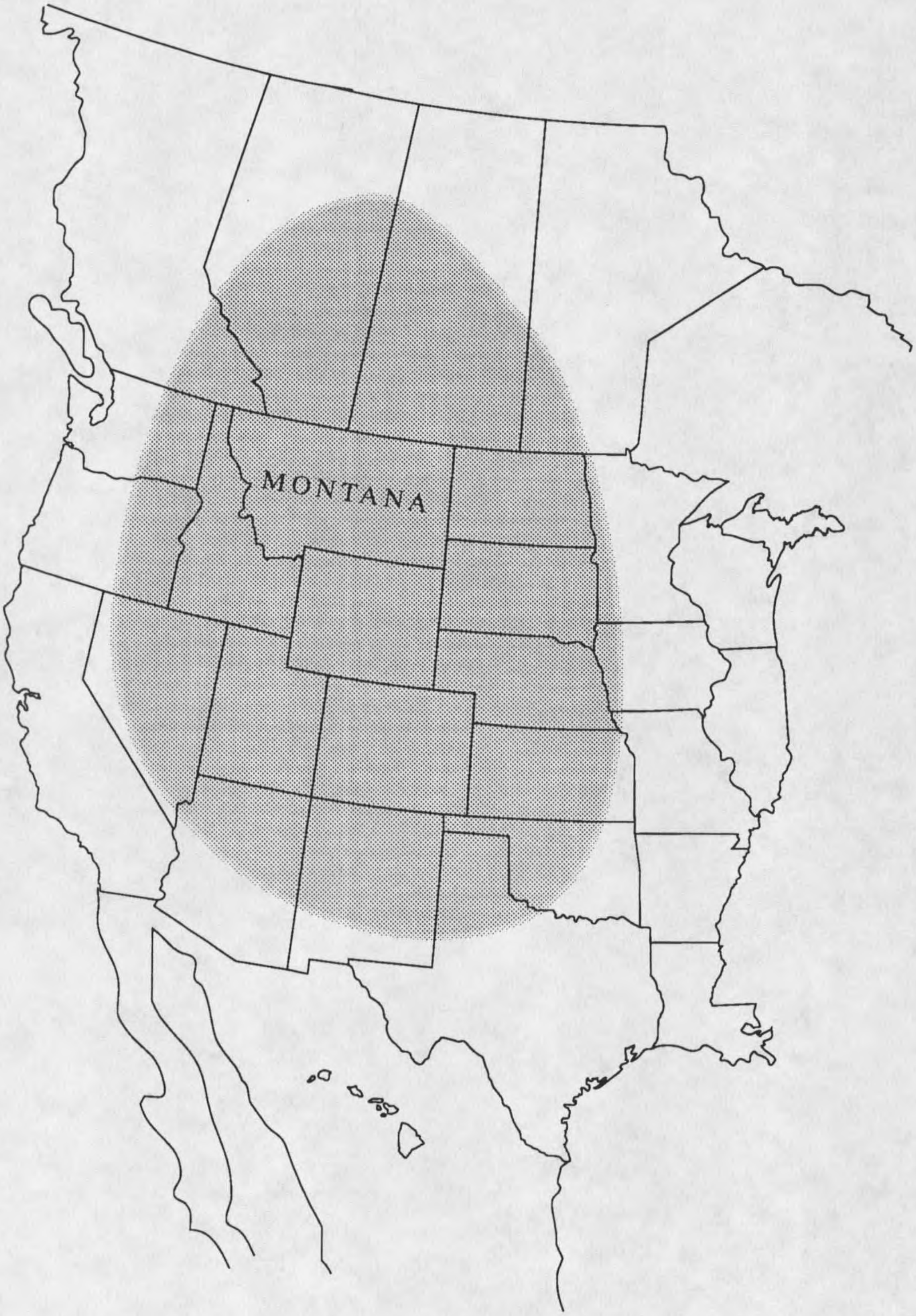

Figure 1. Distribution of the army cutworm moth in North America. Modified from Burton et al. (1980).

The life history of the army cutworm moth is remarkable and required decades for biologists to piece together. Because of the abundance of the moths in the spring and autumn on the Great Plains, Gillette (1904) and Johnson (1905) incorrectly proposed that the army cutworm moth was bivoltine. Cooley (1916) reared army cutworm moths in outdoor cages on the Plains during the summer in Montana, but few individuals survived. This led Cook (1927) to propose that adult army cutworm moths aestivated (i.e., were inactive) under matted vegetation and other debris on the Plains to escape the heat of summer. This "heat-escape hypothesis" also explained why army cutworm moths vanished during summer on the Plains. Simple but elegant experiments conducted by Pepper (1932) determined that army cutworm moths could be kept alive during the summer on the Plains by storing them at cool temperatures.

In May of this same year, Pepper (1932) observed a swarm of army cutworm moths flying southwesterly near Bozeman, Montana. Pepper was the first to hypothesize that these moths migrated to high elevations for the summer. Pruess (1967) developed a more detailed and cohesive theory of army cutworm moth migration based on 4 observations: 1) the absence of adult army cutworm moths on the Plains during the summer in Nebraska, 2) the long distance flight ability of this moth (as demonstrated by experimentation in the mid-1960's), 3) numerous records of the moths at high elevations during the summer, and 4) moths captured on the Plains in the autumn had higher body fat reserves than those collected in spring indicating that they fed during the summer and did not aestivate as previously accepted. Pruess and Pruess (1971) further documented nocturnal unidirectional migration of army cutworm moths at North Platte, Nebraska, and Laramie, Wyoming, using telescopes focused on the moon.

This and the work that has followed has clarified the life history of this complex animal (Fig. 2). The army cutworm moth is holometabolous. The eggs are laid in the

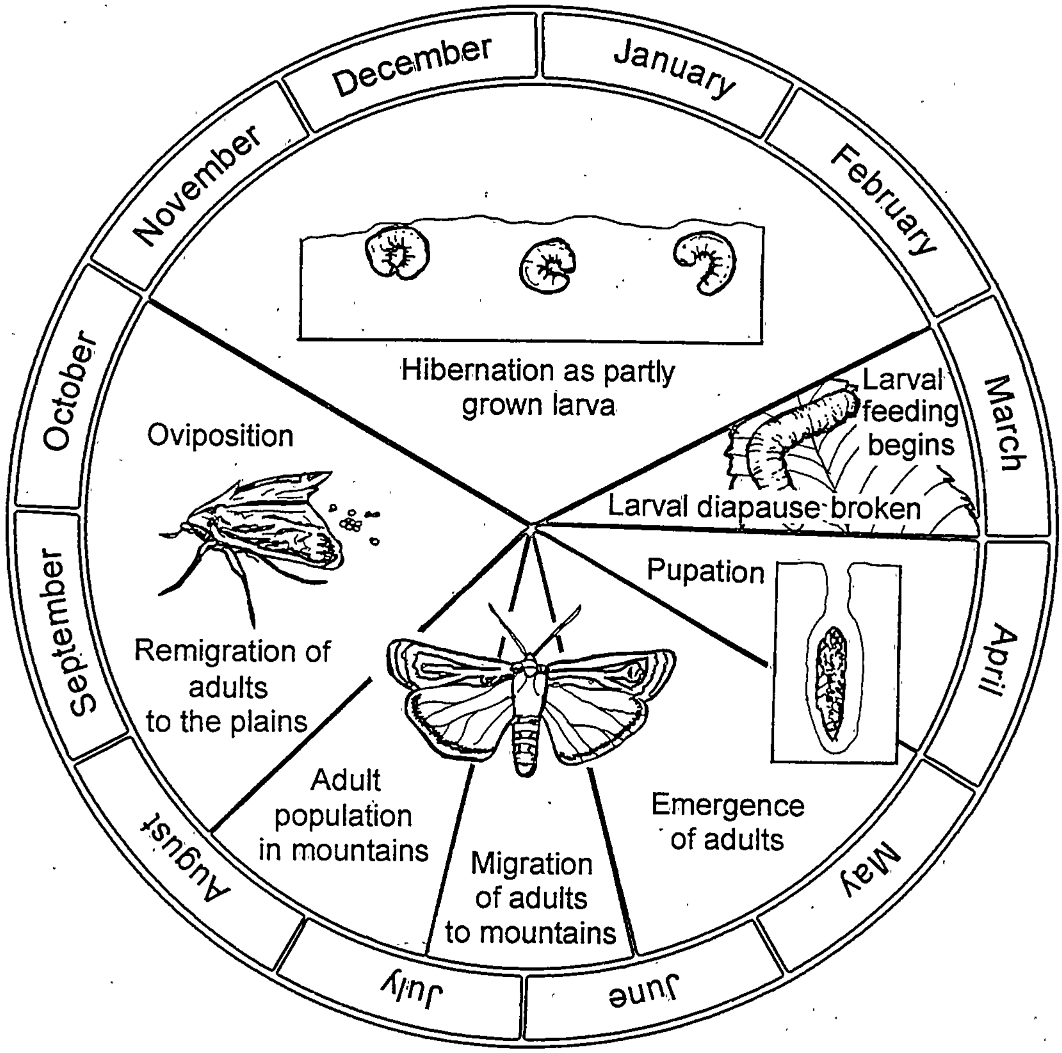

Figure 2. The life cycle of the army cutworm moth. Redrawn from Kendall 1981.

soil of the Great Plains in the autumn and develop to the first or second larval instar before hibernation (Johnson 1905, Cooley 1916, Strickland 1916, Burton et al. 1980, D. Kendall 1981). In spring, the larvae commence to feed on a variety of plants such as alfalfa and small grains (Burton et al. 1980, Morrill 1991). If development is not interrupted by low temperatures and the larva continue to feed, the larval stage may last for only 10 days (Rockburne and Lafontaine 1976). The larval stage can, however, last longer: 25 to 32 days in Kansas (Walkden 1950) and 43 to 63 days in Montana (Cooley 1916). When abundant and short of food, the larvae will move *en masse* to adjacent fields, thus the name "army" cutworm. After a total of 6 or 7 instars from egg to last molt, pupation occurs in underground cells (Snow 1925, Seamans 1927, Burton et al. 1980).

In early summer the newly emerged adult moths enter a migratory phase and fly west into the Rocky Mountains (Pepper 1932, Walken 1950, Chapman et al. 1955, Pruess 1967, Hardwick and Lefkovitch 1971, Burton et al. 1980) where they spend the summer. It is here, while inhabiting the interstia of talus slopes that the moths are excavated and consumed by grizzly bears. They do not become reproductively active until autumn when they return to the plains. On the plains the females enter a settling phase and oviposit approximately 2000 eggs per individual into the soil (Walkden 1950, Burton et al. 1980). The army cutworm moth is univoltine (Cooley 1908, Seamans 1927, Burton et al. 1980, Kendall 1981).

Definitions

Several terms used loosely in the ecological literature are defined below to clarify my use of the terms:

1. Migration is the act of moving from one spatial unit to another (Baker 1982).
2. Remigration is the act of migrating to a spatial unit that is environmentally similar to a spatial unit that has been visited before.
3. Movement is defined as simply a change in position.

Study Area

GNP is located in northwestern Montana adjacent to the Canadian border (Fig. 3). Two mountain ranges dominate the park: the Livingston Range, located on the west side of the park, extends north from the Canadian border southward to Lake McDonald; and the Lewis Range, on the east side, extends the entire length of the park. The continental divide bisects the park following the crest of the Lewis Range northward to about 18 km south of the Canadian border where it turns westward to follow the crest of the Livingston Range into Canada (Carrara and McGimsey 1981). About one third of GNP's 410,000 ha occurs above timberline. Much of the remainder of the park is forested with scattered meadows, which occur most frequently on the eastern side of the park. Relief is precipitous. Deep glaciated valleys and basins divide large, rugged mountain massifs. Many valleys are 1800 m below their surrounding summits (Carrara and McGimsey 1981). Elevations in the park range from 948 m at

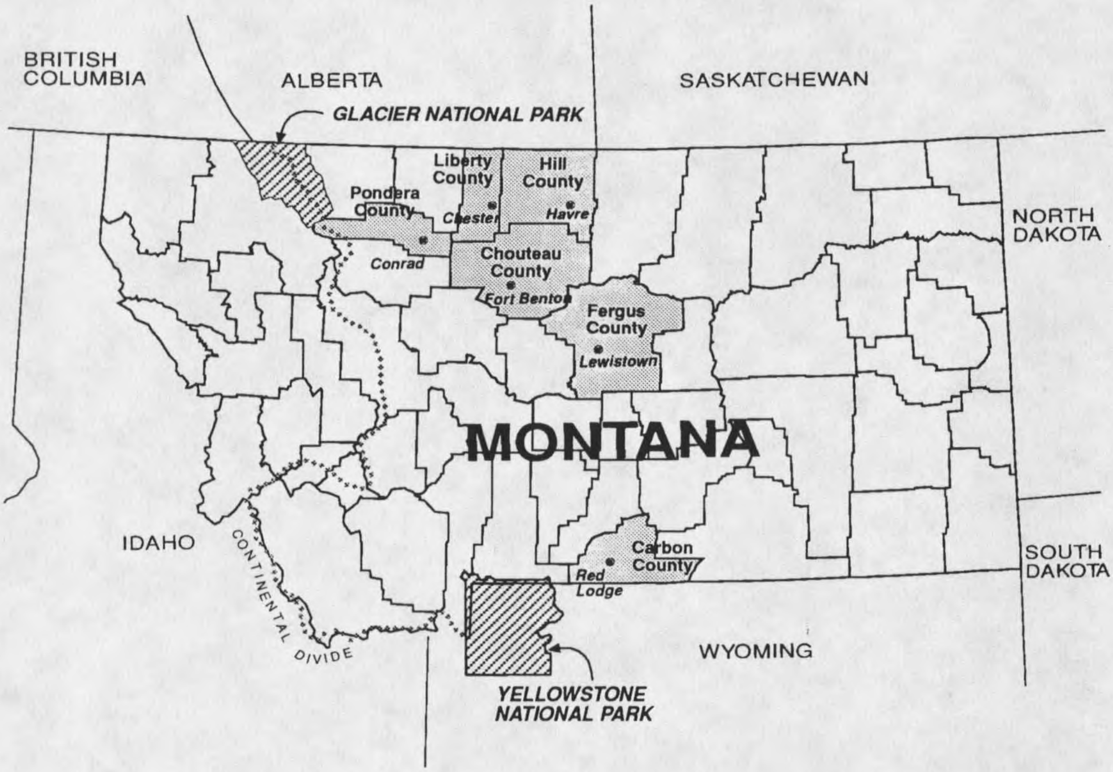

Figure 3. Location map of Glacier National Park, Montana and the location of counties in Montana (shaded areas) where adult army cutworm moths were collected in late summer and early autumn, 1992-1995.

the Middle Fork-North Fork Flathead River confluence to 3,190 m atop Mount Cleveland (Finklin 1986).

The mountains of GNP presumably originated with the uplift and folding of sedimentary rocks of the Precambrian Belt Supergroup during the late Mesozoic. These strata are mostly reddish brown and greenish gray argillites with some quartzites (Carrara and McGimsey 1981). Glaciers shaped the terrain to its present appearance during the Pleistocene (Alden 1953, Dyson 1966, Alt and Hyndman 1991).

The climate is Continental with Pacific Maritime modifications, particularly on the western side of the park (Dightman 1967, Carrara and McGimsey 1981). The alpine climate is characterized by frequent strong (>66 km/h) winds, typically westerly in winter (December-February) and southwesterly during summer (July-August) (Finklin 1986). Precipitation generally increases with elevation, but decreases rapidly with horizontal distance near and beyond the eastern edge of the park (Finklin 1986). Mean July temperatures range from 15 to 17°C in the lower valleys (Finklin 1986). Summer afternoon temperatures usually decrease with increasing elevation, at an average lapse rate of 7.5 to 8°C per 1000 m (Finklin 1986).

Methods

Moth Site Characteristics

I visited 7 alpine moth aggregation sites in GNP before, during, and after seasonal bear use, which occurred from late June to mid-September. Data collected at moth aggregation sites included measurements and descriptions of site characteristics (e.g., elevation, slope, aspect) and bear sign (e.g., dig dimensions and dig-site features, bed dimensions and locations).

To quantify the thermal environment of a talus slope, I placed automatic temperature loggers (HOBO TEMP, Onset Computer Corporation, Pocasset, MA) programmed to measure temperature every 30 minutes for 36 days at the surface and at 3 depths within a southwest-facing talus slope: 10 cm, 20 cm and 30 cm. The thermometers were buried 3 August 1995 and removed 10 September 1995.

Bear Observation Techniques

I observed bear foraging activity at alpine moth aggregation sites using variable power spotting scopes or telescopes at distances of 250 m to 2 km. Moth aggregation study sites were chosen for observability and accessibility, intensity of bear use, minimal bear disturbance by researchers, and researcher safety. Observation posts were chosen on the basis of bear observability and bear avoidance, researcher concealment, and prevailing wind direction. Bears were identified as to species and sex/age classes using established guidelines for field identification of bears (Burkholder 1959, Meehan 1961, Woodgerd 1964, Craighead et al. 1974, Martinka 1974, Egbert and Stokes 1976, Atwell et al. 1980, French et al. 1994, O'Brien and Lindzey 1994). Subadults were distinguished by size and relative body proportions.

Repeated observations of the same bears on a talus slope allowed me to identify many bears individually. Pelage color and shedding patterns, size, conformation, and deformities were the distinguishing characteristics used. Sex, age, family groupings, and behavior traits were used as distinguishing factors, which led to a high confidence in the identification of individuals. Location of each bear observed foraging on moths was recorded on U.S. Geological Service 7.5 minute series topographic maps using Universal Transverse Mercator (UTM) coordinates.