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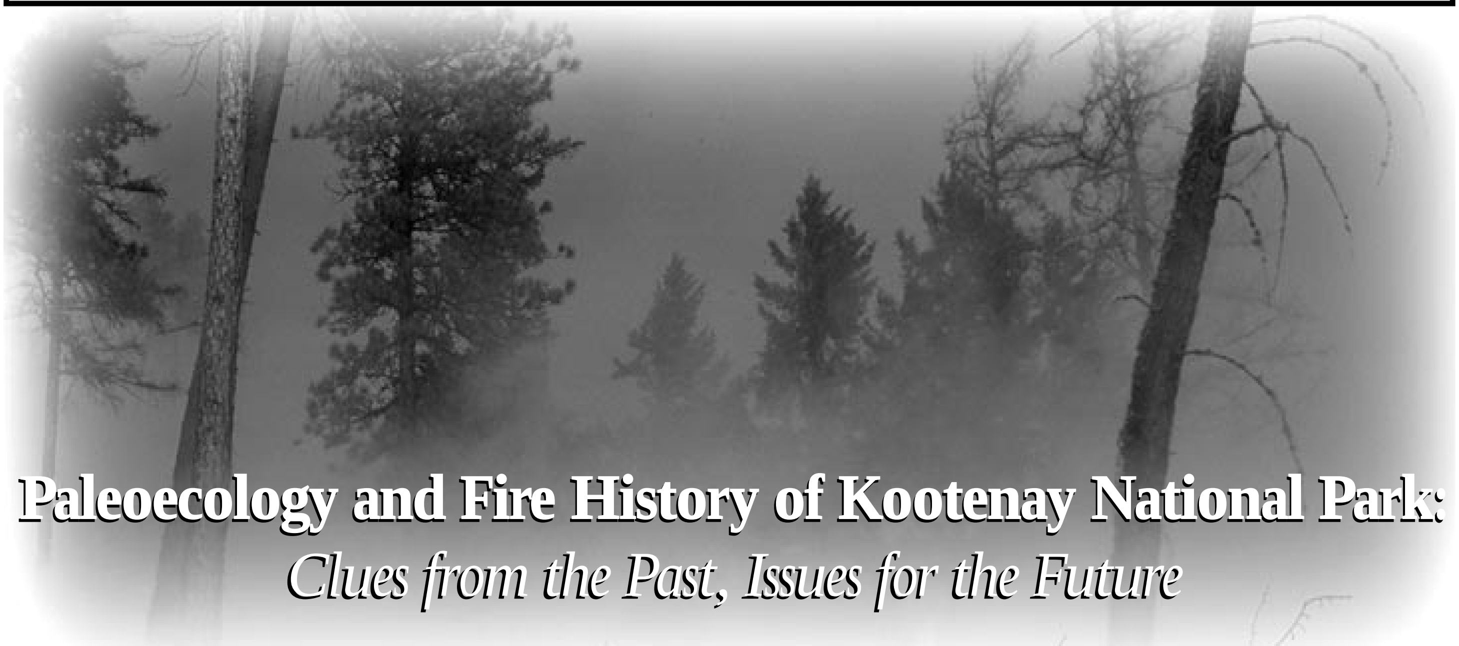

Paleoecology and Fire History of Kootenay National Park:

Clues from the Past, Issues for the Future

Robert C. Walker and Douglas J. Hallett

Forest management in national parks is frequently based, in whole or in part, on maintaining or restoring natural disturbance processes within an estimate of their natural range of variability. The current Kootenay National Park (KNP) Management Plan target is to maintain and/or restore 50% of the long term, average fire cycle. Typical fire reconstructions are based on dendrochronological, fire history studies that extend back approximately 500 years. Masters' (1990) KNP fire history study described changing fire frequencies over that period and indicated that the present stand-age structure and fire frequency is best explained by decade to century level climatic influences.

Forest fires, forest insects and other forest disturbance processes are directly linked to regional climate. Climatic fluctuations occur at periodicities ranging from decades to centuries and even over millennia (Hallett and Walker 2000; Hallett *et al.* In prep). To quantify restoration targets, managers need ecological data sets with temporal depth great enough to define long term variability. Paleological research is an important tool for determining the natural variability of ecosystems (Smol 1992) and allows analysis over millennial time scales. By defining the range of natural variability it may be possible to predict the results of climate change, both natural and human-caused, on vegetation and forest disturbance processes.

The goal of ongoing paleoecological research in KNP is to reconstruct vegetation, forest disturbance processes and climate with sufficient temporal depth to adequately define the range and character of natural variability. We are using high-resolution, paleoecological data to describe the effects of underlying ecological variation and its association with past and future climate change.

METHODS

Our results are based on analysis of sediment cores taken from Dog Lake, a 15.1 ha lake in the montane valley bottom of the Kootenay Valley. Vegetation around the lake is currently in the Montane Spruce biogeoclimatic zone (Meidinger & Pojar 1991) but has changed considerably over the past 10,000 years (Hallett and Walker 2000).

Our techniques include high-resolution analyses of macroscopic charcoal, pollen and other macrofossils at two temporal scales. We extracted a 10,000-year core with a percussion corer and sampled at approximately 40-year intervals for charcoal and pollen (Hallett & Walker 2000). We also extracted a 1,000-year core with a gravity corer and sampled at 6-10 year intervals for charcoal, aquatic macrophyte fossils and arthropod macrofossils (Hallett *et al* in prep).

Charcoal analyses are based on macroscopic charcoal particle accumulation rates or CHAR, which allow us to reconstruct local fire frequency around a lake site. The KNP fire history study (Masters 1990) was used to calibrate the most recent CHAR data. Pollen ratio analyses are based on a dry:wet pollen ratio using local indicator pollen types from Hallett (1996). Dry-forest indicator pollen represents dry-open forests (*Pseudotsuga* and *Larix*, and Poaceae). Wet-forest indicator pollen represents wetter, closed forests (*Picea* and *Abies*). *Chara oospore* macrofossil analyses are based on the algal macrophytes' requirement of a minimum water level to colonize shallower areas of the flat lake basin. The core was

- continued on page 6 -

Research Links

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FEATURE ARTICLES

DEPARTMENTS

FRANCOPHONES

Le texte de cette publication est offert en français. Vous pouvez l'obtenir en écrivant à l'adresse dans la p. 28

UPCOMING DEADLINES

Nov. 30, 2001—SPRING 2002
Mar. 31, 2002—SUM/AUT 2002

EDITORIAL

Do you see what I see? Taking a close look at the little things

Whether we encounter national parks as visitors, staff or researchers, each of us has probably smelled decomposing vegetation, caught a glimpse of something fluttering through the canopy or heard scurrying sounds in the understory. But how often do we really focus on these things? Our mental snapshots tend to include organisms and features that take up considerable space in the big picture — bears, elk, big horn sheep, mountains, lakes, forests. Sometimes we could benefit from a different perspective. Like photographers who strive for new and interesting angles to capture images on film, the authors featured in this edition of *Research Links* take higher, lower and closer points of view. Their work illustrates how research subjects that are “smaller than a breadbox” can reveal information about park management issues related to climate change, long-term ecological processes and habitat fragmentation.

In our lead article, Rob Walker and Doug Hallett examine lake cores for pollen and charcoal (remnants of vegetation and insects) to trace climatic fluctuations and fire history over 10,000 years. The persistence of pollen and insects across millennia enables these researchers to extract valuable information about trends in long-term ecological processes, and possibly to forecast climate change. Some of the insect species preserved in those lake cores still cause concern for forest management. Mountain pine beetles persist today, and their rapid reproduction in host trees and can have large impact on forest ecosystems. By studying habitat choice by mountain pine beetles, Ché Elkin sheds light on why the insects select certain stands in Kootenay National Park.

Several articles and “Highlights” in this issue focus on the movements of small animals. By monitoring butterflies, forest insects, birds, small mammals and parasites we can learn about population viability, habitat quality, and animal behaviour in fragmented habitat. Cyndi Smith, Colleen Cassady St. Clair and Wayne McDonald approach these issues from different angles to give managers a clearer picture of population trends and the effectiveness of wildlife corridors. By narrowing her focus even more, Margo Pybus explains how parasites in Banff National Park can affect the movements of much larger host species. Her work shows that managers should consider giant liver fluke dispersal before translocating deer and elk.

Crustose lichens are very small, very slow growing organisms that can live for thousands of years. Dan McCarthy has been studying these lichens to develop more accurate growth curves that can be used to date geomorphological events. To obtain the information he needs, McCarthy photographs his subjects with a macro lens, then uses photo and GIS software to analyze high resolution images.

By exchanging our typical wide angle view for a macro perspective, McCarthy and the other authors focus on little things. In this issue of *Research Links* we invite you to see what they see and recognise the value in species we often overlook.

Dianne Dickinson
Production Editor of Research Links, Parks Canada WCSC, Calgary.

ERRATA

There were a couple of photo errors in Jack Dubois' article on the "Small Mammal Cooperative Inventory Project" (Research Links 9[1] — Spring 2001, p. 11-13). Franklin's ground squirrels and picas (depicted in the photos on pages 11 and 13) are not in fact among the small mammals found in Wapusk National Park. Our apologies for any confusion. Thank you to Anna Gajda, Backcountry Activities Manager, Gwaii Haanas for her feedback!

Managing the Ecological Integrity of Elk Island National Park

The Role of a Science Advisory Committee

"Ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact."

Report of the Panel on the Ecological Integrity of Canada's Parks (2000)

Garry Scrimgeour

Managing parks to maintain their ecological integrity is now recognized as the core mandate of Parks Canada. However, the task of preserving ecological integrity is daunting because it involves complex scientific, social, economic and political considerations and constraints. Further, the challenge of maintaining ecological integrity within land bases that are increasingly fragmented, prone to complex non-additive industrial stressors and subject to changing climatic conditions is the scientific challenge of the millennium.

Despite the enormity of this pursuit, there is good news. The majority of Parks Canada employees appreciate the extent of the challenge of managing for ecological integrity. Many Parks, like Elk Island National Park (EINP), have taken proactive steps to understand the scientific issues involved and, in an adaptive manner, have charted a course of action. This article is a brief description of EINP's Science Advisory Committee (SAC), its membership and the role it plays in assisting EINP to manage for ecological integrity.

ELK ISLAND'S SCIENCE ADVISORY COMMITTEE

Elk Island established its Science Advisory Committee in January 1998 and it currently includes six members from the University of Alberta, and Provincial and Federal Governments (Table 1, page 24). Because committee members have diverse research interests, they can provide input on a relatively broad suite of scientific issues. SAC meets with the Elk Island National Park Ecosystem Secretariat between three and six times per year. Acting as an independent advisory committee, SAC contributes to discussions on important scientific issues.

During the past 3 years, SAC has: 1) established an administrative body, 2) provided input on the Park's Ecosystem Conservation Plan, 3) commented on the scientific merit of about 35 research proposals received by EINP, 4) reviewed an issue scoping document, 5) commented on a variety of specific management issues or challenges, and 6) initiated a scientific review of seven research and management program areas in EINP. The 6th initiative includes critical evaluations of ungulate management, fire management, biological and chemical monitoring, aquatic resource management, EINP overall disturbance-based management model and the Greater Beaver Hills watershed initiative.

In addition to providing input for scientific issues, the SAC provides a conduit through which park staff can become informed of research studies on ecological issues related to ecosystem management. This allows the park staff to place their research within a broader scientific context and to benefit from research designs and findings from other studies.

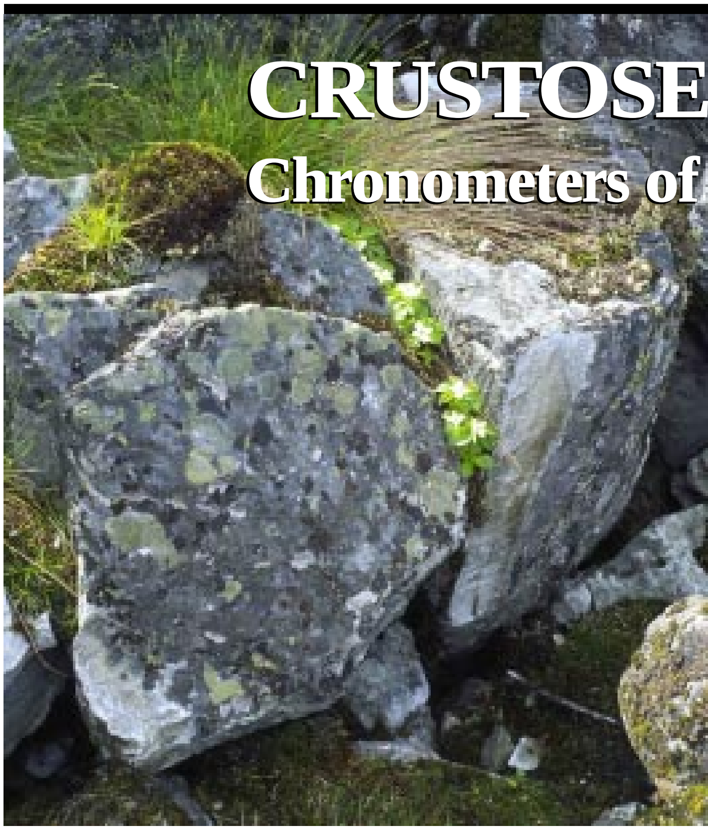
WHERE ARE WE HEADING?

Like many parks, EINP has invested considerable resources in an effort to understand what constitutes an ecological integrity-based management model. Implementing this model and placing more management activities within the context outlined in the "Report of the Panel on the Ecological Integrity of Canada's Park's" are also goals for EINP. Feedback to me has been very favorable and the majority of Park staff acknowledge that the SAC has provided highly relevant and cost effective input on a number of research and management

- continued on page 24 -

History of the SAC

Established in January 1998, the SAC arose as part of a larger process through which EINP responded to the 1994 Parks Canada Guiding Principles and Operational Policy document that emphasized the importance of managing for ecological integrity. This process led EINP to host a 3-day Ecosystem Based Management Workshop in August 1997. The purpose of the workshop was to stimulate discussions and get guidance from leading resource management experts about the best approaches for managing resources in EINP. Forty-five people representing the university community and federal, provincial and municipal government managers/researchers attended the workshop. During the workshop, attendees were divided into three working groups to provide detailed input on issues related to biodiversity, ungulate management, and vegetation/fire.



CRUSTOSE LICHENS:
Chronometers of Environmental Change

Dan McCarthy

Slow growing crustose lichens are some of the most common and longest-lived organisms in Canada's tundra and alpine ecosystems. Though they are the dominant form of vegetation in Canada's northern national parks, it seems that they are seldom the focus of academic research and are rarely mentioned in park interpretive material. Nonetheless, lichens are fascinating and enigmatic. Consider, for example, that some researchers have found large thalli on ^{14}C dated landforms and reasoned that some large crustose lichens may have lived for 3,500 to 8,000 years (e.g., Denton and Karlen 1977; Shroeder-Lanz 1981). Although evidence for this longevity is weak and circumstantial, the claim points out that we know so little about some of the most familiar and potentially oldest organisms in our national parks. Fortunately, long-term monitoring work is beginning to provide insight regarding the growth and ecology of these organisms. Interpretive efforts such as the newly developed Rock Garden Trail in Glacier National Park, BC are also raising public awareness about the beauty and use of these organisms as chronometers of environmental change.

LICHENS AS DATING TOOLS

Lichenometry is a technique that uses the presence, size or coverage of lichens on a surface to estimate the amount of time that the surface has been exposed to the atmosphere. The technique originated in Europe, but was pioneered in the Canadian Arctic by the late Roland Beschel (e.g., Beschel 1950). Lichenometric dating is used mainly by earth scientists to estimate the timing of prehistoric glacial advances, landslides and other geomorphological events. It is especially useful in monitoring polar and alpine environments where eyewitness or documentary accounts are lacking and other methods of dating (e.g., ^{14}C analysis, dendrochronology) are unavailable or yield ambiguous results.

Under ideal circumstances, close estimates of surface age are derived by measuring the diameters of the largest lichens with circular outlines found on landforms of unknown age. Lichen size is compared with a growth curve that is calibrated on deposits of known age. Given a previously calibrated growth curve, almost anyone with a ruler and a small investment of time can produce reasonably accurate age estimates (e.g., ±20 yr) for archeological remains or landform features.

In the Canadian Cordillera, lichenometry is the most economical and accurate dating technique that can be used above timberline to estimate ages for geomorphic events. Growth curves for at least four lichen "species" are now available for use in Jasper and Glacier National Parks, Mount Robson, Peter Lougheed and Tweedsmuir Provincial Parks (e.g., Luckman, 1977; McCarthy, 1985,1993; Watson, 1986; McCarthy and Smith, 1995; Smith and Desloges, 2001). However, several research questions must be addressed before lichenometry can be used to its full potential. Chief among these is the need to determine whether there is significant intra-regional variability in the growth rates of the more useful lichen species. Consider, for example the growth curves for *Rhizocarpon geographicum* and related species shown in Figure 1. These curves can be used to provide minimum estimates of substrate age at sites that have similar micro-environments, but it is not yet clear whether differences in growth rates estimated by the curves are real, a product of methodological errors (e.g., species misidentification), or the result of uncertainties in tree-ring dating controls. Ongoing research is attempting to learn the true nature of intra-regional differences in the radial growth of *R. geographicum* and related species. If we can define these differences more clearly, we can trust the use of lichenometry at sites for which growth curves have not been calibrated. While lichenometry itself does not provide information about environmental change it is an important and inexpensive tool that will allow researchers to better understand the timing of environmental changes.

CURRENT RESEARCH

My lichen research program has three primary components. This includes ecological research, direct measurement of radial growth and the construction of growth curves by sampling lichens on surfaces of known age.

My ecological research is largely focused on the ecology of the yellow-green and black *Rhizocarpons* especially *R. geographicum* and related species. These lichens have a circumpolar and alpine distribution, are extremely slow growing and long lived and are among the most useful species for lichenometry. Unfortunately, very little is known about the ecology of these species and identification keys used in the Canadian Rockies are largely inadequate to classify the range of morphological and other characteristics seen in specimens sampled in the Canadian Cordillera. This situation makes it difficult for potential users of lichenometry to accurately identify the species they are using for dating. Accordingly, collaborative work is underway with lichenologist Katherine Glew of Washington to modify the existing identification key so that it

- *continued on page 12* -

Monitoring Neotropical Migratory Birds in Banff National Park

Cyndi Smith

The maintenance of avian diversity in national parks is an issue that resource managers are only beginning to address. While considerable progress has been made in understanding the landscape level requirements of ungulates and carnivores, neotropical migratory birds challenge us to broaden our thinking to the level of the western hemisphere.

Neotropical migrants (NTMs) are birds that spend most of their lives in the Americas between the Tropics of Cancer and Capricorn, but migrate north to breed. Of the 160 bird species that regularly occur in the Montane Ecoregion of the Bow Valley of Banff National Park, 95 are NTMs (Thomas 1994, Pacas *et al.* 1996).

There is mounting evidence that the populations of NTMs are declining (Thomas 1994, Askins 2000). Initially, habitat loss in the tropics was blamed for these declines, but more recent research shows that there are also problems on the breeding grounds and migration routes. The causes centre largely on human-caused habitat loss, degradation and fragmentation, and on invasive exotic species (Hagan *et al.* 1992). On the summer breeding grounds, the loss of montane habitat (forest and riparian areas) is the biggest threat to NTMs (Hagan *et al.* 1992). Some of this loss is due to degradation and fragmentation (e.g. development in valley bottoms), but also to loss of natural disturbances such as fire, flood, insect and disease outbreaks (Askins 2000).

Long term monitoring of bird species is critical to understanding whether population fluctuations are natural or human-caused. The Monitoring Avian Productivity and Survivorship (MAPS) program was established in 1989 by The Institute for Bird Populations, based at Point Reyes Bird Observatory in California (see sidebar for more information). Its goal is to provide long-term demographic data on landbirds as an aid in identifying the causal factors driving population trends documented by other avian monitoring programs such as the North American Breeding Bird Survey and Christmas Bird Counts (Desante *et al.* 1998). In 1999, the Bow Valley Naturalists established a MAPS station in Banff National Park, Alberta, near where Ranger Creek joins the Bow River, approximately 17 km west of Banff on the Bow Valley Parkway (elev. 1,380 m).

The MAPS program divides the continent into 8 major regions based on biogeographical and meteorological considerations, and each region has target species identified within it. Banff National Park falls into the Northwest Region where the target species are: dusky flycatcher, western flycatcher complex, Swainson's thrush, American robin, warbling vireo, orange-crowned warbler, yellow warbler, MacGillivray's warbler, Wilson's warbler, song sparrow, Lincoln's sparrow, and "Oregon" dark-eyed junco (for scientific names see Table 1 page 15).

The MAPS Program is a recommended survey in the Canadian Landbird Monitoring Strategy of the Canadian Wildlife Service (Anon. 1994). The *Special Resources of Banff National Park* (Achuff *et al.* 1986) recommended further study of Bird Community 9 (montane shrub wetland; of Holroyd and Van Tighem 1983), which is almost

- continued on page 14 -

What is MAPS?

The Institute for Bird Populations (IBP) is a nonprofit corporation dedicated to fostering a global approach to research and the dissemination of information on changes in the abundance, distribution, and ecology of bird populations. It is based at Point Reyes Bird Observatory in California, USA. IBP focusses on a number of programs to achieve its goals —one of these programs is Monitoring Avian Productivity and Survivorship (MAPS), established in 1989.

MAPS is modelled after the successful British Constant Effort Sites scheme operated by the British Trust for Ornithology. It utilizes a standardized constant-effort mist-netting protocol at a network of stations, now numbering over 500 in North America.

The premise behind MAPS is the monitoring of vital rates (primary demographic parameters such as productivity and survivorship). It is important to monitor vital rates because: (1) they are directly affected by environmental stressors and management actions, usually without the time lag often associated with monitoring population size, (2) they provide crucial information about the stage of the life cycle at which population change is being affected, and (3) they provide crucial information about the viability of the population being monitored and about the quality of the habitat or landscape in which the population occurs.

Further information about IBP and MAPS may be obtained from their website http://www.birdpop.org.
An overview of the program is also available at the site for downloading.

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extracted from an area just outside the current Chara zone, which is currently restricted to the areas deeper than 3.5 m in the basin. During high water levels Chara expands in the broad basin and conversely, it contracts to the deeper holes during low water levels.

Macroscopic Charcoal Analysis

The inferred fire frequency, based on the charcoal record, is plotted together with the dry:wet pollen ratio data (Figure 1). The 10,000 year CHAR record divides visually into three periods: Period 3 (ca. 10,000-8200 calendar years BP) of intermediate charcoal peak frequency; Period 2 (ca. 8200-4000 years BP) of high charcoal peak frequency, and; Period 1 (ca. 4,000 to present).

Pollen Ratio Analysis

The 10,000 year pollen ratio data corresponds to the charcoal zones (Fig. 2). The Zone 3 pollen ratio does not become effective until Pseudotsuga-Larix pollen enters the core at around 9000 years BP. Near the end of Period 3 the ratio increases and indicates dry-open forests. The Period 2 ratio consistently indicates dry-open forests. The highest values (0.2) occur from ca. 6100-4500 years BP. A decrease begins by 4500 years BP, indicating wetter closed forests. The Period 1 ratio continues to decrease indicating predominately wet-closed forests. The lowest values (-1.0) occur from ca. 3500-2800 years BP. This represents a prolonged period of wet-closed forests and corresponds to glacial advances in the Rockies (Hallett and Walker, 2000). After 2800 years BP, the ratio increases with two high values centred at 1900 and 1000 years BP. These two peaks of dry-open forest represent the last periods of dry open forests similar to those of Period 2. The ratio decreases rapidly after 700 years BP and indicates a return to wet-closed forests.

The 1,000 year record indicates a strong relationship between periodic drought and large fires (Figure 2). Charcoal peaks in the 1,000 year sediments correspond to nearby, upwind polygons on the time-since-fire map (Masters 1990) through the 1640s. The presence or absence of Chara indicates high or low lake levels. The lowest lake levels and largest fires occur during the Medieval Warm Period 1000-1300 and at approximately 1800 AD. These are the only times when Chara is completely absent from the record. Other periods of low lake levels and large fires are 1490-1500s, 1600-1650s, and 1890-1920s. The Little Ice Age (1300-1850) was generally a period of high lake levels and little fire activity.

DISCUSSION

The 10,000 year Dog Lake record indicates a wide range of natural variability for climate, fire and vegetation change in the Kootenay Valley since glaciation. In general, forest cover and fire frequency around the lake has shifted with regional climate through 3 distinct climatic periods.

Period 3
(ca. 10,000-8,200 calender years BP)

Amounts of Poaceae, Juniperus and Pinus pollen from 10,000 to 9000 years BP (Hallett, 1996) are indications of dry-open conditions. Low pollen ratios in this zone are not indicative of dry:wet vegetation cover because Pseudotsuga/Larix pollen does not enter the core until 9000 years BP. By the end of zone three, Pseudotsuga/Larix pollen begins to change the ratio to dry-open forests.

Period 2
(ca. 8,200-4,000 calendar years BP)

The time of maximum aridity in much of western North America occurred around 6000 years BP (Thompson et al., 1993). The highest fire frequencies recorded in the Dog Lake record occur in this zone when dry open forests dominated the valley.

Period 1
(ca. 4,000 calendar years BP-present)

The decline in fire frequency, indicative of wetter/cooler conditions, after 4500 calendar years BP corresponds with the first recorded Neoglacial advances in the Rockies. Fire frequencies appear to increase slightly in the last 2000 years and pollen ratios indicate a return to drier, more open forests.

The high resolution reconstructions for the last millennium at Dog Lake demonstrate the close coupling of regional climate and fire regimes. Droughts occurred periodically and were accompanied by large, stand destroying fire events. The Medieval Warm Period corresponds to low lake levels and frequent fire activity. The Little Ice Age corresponds to generally high lake levels and little fire activity.

CONCLUSIONS

Three main conclusions arise from the data discussed above. First, there is no steady state for vegetation or fire in the Kootenay Valley. Rather, there are several possible ecosystem

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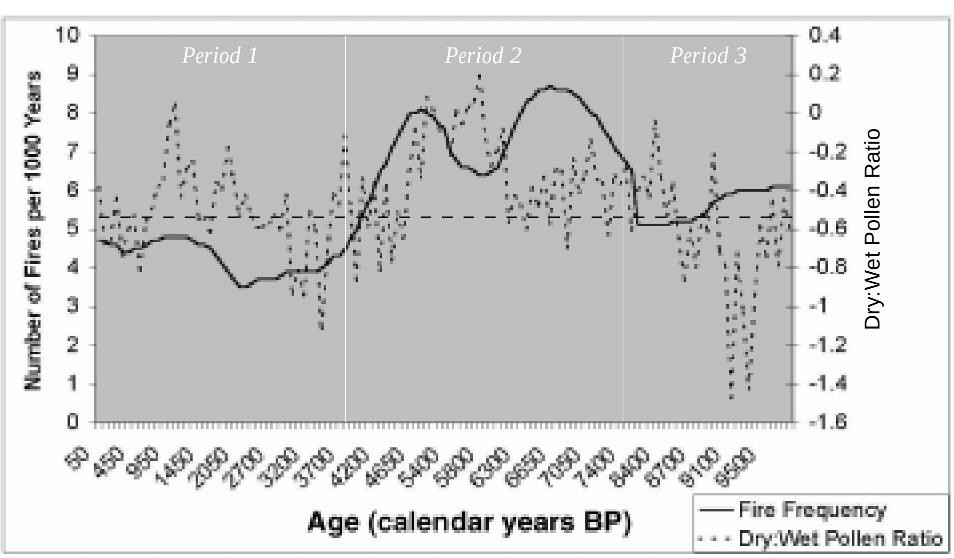

Figure 1. The inferred fire frequency, based on the charcoal record, and dry:wet pollen ratios are shown for the 10,000 year Dog Lake sediment core. Log (base 10) pollen ratios of Pseudotsuga-Larix + Poaceae divided by Picea + Abies are used to infer periods of dry-open and wet-closed forests. Increasing pollen ratio numbers indicate drier, more open forest conditions. The dry:wet ratio is only meaningful after the first arrival of Pseudotsuga-Larix pollen in the core at approximately 9000 years BP. Dashed horizontal line represents current forest conditions indicated by pollen ratios. For a more detailed presentation of these results, see Hallett and Walker 2000.

Paleoecology and Fire History of Kootenay National Park

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states corresponding to Periods 1-3 as well as periods of transition.

Second, the range of natural variability for climate and fire in the Kootenay Valley is very broad. Resulting forest conditions at Dog Lake range from dry, open, Interior Douglas Fir to closed, wet, Englemann Spruce/ Subalpine Fir (Meidinger & Pojar 1991). Current conditions are intermediate to these forest types.

Third, current global climate trends and the evidence of periodic drought at Dog Lake and at other locations throughout western North America, indicate that the frequency and severity of fire events may increase in the near future (Flannigan & Van Wagner 1991, Wotton & Flannigan 1993). Based on the drought and fire frequency reconstruction for Dog Lake, the next peak drought period is forecast for 2030-2050 AD (Hallett et al. in prep). Drought may also cause increases in forest insects and other pathogenic organisms that may be currently climate limited (Price & Apps 1996). Interactions between climate, fire and bark beetles over the last millennium are currently under investigation in KNP following the preliminary work reported in Prenzel and Walker (1996).

Managers must look beyond traditional methods of assessing natural variability of forested ecosystems when determining management targets. Traditional, dendrochronological fire histories analyze a small portion of a continuously varying record and may provide a false sense of the range of both past conditions and possible future conditions. Short term datasheets must be considered in relation to longer term paleoecological data sets.

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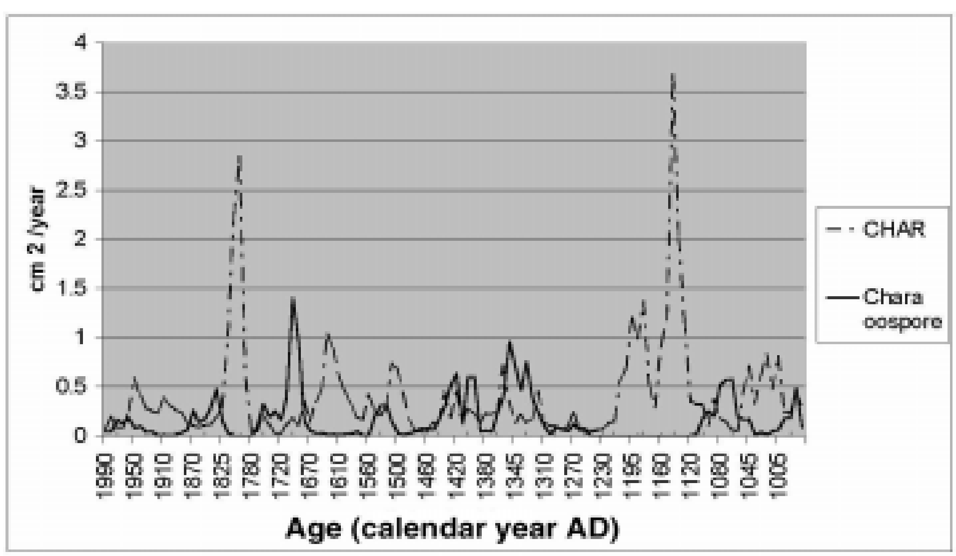
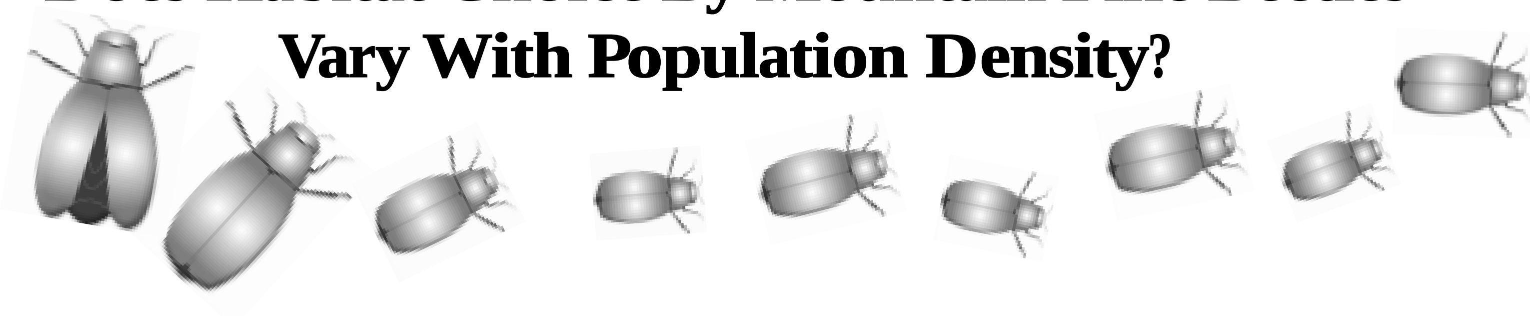


Figure 2. Charcoal particles/cm²/year and Chara oogonia /cm²/year are shown for the 1,000 year Dog Lake sediment core. CHAR peaks above 0.4 represent fires close to the lake. CHAR peaks from 1.0 to 3.0 represent large, stand destroying fires in the watershed. Increasing levels of Chara macrofossils indicate increasingly wetter climate. Absence of Chara macrofossils indicates drought conditions. Note the periods of absent Chara macrofossils and associated CHAR peaks. For a more detailed representation of these results, see Hallett et al in preparation

Does Habitat Choice By Mountain Pine Beetles Vary With Population Density?



Ché Elkin

Mountain pine beetle (MPB) (*Dendroctonus ponderosae* Hopk.) is an aggressive bark beetle, common to Western North American coniferous forests, that exhibits outbreak population dynamics. During an outbreak MPB density can increase by several orders of magnitude and beetle induced tree mortality can occur over thousands of hectares (Cole *et al.* 1976). Such an outbreak is currently underway in BC. Because of the scale and severity of MPB's interaction with their host trees they are an important force in shaping montane forest ecology. Outbreaks not only modify the composition and dynamics of forest communities, but they also directly modify the beetles' environment (Raffa & Berryman, 1983). The objective of this research is to determine whether MPB behaviour changes in response to MPB population density, and to improve our ability to predict the growth and spread of MPB populations.

Population dynamics, host attack strategies and beetle reproductive strategies may differ considerably between low density and high density (outbreak) populations (Raffa & Berryman 1983). Successful colonization and beetle reproduction in a host tree only occurs when beetle aggregation is sufficient to overwhelm the tree's anti-parasite defenses. A tree's ability to resist colonization depends on the condition of the tree and the intensity of the beetle attack. When beetle population densities are low, only trees that are weakened with corresponding low defenses (Berryman 1976) are available for colonization (Hodges & Pickard 1971). In contrast, outbreak populations with high population densities allow beetles to successfully mass-attack trees that possess strong anti-parasite defenses. The ability to attack trees with strong defenses allows beetles to access the thick, nutritive phloem layer of the trees. These trees are high quality reproductive environments. In addition, suitable hosts are more available to high-density MPB populations because the beetles are not restricted to attacking weakened hosts.

The condition of hosts attacked by MPB, and the amount of energy the beetles invest in locating a host tree, may change with beetle population density. In low-density populations, beetles that can be choosy, and invest more energy to locate weakened trees, are predicted to have high reproductive success. Conversely, in high-density populations, beetles that are less choosy in deciding what host to attack may have high reproductive success because they are not allocating energy towards host location that can otherwise be invested in reproduction.

The small size and fast movements of MPB make it difficult to examine host choice behaviour by individual beetles. Therefore, I examined host choice indirectly by comparing the condition of beetles visiting an individual host tree to the condition of beetles that make the decision to attack the tree. Beetle condition was measured as the percent fat of a beetle's body mass; fat is the primary energy used by beetles during flight (Thompson & Bennett 1970). Within a stand, if a host tree is of poor quality, as measured by the low reproductive success of beetles reproducing within it, I predict that it will only be attacked by beetles that have low energy reserves (i.e. beetles that cannot invest more energy to locate a better host). Therefore, I predict the energetic condition of beetles attacking a poor quality tree will be low relative to the condition of beetles that visit the tree (Figure 1).

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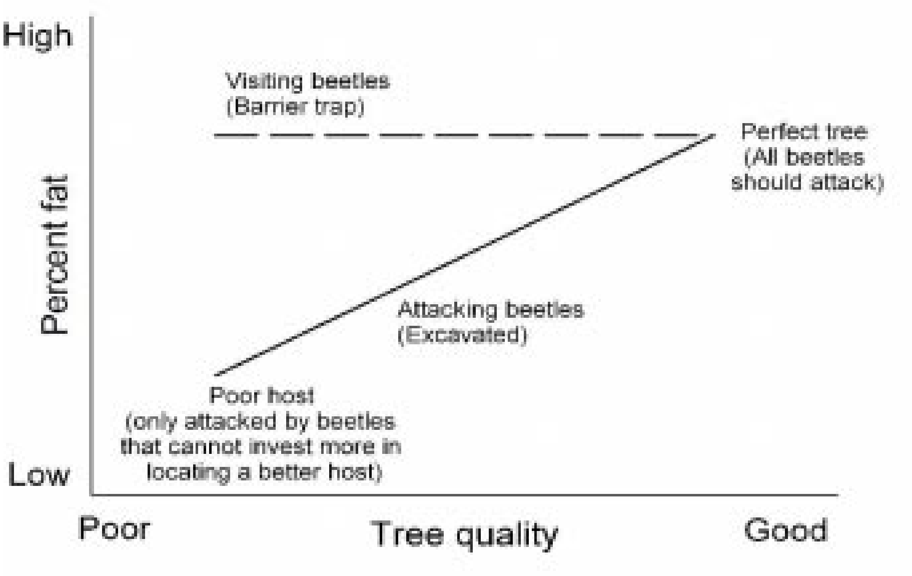

Figure 1. Predicted host choice by different condition (percent fat) beetles on host trees that vary in quality. Good condition beetles are predicted to be more selective in choosing which host trees to attack (interaction between visiting and attacking beetles, and tree quality).

Does Habitat Choice By Mountain Pine Beetles Vary With Population Density?

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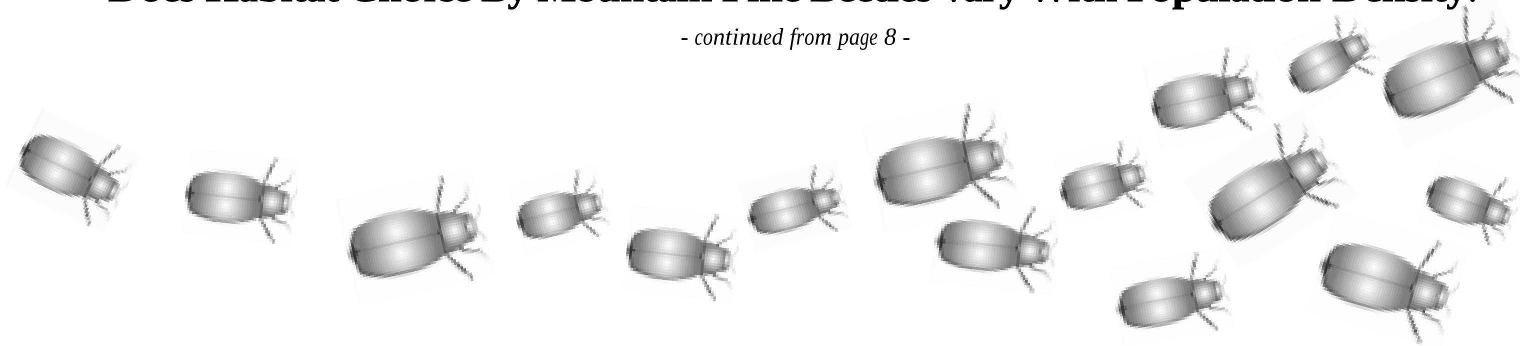

Between populations, if one population of beetles was more selective than another for the same tree stand, the condition of beetles visiting trees should be relatively high compared to the condition of beetles attacking trees. In low density beetle populations, poor host selection may carry a high reproductive cost because attacking a tree that is not colonized successfully can result in the death of offspring and possibly the parent beetle. Consequently, I expect that low-density beetle populations will be more selective, and the mean condition of beetles visiting trees will be high compared to the mean condition of beetles attacking trees (Figure 2).

The results presented here are preliminary findings of experiments conducted in Kootenay National Park during the summer of 2000 and experiments done in the Columbia Valley in 1999.

METHODS

During June, 2000 I selected five sites in Kootenay National Park that varied with respect to MPB density and availability of suitable host trees. At each site, five focal trees were chosen with diameter at breast height (DBH) between 60 and 90 cm. Focal trees were separated by 30 m and arranged in a pentagon formation. A 20x30 cm Plexiglas barrier trap was attached to each focal tree at height of 1.5 m to catch visiting beetles.

I initiated MPB aggregations on each focal tree by “implanting” 5 female and 2 male MPB that were newly emerged. I attached 20x30 cm sheets of aluminum window screening to the north side of each focal tree at a height of 1.3 m. The beetles to be implanted were placed within the pocket created between the window screening and the tree trunk. This technique allowed the beetles to select where they would enter the tree, and allowed the natural production and diffusion of aggregation pheromones.

Following beetle implantation all focal trees were checked bi-weekly. I assessed attack density by counting and marking all new MPB attacks on focal trees. To determine the quality of beetles choosing to settle, a subset of newly attacking beetles were excavated from each focal tree and immediately killed. Visiting beetles caught in barrier traps were also collected. All excavated beetles and beetles caught in the barrier traps were sexed, the width of their pronotum measured, and their percent body fat (by mass) determined by petroleum ether fat extraction as described by Anderbrant (1988). To account for differences in the fat content of beetles emerging from each site I normalized my measurement of percent fat by dividing individual measurements by the mean percent fat of beetles at each site.

Following the MPB flight period I measured MPB population density and the availability of host trees at each site. Circular plots, 20 m in diameter, were established around each focal tree. I measured the DBH of all trees within the plots and recorded the density of attacks on the trees. Mountain pine beetle attack density was measured by counting the number of new entrance holes within a 20x20 cm quadrat; attack density was assessed at 1.5 m on the north and south side of each tree. I evaluated population densities as the cumulative number of attacks/m^2 summed across all attacked trees within a plot.

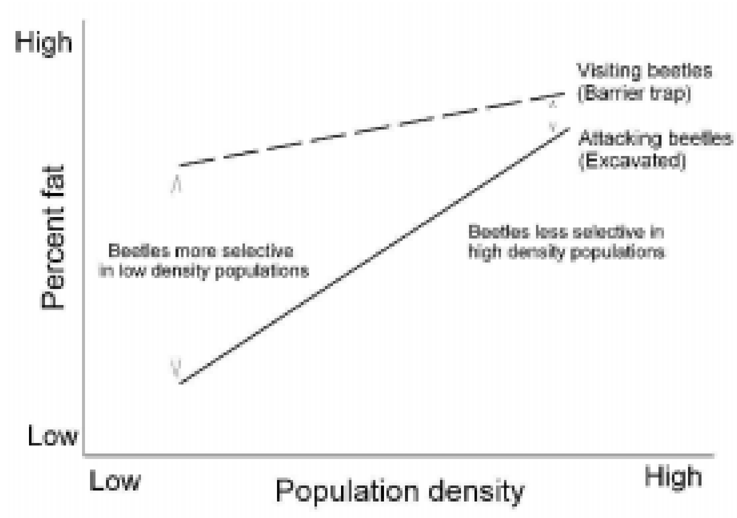

Figure 2. Predicted host choice by different condition (percent fat) beetles across sites with increasing population densities. Mean condition of beetles visiting and attacking beetles will be lower in low-density populations due to the decreased availability of suitable hosts. Beetles in low density populations are predicted to be more selective in choosing a host tree to attack because the costs of making a poor host choice are greater (potentially zero reproductive success because the host tree is not successfully colonized).

The reproductive success achieved by MPB in a host tree depends on the tree’s level of antiparasite defenses, phloem quantity and quality, and the level of intraspecific competition among beetle larvae. I used a model created by Safranyik *et al.* (1999) to determine the quality of each focal tree with respect to beetle reproductive success. The model uses focal tree DBH and MPB attack density to calculate the probability of a larva surviving until pupation. I used the probability of an oviposited egg surviving to pupation as a surrogate measure of host dependent reproductive success.

To determine how the quality of beetles visiting and attacking a tree of a given quality varied with beetle density, I analyzed beetles’ fat content using a multiple regression with the independent variables of collection method (barrier trap vs. excavated beetles), host quality and beetle population density. I also included the

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Does Habitat Choice By Mountain Pine Beetles Vary With Population Density?

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interaction terms among collection method, host quality and population density to see whether the difference between visiting and attacking beetles varied with host condition and population density, respectively.

RESULTS

The above multiple regression model accounted for 35.9% of the variation in percent fat of all the beetles analyzed (multiple regression: N=621; $P < 0.0001$). The condition of beetles both visiting and attacking higher quality hosts was greater than the condition of beetles found on lower quality hosts (Figure 3) ($F= 8.2$, $DF=1,605$, $P < 0.003$). This suggests that beetles in good condition were better at locating good quality hosts within a stand. Attacking beetles had a higher percent fat than beetles visiting trees ($F= 11.3$, $DF= 1,605$, $P< 0.001$). This finding is contrary to my prediction that attacking beetles should be in worse condition because they are a subset of all the beetles that visit a tree. A possible explanation is that attacking beetles may increase their fat reserves during the brief time they were excavating galleries before I was able to remove them from the trees. The difference in quality of beetles visiting and attacking a tree did not vary with host quality (interaction between collection method and host quality: $P > 0.2$), indicating that beetles in better condition were as likely to accept a tree after visiting regardless of tree quality.

In higher density populations, the general condition of beetles visiting and attacking trees was better than in lower density populations (Figure 4)($F= 8.2$, $DF=9,605$, $P<0.001$). Contrary to my original prediction (Figure 2), beetles in good condition were more selective with respect to host quality in higher density populations. The difference in quality between visiting and attacking beetles was greater in high density populations than in low density populations (Figure 4)(interaction between collection method and population density: $F= 4.8$, $DF= 1,605$, $P< 0.03$).

DISCUSSION

These preliminary findings suggest that the ability of MPB to locate hosts and MPB selectivity with respect to host quality, depend on beetle condition and the density of the MPB population. Within a stand, beetles that were in better condition were better at locating higher quality hosts than were beetles in poorer condition. Variation in the reproductive success of good condition and poor condition beetles may therefore be magnified because good condition beetles are benefiting from not only having more energy to invest in reproduction, but also because on average they are able to reproduce within hosts that will yield higher reproductive success.

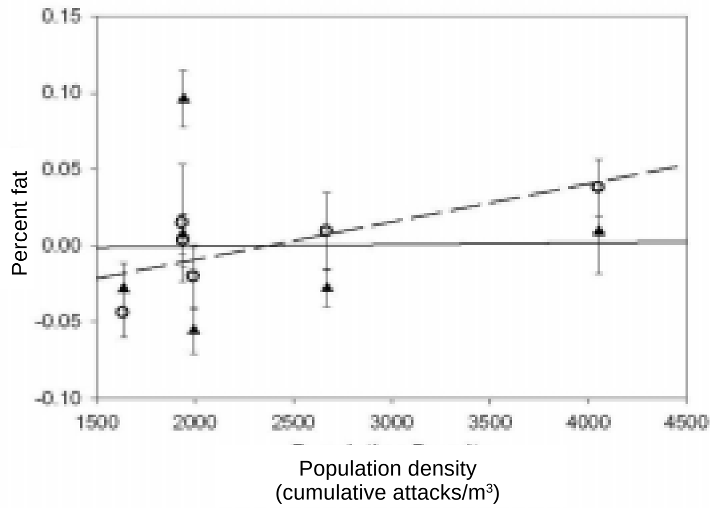

Figure 4. Standardized mean (±SE) percent fat of beetles visiting (O) and attacking (▲) host trees in sites with varying population density. The linear regression line of percent fat vs. population density is represented for visiting beetles (O) by the dashed line, and the solid line for attacking beetles (▲)

My finding that beetles in high-density populations were more selective than beetles in low-density populations may reflect the limited number of suitable hosts available to MPB in low-density populations. If suitable hosts are sufficiently rare in low-density beetle populations, MPB may not be selective with respect to host quality because the probability of locating other potential hosts is very low. Alternatively, the high degree of selectivity displayed by MPB in high-density populations may reflect the high cost of larval intraspecific competition. If larval competition is more pronounced in high-density MPB populations, beetles that are selective and attack a host on which a MPB aggregation is beginning to form may achieve greater reproductive success.

MPB is a destructive pest species and considerable work has been done to elucidate which factors influence their transition from low density to high density populations. However, it is still

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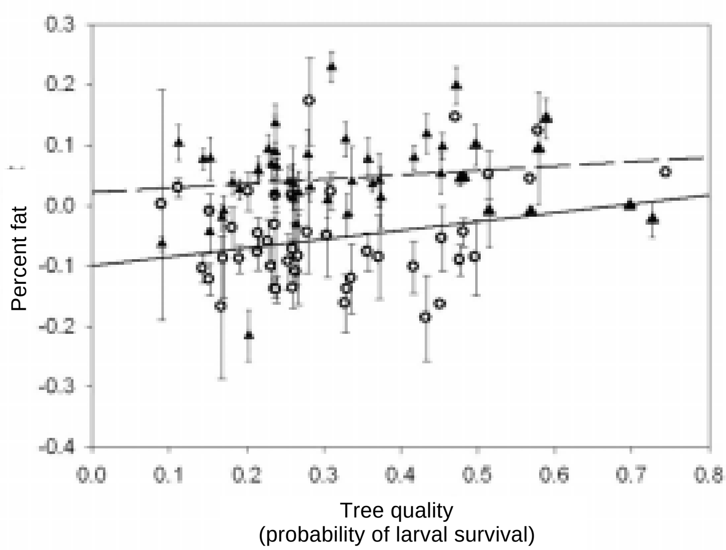

Figure 3. Standardized mean (±SE) percent fat of beetles visiting (O) and attacking (▲) host trees that vary in quality. The linear regression line of percent fat vs. host quality is represented for visiting beetles (O) by the dashed line, and the solid line for attacking beetles (▲)

Does Habitat Choice By Mountain Pine Beetles Vary With Population Density?

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not clear how abiotic and biotic factors interact to facilitate outbreaks. The preliminary results of this research suggest that examining the interactions between beetle condition, beetle behaviour, and population density may be important in understanding mountain pine beetle population dynamics.

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Monitoring Neotropical Migratory Birds in Banff National Park

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Crustose Lichens

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is easier for nonlicheologists to use. We are optimistic that a more robust key will lead to an increased understanding of intra-regional differences in growth and colonization. However, morphological traits alone may not tell us much. (How useful is an ability to recognize the lichen equivalent of "blondes, redheads and brunettes"?)

In 1996, permanent plots were established to monitor lichen growth and community development on quartzites near the Illecillewaet Glacier in Glacier National Park and on a rockslide near Jonas Creek in Jasper National Park. Approximately 150 crustose lichen thalli have been marked, measured and photographed annually at these sites. Geographic Information Systems (GIS) software is also being used to monitor recruitment and morphological changes in the lichen communities.

Preliminary results of the growth rate studies show that there is tremendous variation in radial growth rates both within (Figure 2) and between thalli of all sizes (Figure 3). In Figure 2, for example, it can be seen that parts of the thallus margin show no growth and other areas show "rapid" growth. This variability raises the question of what value is best used to represent the radial growth rate of a lichen thallus. In addition, there are indications that larger (presumably older) thalli may have slower radial growth than is found in smaller (presumably younger) thalli. Unfortunately, a larger data set is needed before I can establish whether this represents a statistically significant trend. Nonetheless, the observations are consistent with anecdotal reports from Europe and long-term growth rates estimated by the locally calibrated growth curve.

A publication is now being prepared (McCarthy, *in prep.*) to document the development of a growth curve for *R. geographicum* and related species at the Illecillewaet Glacier. The trend represented in that curve shows that radial growth rates at that glacier and at Mount Edith Cavell (about 250 km to the North) are similar for the first century of growth (Figure 1). This is somewhat surprising because more rapid growth rates were expected at the wetter Illecillewaet site.

IMPLICATIONS FOR FUTURE RESEARCH

Further study is needed to determine whether identical lichen species or subspecies ("blondes, redheads or brunettes") were measured in previous studies. Perhaps it will be possible to use a single growth curve to estimate ages for lichen colonized surfaces throughout the cordillera. If this is the case, we could place greater trust in the ages estimated by lichenometry and researchers would be freed from the difficult task of developing a growth curve for each new study site.

During preliminary testing I developed a technique that uses macro-photography and Adobe Photoshop software to collect accurate percentage cover data from lichen communities (McCarthy and Zaniewski 2001). Collaborative work has also begun with Frank Fueten of Brock University. That project will attempt to modify existing geological software so that it can be used to automate the extraction of lichen data from digitized photographs. It is likely that the software will be distributed as "freeware" early in the new year.

Work also continues on the development of a better identification key for *R. geographicum* and related species in the Canadian Cordillera. Lichenologist Katherine Glew and I are analyzing voucher samples. We developed a preliminary key that will be modified as the characteristics of the yellow-green and black *Rhizocarpons* are studied in greater depth.

Data collected with image analysis software may also resolve the debate over claims that lichen thalli live for several thousand years.

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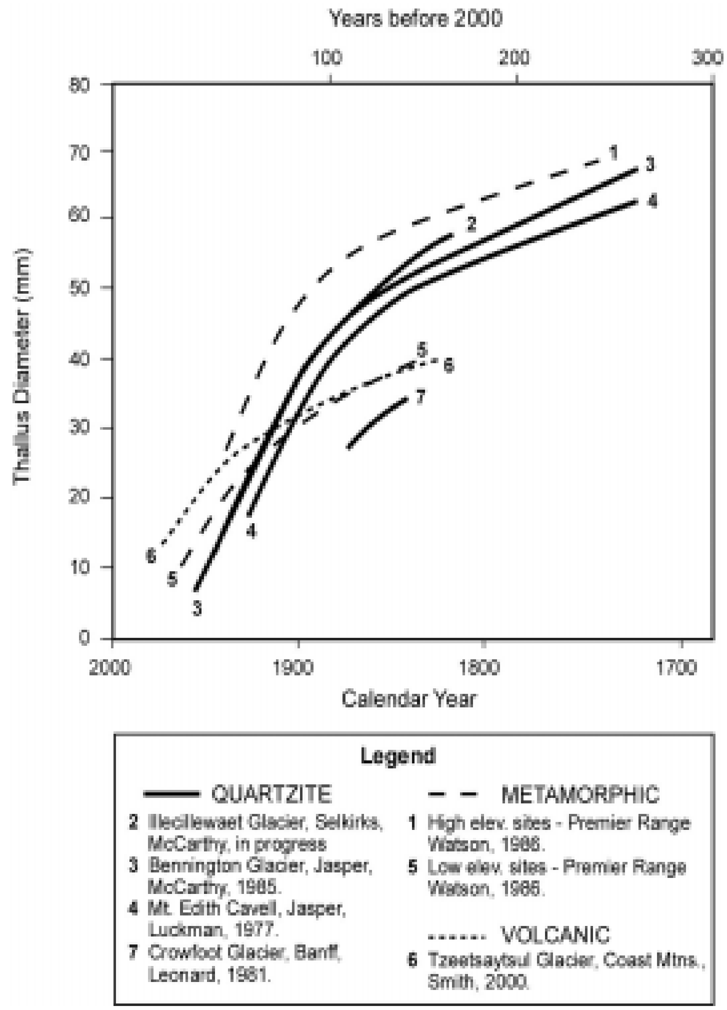

Figure 1. Growth curves indicating rates of radial growth in thalli of Rhizocarpon geographicum and related species. These curves were developed from measurements done at historically and tree-ring dated sites near glaciers in Alberta and British Columbia. It is not clear whether the apparent variation in growth rates is real or may be due to errors inherent in the calibration techniques. The growth curves enable users of lichenometry to estimate minimum ages for lichen covered surfaces at sites near where these curves were calibrated

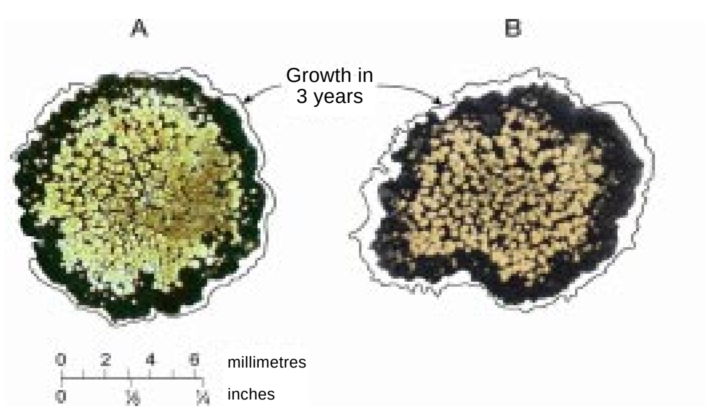

Figure 2. The growth of these Rhizocarpon thalli has been monitored for three years. Users of lichenometry assume that lichens with circular outlines (A) are single individuals that achieved a circular shape by slow radial expansion, while lichens with irregular shapes (B) may form by merging with neighbors.

Crustose Lichens

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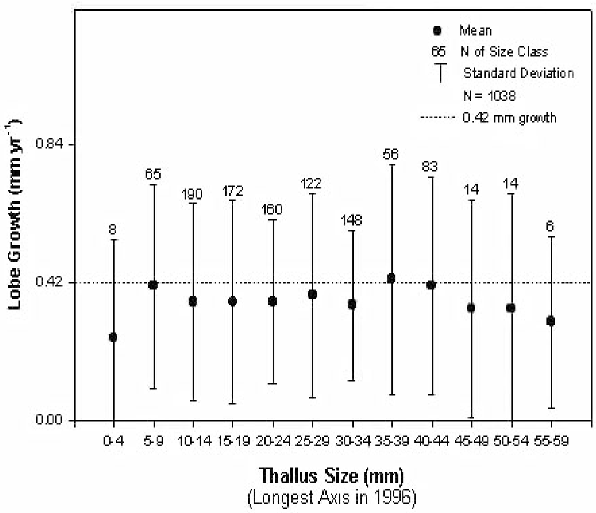

Figure 3. This graph shows annual radial growth rates of Rhizocarpon thalli measured in the summers of 1996 and 1997at the Illecillewaet Glacier. The dashed line represents the growth rate (0.42 mm yr^{-1}) that was estimated by Luckman (1977) at Mount Edith Cavell in Jasper National Park.

The aim is to test the hypothesis that some enormous and presumably old thalli may be much younger than their size suggests. My interest has been sparked by recent reports that some species of *Rhizocarpon* do not grow outward solely by slow radial expansion from a central point, but can fuse with other thalli, leaving no physical or molecular evidence to show that they were once individuals. Image analysis software allows the collection of large, quantitative data sets, so it should be possible to establish statistically whether rates of thallus fusion and thallus circularity increase with age. Smooth bedrock in glacier forefields is ideal for this sort of study because the lichen populations have not been disturbed artificially and are found on surfaces of known age.

As we learn more about the nature of lichen colonization and growth we may resolve questions about the longevity of slow growing crustose lichens and will gain appreciation for why lichenometry works (McCarthy 1999). Meanwhile, lichenometry is still one of the most useful techniques for measuring alpine environmental change. Will we soon use photographs and computer software to estimate lichenometric ages quickly? Can we prove that a lichen can live for 8000 years? Do different morphological types ("blondes, redheads and brunettes") of *Rhizocarpons* live longer or exhibit different "behavior"? Clearly, lichens are more fascinating and useful than they appear at first glance.

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Monitoring Neotropical Migratory Birds

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wholly confined to the Vermilion Lakes Ecosection in the Montane Ecoregion. Waterfowl species of this community have been studied extensively, but only recently have we focused on landbird surveys.

The site near Ranger Creek was chosen as (1) being representative of the ecosection (wet shrub/spruce complex), (2) receiving little human traffic, and (3) having easy access. The station is situated in the Vermilion Lakes Ecosite 3, which encompasses wet level floodplains dominated by forest and shrub vegetation (Holroyd and Van Tighem 1983). Vegetation patterns are complex. The 4 primary habitats are: closed canopy spruce forest, shrubland, montane meadow and closed canopy aspen-spruce forest.

The only other MAPS station in a national park in western Canada is in Mount Revelstoke National Park, British Columbia and is operated by the Friends of Mount Revelstoke and Glacier.

METHODS

The MAPS protocol consists of standardized constant-effort mist-netting during the breeding season (Burton and Desante 1998). The breeding season extends from May to August, depending on local latitude and altitude, and is divided into 10 – 10-day periods. For Ranger Creek, the MAPS season begins in period 5 (June 10 - June 19) and ends with period 10 (July 30 - August 8). Ten mist nets were operated for 6 hours from sunrise on 1 day during each of the 6 periods.

The mist nets were placed where birds could be captured most efficiently, such as the brushy portions of wooded areas, forest breaks or edges, and the vicinity of water. The type and location of all nets are kept constant for the duration of the study. To facilitate constant-effort comparison of data, nets are opened, checked, and closed in the same order on all days of operation.

Each bird captured is marked with a uniquely numbered, internationally recognized aluminum leg band. Band number, species, age and sex, ageing and sexing criteria, weight, wing length, moult condition, date, time, and net number are recorded for all birds captured, including recaptures. The times of opening and closing each net and beginning of each net run are recorded each day so that effort can be calculated for each 10-day period. In addition, all species that are identified only by call, or were observed at the station are also recorded.

All species that were captured, observed or heard at the station each day were recorded, along with their apparent breeding status. At the end of the season the status for each species was reviewed and a breeding status assigned. The criteria for assigning breeding status were: nest with egg or young, or in the process of being built; adult seen carrying nest material, food or fecal sac; very young fledgings being fed by parents; a young bird incapable of sustained flight, and; a territorial male present throughout the breeding season.

RESULTS

From 1998-2000, 540 birds (including recaptures) of 41 species have been captured: 25 birds of 13 species during a pilot day in 1998, 282 birds of 37 species in 1999, and 233 birds of 31 species in 2000. In 2000, a total of 39 juveniles of 20 species were captured, compared to only 12 juveniles of six species in 1999. The capture rate was 79 birds/100 net hours in 1999 and 61 birds/100 net hours in 2000.

Fewer new adults were banded in 2000 than 1999 (111 vs. 183; 19 on the pilot day in 1998), which is to be expected after the initial high number of captures when a site is newly established. Thirteen individuals, representing 9 species, have been banded in one year and recaptured in a subsequent year. All other recaptures were banded and recaptured in the same year.

The species list for the Ranger Creek station totalled 74 bird species including those that were captured, as well as any identified only by call or observed at the site; of these, 35 species were confirmed to be breeding (Table 1).

DISCUSSION

Based on the first two years of operation of the Ranger Creek MAPS station, it appears that the site was well chosen to represent the montane wet shrub complex, and its avian fauna. The average capture rate of 70 birds/100 net hours was considerably higher than the average capture rate of 30 birds/100 net hours from 1996 to 1999 at the MAPS station at the Inglewood Bird Sanctuary in Calgary, Alberta (Collister *et al.* 1997, Booth and Collister 1998 and 1999, Collister *et al.* 2000). This suggests that the abundance of individuals at Ranger Creek is fairly high. Productivity, as suggested by number of juveniles banded, was considerably higher in 2000 than in 1999 (when there was a lot of cold, wet weather in July).

Fifty-two of the 74 species identified at the site were NTMs; 23 of the species captured and banded were breeding NTMs. All of the target species, except for dusky flycatcher and western flycatcher, were captured, observed or heard at the site; all were confirmed breeding except for MacGillivray's warbler. The Institute for Bird Populations (IBP)will analyse mark-recapture data from breeding target species to assess population and demographic information. Local data can then be compared to those obtained from other MAPS stations across the continent. Annual indices and longer-term trends in adult population size and post-fledging productivity will be determined from analyses of numbers and proportions of adult and young birds captured during the breeding season. Annual estimates and identification of longer-term trends of adult survivorship, adult population size, and recruitment into the adult population will be possible from analyses of mark-recapture data on adult birds. But it will be a few years before the data gathered from the Ranger Creek station can be analyzed, due to the considerable natural variation in abundance and in weather effects.

We will be able to use the same methods to analyse mark-recapture data from breeding species not targetted by IBP. These indices and estimates can be used by park managers to identify the proximate causes of population changes in the target species, identify conservation and management actions to help reverse the population trends of declining species, and evaluate the effectiveness of conservation and management actions.

Monitoring of avian use of the site will also provide valuable baseline data to study the effects of vegetation changes and altered hydrological processes on avian fauna, as the station is situated on the edge of an active beaver dam.

Long-term monitoring of neotropical migratory birds will assist Banff National Park managers to assess the state of biodiversity in the park and contribute to understanding trends at the continental and hemispheric scale (thus fulfilling the agency's international obligations), to track progress towards the maintenance or restoration of ecological integrity, and to identify more specific research needs (Parks Canada Agency 2000).

ACKNOWLEDGEMENTS

Sixteen volunteers contributed 370 hours to the MAPS project in 1999; in 2000 twenty-one volunteers contributed 283 hours. The

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Monitoring Neotropical Migratory Birds

- continued from page 14 -

encouragement and professional assistance of Doug Collister, Grahame Booth, Greg Meyer and Dale Paton, all banders from the Calgary Bird Banding Society, was greatly appreciated. Funding was received from the James L. Baillie Memorial Fund of Bird Studies Canada with funds raised through the annual Baillie Birdathon, the Bow Valley Naturalists, Parks Canada and donations from volunteers.

Cyndi Smith is the MAPS Coordinator for the Bow Valley Naturalists. She has been a park warden in Banff National Park since 1990, but has just moved to Waterton Lakes National Park to the position of conservation biologist. Her research interests include harlequin ducks. Tel. (403) 859-5137; fax (403) 859-2279; email: cyndi_smith@pch.gc.ca.

- references on page 11 -

Table 1. Species captured (not including recaptures), heard or observed at Ranger Creek MAPS station 1998-2000. Breeding status and number of birds banded given for each species by age.

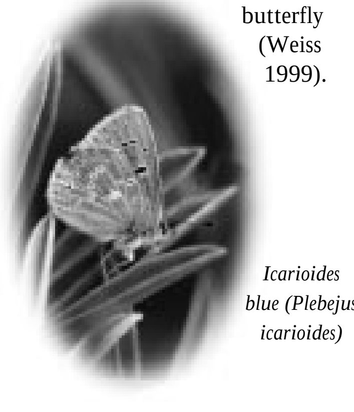
Common (Scientific) Name	**Breeding Status[1] / # Adults Banded / # Young Banded**
Captured	
Common snipe (*Gallinago gallinago*)	B/1/0
Calliope hummingbird*[2] (*Stellula calliope*)	B/0/0
Rufous hummingbird*[2] (*Selasphorus rufus*)	B/0/0
Unidentified Traill's flycatcher*[3]	B/18/0
Willow flycatcher* (*Empidonax traillii*)	B/5/7
Least flycatcher* (*E. minimus*)	B/6/1
Hammond's flycatcher* (*E. hammondii*)	T/1/0
Warbling vireo* (*Vermivora gilvus*)	B/7/0
Northern rough-winged swallow* (*Stelgidopteryx serripennis*)	T/2/0
Black-capped chickadee (*Poecile atricapillus*)	B/2/2
Mountain chickadee (*P. gambeli*)	T/1/0
Boreal chickadee (*P. hudsonicus*)	T/1/0
Red-breasted nuthatch (*Sitta canadensis*)	B/2/1
Golden-crowned kinglet (*Regulus satrapa*)	B/2/2
Ruby-crowned kinglet* (*R. calendula*)	B/11/2
Swainson's thrush* (*Catharus ustulatus*)	B/4/0
American robin* (*Turdus migratorius*)	B/19/3
Varied thrush (*Ixoreus naevius*)	T/1/0
Cedar waxwing* (*Bombycilla cedrorum*)	B/3/0
Tennessee warbler* (*Vermivora peregrina*)	T/2/0
Orange-crowned warbler* (*V. celata*)	B/8/0
Nashville warbler* (*V. ruficapilla*)	M/1/1
Yellow warbler* (*Dendroica petechia*)	B/31/3
Magnolia warbler* (*D. magnolia*)	T/2/0
Yellow-rumped warbler*[4] (*D. coronata*)	B/2/4
Audubon's warbler* (*D. c. audubonii*)	B/19/6
Myrtle's warbler (*D. c. coronata*)	B/5/2
Townsend's warbler* (*D. townsendi*)	B/2/2
Blackpoll warbler* (*D. striata*)	B/4/0
American redstart* (*Setophaga ruticilla*)	T/10/1
Northern waterthrush* (*Seiurus noveboracensis*)	B/14/1
MacGillivray's warbler* (*Oporornis tolmei*)	T/5/0
Common yellowthroat (*Geothlypis trichas*)	B/25/1
Wilson's warbler* (*Wilsonia pusilla*)	B/30/2
Chipping sparrow* (*Spizella passerina*)	B/10/1
Fox sparrow (*Passerella iliaca*)	B/11/3
Lincoln's sparrow* (*Melospiza lincolnii*)	B/12/3
White-crowned sparrow* (*Zonotrichia leucophrys*)	B/3/0
"Oregon" dark-eyed junco (*Junco hyemalis*)	B/8/2
Brown-headed cowbird* (*Molothrus ater*)	B/5/5
Pine grosbeak (*Pinicola enucleator*)	L/1/0
White-winged crossbill (*Loxia leucoptera*)	B/2/0
Pine siskin (*Carduelis pinus*)	B/15/1
Total banded:	***313(adults); 56 (young)***

Heard or seen only	
Common loon (*Gavia immer*)	T
Great blue heron* (*Ardea herodias*)	B
Canada goose (*Branta canadensis*)	T
Mallard (*Anas platyrhynchos*)	T
Blue-winged teal* (*A. discors*)	B
Common goldeneye (*Bucephala clangula*)	T
Osprey (*Pandion haliaetus*)	T
Bald eagle (*Haliaeetus leucocephalus*)	T
Sharp-shinned hawk* (*Accipiter striatus*)	T
Cooper's hawk (*A. cooperii*)	T
Red-tailed hawk* (*Buteo jamaicensis*)	T
Golden eagle (*Aquila chrysaetos*)	T
Ruffed grouse (*Bonasa umbellus*)	T
Blue grouse (*Dendragapus obscurus*)	T
Sora (*Porzana carolina*)	B
Lesser yellowlegs (*Tringa flavipes*)	M
Belted kingfisher (*Ceryle alcyon*)	T
Yellow-shafted flicker (*Colaptes auratus*)	T
Pileated woodpecker (*Dryocopus pileatus*)	T
Western wood-pewee (*Contopus sordidulus*)	T
Alder flycatcher (*Empidonax alnorum*)	L
Eastern kingbird* (*Tyrannus tyrannus*)	T
Cassin's vireo (*Vireo cassinii*)	B
Blue-headed vireo (*V. solitarius*)	T
Gray jay (*Perisoreus canadensis*)	T
American crow (*Corvus brachyrhynchos*)	T
Common raven (*C. corax*)	T
Cliff swallow* (*Petrochelidon pyrrhonota*)	T
Barn swallow* (*Hirundo rustica*)	T
Brown creeper* (*Certhia americana*)	T
Savannah sparrow* (*Passerculus sandwichensis*)	T
Song sparrow (*Melospiza melodia*)	B
Red-winged blackbird* (*Agelaius phoeniceus*)	B
Brewer's blackbird* (*Euphagus cyanocephalus*)	T
Total species:	***74***[3,4]
Total species breeding:	***35***

* Neotropical migrant
[1] B - breeders L - likely breeders T - transients M – migrants
[2] The hummingbirds were released unbanded, as we were not authorized to band those species.
[3] Traill's is used when unable to differentiate between alder and willow flycatchers. (Only willow flycatchers were used in the species total.)
[4] Yellow-rumped is used when unable to differentiate between Audubon's and Myrtle's subspecies. (Subspecies do not contribute to species totals).

Winged Wonders

Butterflies are ambassadors of the insect world – they are colorful, harmless, slow flying creatures that are active only on the nicest days. However, in addition to their obvious beauty butterflies are very important ecologically. Butterflies can be important indicators of environmental conditions because they have very specific food plant and habitat needs that are often affected by weather, plant distribution and disturbance (Ries *et al.* 2001). A good Rocky Mountain example is *Parnassius smintheus.* This butterfly needs *Sedum lanceolatum* for the larval host plant and asters for adult nectar plants – thus limiting its Alberta distribution largely to the Rockies (Bird *et al.* 1995). In Iowa butterflies are used as an indicator species of prairie habitat decline, and in California they are considered an umbrella species for serpentine grasslands (Launer and Murphy 1992). Butterflies are also excellent indicators of environmental change. For example, increasing pollution from car exhaust in the San Francisco area contributes directly to the decline of the threatened Bay checkerspot butterfly (Weiss 1999).



Icarioides blue (Plebejus icarioides)

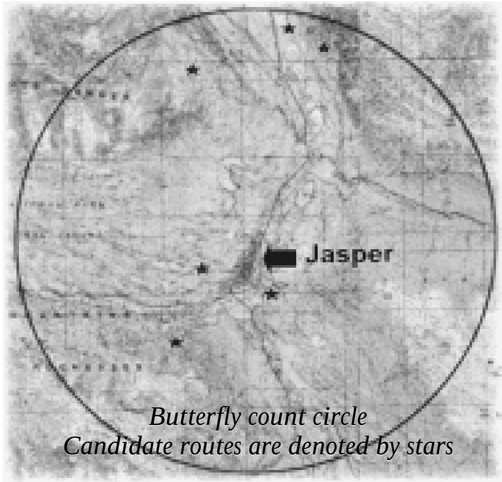
Photo and sidebar by Shelley Humphries

JASPER NATIONAL PARK ANNUAL BUTTERFLY COUNT

We know less about the butterflies of Jasper National Park than we do about butterflies in many other places in Alberta. This is unfortunate because the park has some interesting ecological boundaries, and agriculture and urbanization have not dramatically altered the native plant communities. By beginning a butterfly monitoring program Parks Canada aims to satisfy its mandate to maintain ecological integrity, increase our scientific knowledge and communicate the value of our natural heritage to the public.

There are about 30 annual butterfly counts in Alberta and over 400 counts across North America. The North American Butterfly Association (NABA) has formally organized the counts since 1975. Butterfly counts are similar to Christmas bird counts in that participants conduct a 24-hour census within non-overlapping circles of 24 km in diameter, return annually near the same date and census again. Experienced counters can identify butterflies on the wing using only binoculars. For the less experienced a few special tools and techniques make delicate butterflies remarkably easy to handle, identify and release. NABA compiles the counts, publishes them annually and uses the data to track large scale changes in butterfly populations, range expansions, range contractions, new species and loss of species. The count circle started in Jasper is special because the diversity of habitats from montane to alpine would be difficult to find elsewhere the province.

The first Jasper count was a bit of a disaster — heavy rain on count day sent everyone home. A practice count in advance of the public event gave us 17 species. (The second Jasper count is scheduled for Sunday July 22.) It is too early in the history of this count location to draw any conclusions about our data, but a few "oddities" were collected and will be sent to a local butterfly expert for identification.



Butterfly count circle
Candidate routes are denoted by stars

Counts have been criticized for the quality of the data they generate, particularly data related to population estimates. However, they are excellent starting points. In many locations, basic single-day counts are the only semi-systematic form of insect monitoring, and as a minimum they can be used to establish lists of expected species. More importantly, insect counting provides an opportunity for insect enthusiasts to come together. These enthusiasts can introduce park visitors to the study of insects, enhancing visitor experience and knowledge, which can lead to greater support for preservation and protection.

To get involved in a butterfly count in Alberta visit http://owlnut.rr.ualberta.ca/~barb/countlist.html. To start your own count or find compilers and information for other provinces visit the North American Butterfly Association website: http://www.naba.org

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White Admiral (Limenitis arthemis)

Butterfly identification

Photos: Shelley Humphries

IGHLIGHTS

ENTERPRISE AND INDUSTRY: CONSERVING CANADA'S INDUSTRIAL HERITAGE
March 29-31, 2001, Vancouver, BC

Of Canada's 860 national historic sites, close to 50 are designated for themes related to the history of industry in Canada. Parks Canada Agency owns very few of these sites; in fact the great majority of them are owned/operated by other levels of government or not-for-profit organizations. Fifteen of these sites are identified for support through the National Cost Share Program; others are struggling to survive on small operating grants, fund raising, site revenue and volunteer labour. A growing awareness of the need to share information among these diverse sites prompted Parks Canada to host a workshop on this theme in Vancouver.

The workshop consisted of seven sessions. Topics included interpretive planning, environmental and safety issues, and the management of industrial districts. Speakers came from across the country representing a variety of sites and fields of expertise, including the coal industry in the Maritimes, gold mining in Quebec, brick making in Saskatchewan, the oil and gas industry in Alberta and sawmills in British Columbia. The 65 participants included operators of industrial sites and experts in the field of industrial history/ archaeology, conservation, interpretation and site management. Approximately two-thirds of the participants came from organizations other than Parks Canada.

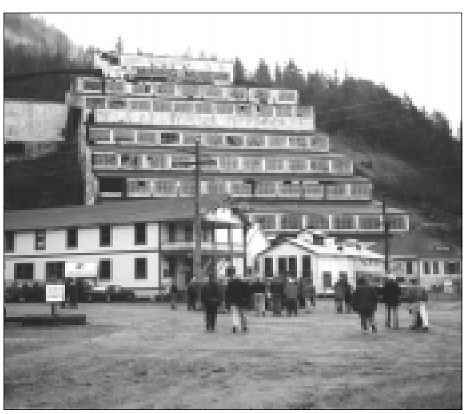

Photo: Katharine Kinnear

Field trips to the Gulf of Georgia Cannery NHS and the Britannia Mine and Concentrator NHS (above) gave the participants a first hand look at the challenges and successes of two unique industrial heritage sites.

Of particular interest to representatives of non-Parks Canada owned sites was Margaret Archibald's talk on new directions in national historic site planning. The opportunity to share the unique challenges of industrial heritage sites was much appreciated by the participants. Staff at the Britannia Mine and Concentrator NHS came away with new ideas on interpretive planning as a result of Rob Ward's presentation on the Canada Place exhibit in Banff. Representatives of mining sites from across the country pooled their experiences in dealing with environmental concerns specific to decommissioned mines. The pioneering educational programs of the Lowell National Historic Park in Massachusetts sparked interest among representatives of national historic districts in Canada. Finally, the original revenue-generating strategies of sites such as the North Pacific Cannery NHS were of interest to all.

Generous support for the workshop came from the New Sites Initiatives program, as a means of providing professional and technical advice to the family of national historic sites. The BC Heritage Branch offered sponsorship and expertise. Abstracts of the workshop sessions are available; please contact Katharine Kinnear.

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Preserving Ecological Processes:
FOREST INSECT AND DISEASE MANAGEMENT IN JASPER

Jasper National Park (JNP) is compiling information on the status of insects and spread of disease in forest ecosystems. As part of this initiative, I completed a review and assessment of forest insect and disease management data and recommended improvements to vegetation management in JNP as it relates to forest insects and diseases.

This project involved review and analysis of available data on insect and disease activity to identify knowledge gaps and increase understanding of these ecological processes in JNP. The results showed that data were skewed to human use and transportation corridors, that point locations were limited (especially for disease locations), and that there was very little baseline information regarding forest insect and disease activity in JNP.

The vegetation component of the study incorporated multiple accounts analysis (MAA) to identify deficiencies in vegetation management relating to forest insects and diseases. Vegetation management actions were evaluated in terms of their consistency with the fundamental principles of Parks Canada (the criteria) using indicators I developed. The indicators were used to assess whether or not management actions were aimed at fulfilling the fundamental principles (the criteria). Indicators included: adequacy of scientific information, co-operation and communication with adjacent land managers, adaptive management and visitor experience.

Based on information gaps revealed by the insect and disease data analysis, I recommend the following: Key future projects should include the establishment of a research framework for assessing and evaluating insect and disease activity in Jasper National Park. Baseline data should be collected, and monitoring projects established. This information should build on the existing database, and possibly be used to establish a risk-rating system. Specific projects include investigations into the relationship between fire and insects/diseases, and paleo-ecological research that would provide information on the historic cycling of insect and disease activity. Projects should be identified and rated by priority to aid managers in the allocation of resources. In general, JNP needs to improve communication with the public and adjacent land managers about insect and disease issues, and attempt to understand public perceptions of management actions. Parks should continue to develop relationships with adjacent land managers, create a comprehensive forest insect and disease plan, and create a public information strategy.

As this project concluded, we discovered the first mountain pine beetle occurrences in JNP in recorded history, providing a good opportunity to put the new research framework into practice.

Special thanks to my supervisory committee: Alan Westhaver, Mary Reid and Cormack Gates.

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Can a Chickadee Cross the Road?

Barriers to bird movement in the Bow Valley of Banff National Park

Colleen Cassady St. Clair

"Daggers in the heart of wilderness!" is the charge Michael Soulé levied at roads at a recent meeting of the Society for Conservation Biology. Soulé, one of the founders of both the society and the discipline was referring to the direct and indirect damage done by roads in seemingly pristine areas. Indeed, roads have emerged as one of the biggest conservation problems of industrialised countries. In the US, the direct and indirect effects of roads are estimated to impact as much as 20% of the land base (Forman 2000). It is thus little wonder that roads have been the focus of so much recent attention within Canadian National Parks, particularly in the Bow Valley of Banff National Park.

Much of the attention to the problem of roads in Banff has deservedly focused on large mammals, particularly carnivores (Clevenger 1999, Gloyne and Clevenger 1999). For these species, the Trans Canada Highway was previously a source of substantial mortality. Fencing, constructed between 1984 and 1997, has reduced the mortality (Clevenger *et al.* 2001), but has become an impermeable barrier to animals larger than a breadbox. Crossing structures were built to mitigate this barrier effect and ongoing research addresses both the severity of the barrier and the effectiveness of these structures. But this focus on large animals has logistical, financial, and biological limitations, creating gaps in our knowledge that may profitably be filled with research on smaller species that may also suffer barrier effects.

Forest birds are among the groups that have received relatively little attention in North America in the context of road problems. This neglect may stem from the fact that birds, especially those that migrate across continents, are commonly perceived as being capable of using flight to avoid the inherent dangers of roads. Yet many forest-dwelling species are reluctant to cross gaps in forest cover as narrow as 50 m (Desrochers and Hannon 1997, St. Clair *et al.* 1998), a distance narrower than most four lane highways and their cleared verges. Moreover, birds elsewhere suffer considerable road-caused mortality (Dhindsa *et al.* 1988) and avoid habitats near roads (Reijnen *et al.* 1995).

Beyond the importance of understanding the effects of roads on bird populations, studying this group allows a focus on some of the generalities of road effects. Several issues merit attention, but 4 general questions have pertinence across taxa and form the basis of this study. *First*, how does the barrier effect of roads compare to other barriers of both natural and anthropogenic origin? This question acknowledges that natural barriers, like meadows and rivers, may also impede the movement of forest-dwelling animals. *Second*, is there evidence that parallel barriers create a cumulative effect that is masked by examination of individual barriers? In the Bow Valley, the Highway parallels three anthropogenic barriers (the Bow Valley Parkway, the Epcor Utility Line and the CPR mainline) and a major natural barrier (the Bow River) and examining each of these in isolation may mask their combined effect. *Third*, does the presence of a major road degrade the quality of the surrounding habitat? For birds, this is especially likely through the effect of noise and may extend considerably beyond the visible road footprint. And *finally*, are some species more vulnerable to road-caused mortality and does this vulnerability correlate to specific life history characteristics? Species that forage on road verges, those that are poor flyers, or species that fly close to the ground may be more vulnerable to road-caused mortality and hence disproportionately represented in roadkill surveys.

In collaboration with Marc Bélisle and Tony Clevenger, data were collected to answer all 4 of these questions. However, only those data pertaining to the first and second questions have been analysed to date and only these two will be discussed in the methods and results that follow. A parallel study with similar objectives was conducted on small mammals by Wayne McDonald (see his article on page 19 of this issue). Both studies have relied on small-scale experiments to identify some of the processes associated with road effects.

METHODS

I compared the permeability of different barrier types using audio playbacks of a chickadee (*Poecile atricapillus*) mobbing call (*sensu* Desrochers and Hannon 1997, St. Clair *et al*. 1998). This sound, familiar to any northern forest dweller, is a veritable magnet to many other bird species. The purpose of this stimulus was to standardise the motivation individuals would have to travel a given distance under different barrier configurations. Playback trials consisted of an origin and a destination site in each of three gap types (road, river, meadow) and 2 treatments (parallel vs. across gap) and ranging in size from 15 – 130 m (mean = 60 m 30 m st dev). The parallel trials provided a control for the substantial variation in the noise associated with the three types of gaps. Once birds were lured to the origin site, I attempted to attract them to a predetermined destination and scored the response of individuals as either positive (responded) or negative (did not respond) for analysis by logistic regression. I expected that birds would be less willing to cross gaps of any type than to travel parallel to them, that they would be less willing to cross roads than rivers or meadows, and that their willingness to respond in any barrier configuration would decline with the distance between the origin and destination.

Postdoctoral fellow Marc Bélisle assessed the cumulative effect of parallel barriers. Marc used a protocol similar to one he developed in Québec (Bélisle *et al*. 2001) and relocated territorial, mated male birds to standardize their motivation to travel over a larger spatial scale than could be employed with the playback trials. Birds were captured with audio playbacks and relocated 1-2 km either parallel or perpendicular to the series of barriers that occurs in the Bow Valley during May and

- continued on page 25 -

Effects of Habitat Fragmentation on Small Mammal Movement
in Banff National Park

Wayne McDonald

Habitat fragmentation disrupts animal movement between isolated patches, potentially reducing immigration and leading to increased inbreeding and loss of genetic variation at the population level (Burkey 1989). The effects of movement on gene flow and population persistence are assumed, but little is known about how barriers and corridors within fragmented landscapes influence movement. Natural and anthropogenic barriers can vary in their permeability because of differences in the degree of contrast with surrounding habitat, thickness, and sharpness (Wiens 1992). Differences in these parameters suggest that artificial barriers are less permeable to movement than natural barriers (Forman 1995, Margalef 1979).

Barrier permeability may also be a function of the life history strategy and habitat requirements of the animal (Garman *et al.* 1994, Marinelli and Neal 1995). Nocturnal, generalist species may have less difficulty crossing barriers than specialist species because they rely less on overhead cover to avoid visual predators and do not use any particular habitat type exclusively. A proposed method of improving the permeability of barriers is to create corridors that facilitate animal movement. However there is little empirical evidence that corridors serve a role in species conservation because monitoring existing corridors use can be logistically difficult, particularly with carnivores which have been a focal species group in previous studies. Our understanding of barrier permeability and corridor efficacy would improve with detailed information on the precise trajectory of moving animals when they encounter barriers and corridors.

Fragmentation issues such as barrier permeability and corridor efficacy are of particular concern in Banff National Park (BNP) where dissection of the surrounding landscape by the Trans-Canada Highway (TCH) creates an artificial barrier that clearly influences animal movement. But the presence of this artificial barrier also provides an excellent opportunity to examine the effects of barrier type and permeability on animal movement more generally. A similar opportunity exists to study the ways that corridors can mitigate barriers by examining the overpasses and underpasses that have been constructed along the TCH. There is evidence that a variety of animals use the structures, but few studies examined preferences in structure type. Further, research to date has not documented the distance animals will travel to cross the structures, nor determined whether the distance varies with habitat use patterns. Basic questions concerning barrier permeability and crossing structure efficacy have relevance to all animals contending with fragmented habitats, but they are difficult to address with the rare and wide-ranging animals that have been studied to date.

Instead, I am examining these issues using abundant and flexible small mammals for which some perceptual responses may be generalized to other species. In particular microtene rodents such as meadow voles (*Microtus pennsylvanicus*), deer mice (*Peromyscus maniculatus*), and red-backed voles (*Clethrionomys gapperi*) are ideal for such small-scale manipulations. These species represent different habitat preferences and life-history strategies: meadow voles prefer open grasslands, red-backed voles specialize in forested habitats, and deer mice are habitat generalists. I measured relative differences in barrier permeability, preferences in structure type, the impact of cover on crossing structure use, the distance animals will travel to use crossing structures, and whether movement responses varied with activity strategy and habitat use patterns.

Red-backed vole

METHODS

All individuals were live-trapped using Longworth live-traps baited with sunflower seeds. Prior to their release, all animals were marked with a fluorescent dye to facilitate fine scale monitoring of movement paths by rolling each individual gently in a plastic bag containing a small quantity of dye. Mice and voles were released at the beginning of their active periods - early morning for diurnal species such as meadow voles and early evening for nocturnal species such as deer mice and red-backed voles. The subsequent trail of each relocated individual was tracked via a "black light" that revealed a bright trail indicating the animal's precise trajectory. (Latex gloves were worn whenever handling the animals to protect against Hanta virus.)

To determine differences in barrier permeability, I relocated meadow voles, red-backed voles, and deer mice similar distances across the TCH (an artificial barrier), across the forested median of the TCH (a natural barrier), and along the TCH (continuous habitat) into similar habitat. Movement responses to barriers and corridors were measured by the return success and path characteristics of individuals encountering barriers and crossing structures. I used relocations of individuals directly across the TCH in areas adjacent to crossing structures to determine the elements that promote crossing structure success. To assess preferences in crossing structure type, individuals were relocated directly across (i) two overpasses, (ii) 9 – 3m diameter underpasses, and (iii) 9 – 0.3m diameter underpasses and then released 2m from the

- continued on page 20 -

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entrances. All underpasses and overpasses are approximately 60m long.

To determine the role of ground cover in improving the function of crossing structures I manipulated cover at the entrances to 2 overpasses and 9 – 3m underpasses. Prior to all relocations, both the amount of cover (none or heavy) and the placement of the cover (near the edges of structures, in the middle, or both) were varied within structures and at the entrances using freshly cut spruce boughs to represent natural cover.

To quantify the distance individuals would travel to use crossing structures as a function of predictable attributes like body or home range size, I captured individuals adjacent to the TCH and relocated them directly across the road to similar habitat. Animals were marked with fluorescent dye and released at distances of 20 m, 40m and 60m from overpasses and underpasses, distances that represented roughly 1, 2 and 3 microtene home ranges respectively. For all relocations, animals were first captured on successive occasions to establish their residency. If relocated animals failed to return to their territories on their own, they were captured at the release site and returned. No experimental subjects were killed on the highway.

RESULTS

Logistic regressions were preformed to test for the effects of barrier and crossing structure attributes on return success. All species tended to be less successful in crossing artificial barriers than natural barriers (Figure 1a, n = 62), indicating that mice and voles are less able or less willing to travel across artificial barriers. Deer mice (nocturnal, habitat generalists) were more successful in crossing all barrier types than meadow voles or red-backed voles (diurnal, habitat specialists).

Comparison of crossing structure preferences revealed that small mammals

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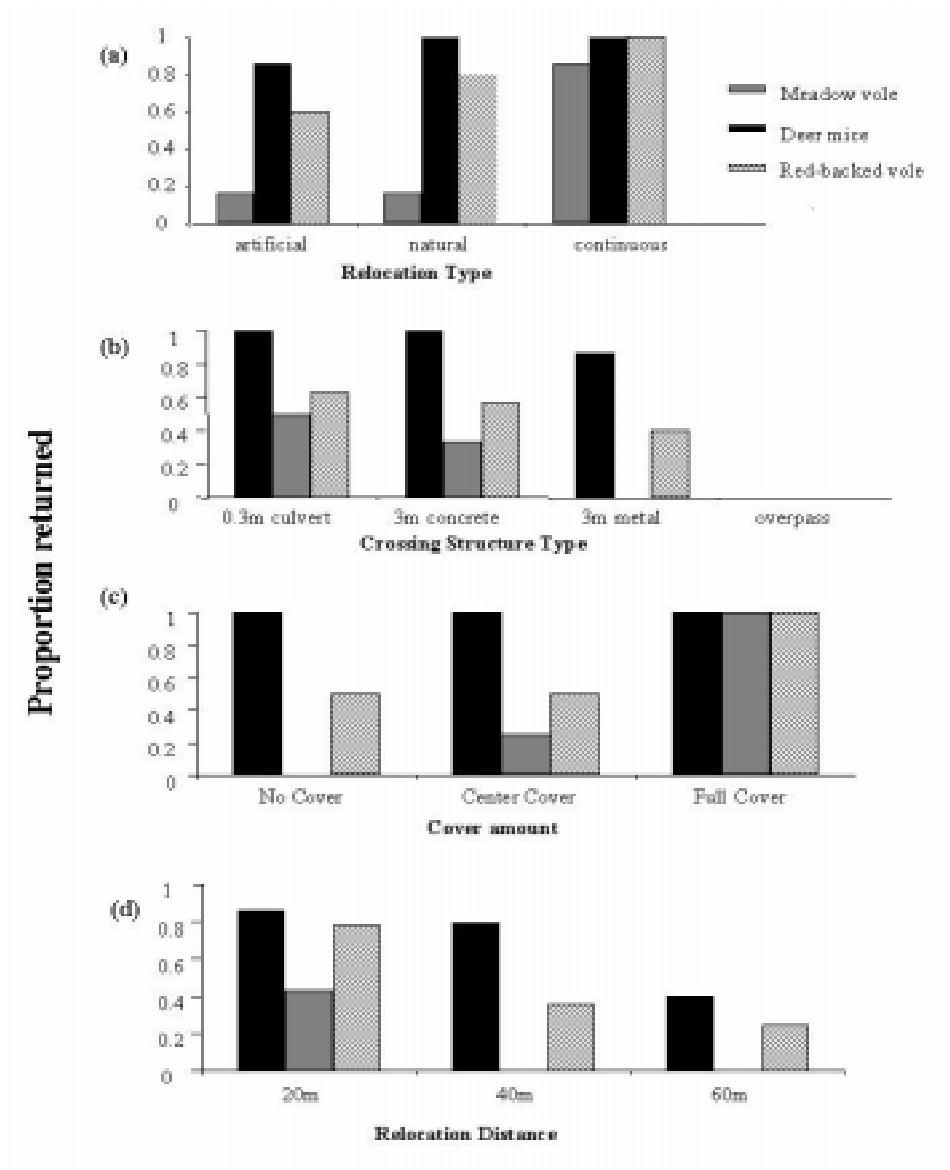

Figure 1: Effect of (a) barrier permeability, (b) crossing structure type, (c) cover amount, and (d) distance from crossing structures on the proportion of deer mice, meadow voles, and red-backed voles successfully returning to their original capture location.

Effects of Habitat Fragmentation on Small Mammal Movement

- continued fron page 20 -

preferred crossing 0.3m diameter underpasses compared to larger underpasses or overpasses (Figure 1b, n = 73). Deer mice were more likely to return for all crossing structure types except overpasses, over which no animals returned. Meadow voles and red-backed voles seemed more likely to cross when cover was present, although deer mice had the highest success rate for all cover levels (Figure 1c, n = 34). Crossing structure efficacy declined as the distance from an animal's home territory increased (Figure 1d, n = 75). Animals also appeared to be more reluctant to travel to crossing structures when the distance exceeded one home-range size (20 m). Deer mice returned to the crossing structures most often, while meadow voles had the lowest return success for all distances.

DISCUSSION

Based on the results of this study, habitat preferences and life-history strategies probably influence permeability. Meadow voles rarely crossed barriers or crossing structures, but the structures had very little of the meadow habitat that voles use almost exclusively. Deer mice may have found barriers and crossing structures easier to cross because of reduced traffic volumes and predation risk at night when they are most active.

Individuals may prefer crossing structures of a particular size, shape, or composition based upon the physical and behavioural attributes of the animal. It is possible that small mammals preferred 0.3m diameter underpasses because smaller underpasses provided the most overhead cover relative to body size. Perhaps the most effective corridors are those scaled to the animal of conservation concern.

The effectiveness of crossing structures may be improved by adding overhead cover to confer greater freedom of movement and provide animals with protection from predation. The placement and type of cover could be important considerations in crossing structure construction and provide a relatively inexpensive way of improving their effectiveness. For example, logs and brush piles at the entrances to and within structures may encourage small mammals to cross. Larger animals may require patches of brush with more vertical cover.

The decline in animal use of crossing structures as the distance to the structure increases may have important implications for the future placement of wildlife corridors in fragmented landscapes. If frequent use of crossing structures is desired for a particular target species, these structures may need to be constructed no more than 1or 2 home ranges apart to have a conservation impact. My own results suggest that animals are reluctant to travel to crossing structures when the distance exceeds the animal's home-range size. Perhaps this indicates that animals are reluctant to cross the territory of a conspecific to reach a corridor.

CONCLUSIONS

It appears that animals respond to barriers and corridors based in part on when the animals are active and the extent to which they rely on overhead cover to move. In general, animals crossed natural barriers more often than artificial barriers, and prefer corridors with overhead cover that are within 1 or 2 home ranges of their territory. The characteristics observed in small mammals may be applied to species of greater management concern to design more effective crossing structures. By understanding behavioural responses to fragmentation and resulting population dynamics, Parks Canada can manage species of concern more effectively across spatial scales.

ACKNOWLEDGEMENTS

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GIANT LIVER FLUKE:

Smaller than a Breadbox...but larger than a Wapiti or Moose!

M.J. Pybus

Fascioloides magna, the giant liver fluke (GLF), is truly a giant among its kind. Although relatively small (adults are only 78 mm long, 35 mm wide, 3 mm thick), these flukes are some of the largest trematodes known to science. They generally live as benign residents in the liver of a variety of cervids. However, in some situations these diminutive flatworms can directly or indirectly cause mortality in wapiti [elk] (*Cervus elaphus*) and moose (*Alces alces*) or pose significant concerns for wildlife managers.

The giant liver fluke was first documented in the National Parks of western Canada in the 1920s and 30s (Cameron 1923, Swales 1935). Although present in the Kootenay/Golden areas of British Columbia, it was not detected in Banff National Park (BNP) until the early 1960s (Flook and Stenton 1969). These authors predicted it would establish in wapiti in the Bow Valley and perhaps spread along the east slopes of the Rockies. The opportunity to test this prediction arose in conjunction with evaluation of the effects of fencing the Trans-Canada Highway in BNP (Woods 1990). Between 1984 and 1991, livers were collected from 412 cervids in BNP, largely road-killed wapiti. For comparison, 122 livers were also collected in Kootenay National Park (KNP). Livers were sliced at 5 mm intervals and examined for flukes. Data were used to examine the interplay among GLF and ungulate hosts within the parks.

In total, 381 wapiti, 68 mule deer (*Odocoileus hemionus*), 54 white-tailed deer (*Odocoileus virginianus*), and 31 moose from the two parks were examined. The general patterns of infection with GLF were similar in both parks; however, actual prevalence (% infected) was higher and intensity (mean number of GLF per infected individuals) was lower in KNP than in BNP. In each park the annual prevalence in wapiti increased during the sampling period and the prevalence also increased with increasing age of wapiti. Intensity was lowest in young of the year (<10 GLF), but did not differ between yearlings (25-35) and adults (30-35). Prevalence did not differ between male and female wapiti, but overall intensity was generally twice as high in males. Super-infections of >100 GLF in individual wapiti were more common in later years of the study. The maximum single intensity was over 600 GLF!

Prevalence and intensity differed among other cervids but the patterns were similar in each park. Overall prevalence was lowest in mule deer (approximately 5%), and higher in white-tailed deer (30-40%) and moose (50-60%). Intensity differed among these species but never exceeded 30 GLF. Mature flukes were found only in wapiti and white-tailed deer. Thus, these hosts are required to maintain a population of GLF, with spillover into moose and, rarely, mule deer. The few bighorn sheep (*Ovis canadensis*) and mountain goats (*Oreamnos americanus*) examined were not infected. GLF was considered directly associated with mortality of at least 7 wapiti as well as with significant tissue damage in wapiti and moose.

GLF is well established in KNP and prevalence values recorded in this study are similar to those from the early 1960s (Flook and Stenton 1969). However, there has been a significant change in BNP and it appears the predictions of Flook and Stenton (1969) were correct. Since the 1960s, GLF has established a successful population and now is well distributed in the Bow Valley region of BNP. The year-round use of the Vermilion Lakes region, high concentrations of wapiti in the lower Bow Valley, and limited natural predation in these areas undoubtedly contributed to this success. However, data from surrounding provincial lands indicate GLF is largely restricted to the park and further eastward dispersal is limited (Pybus 1990).

LIFE CYCLE OF GLF

Adult GLF live in liver tissues. They produce eggs that pass into the intestine and eventually exit in the faeces. Eggs hatch in water and the newly-released larvae burrow into common aquatic snails where they multiply in number until they eventually leave and encyst on submergent/emergent vegetation. Herbivores ingest the cysts when they graze on contaminated vegetation. The cysts are activated in the gut and immature flukes migrate through various tissues until they reach the liver. Here they tunnel through the tissues until they find another fluke, at which time they stop, mature, cross-fertilize, and produce eggs.

SHOULD PARKS CANADA TAKE PRESCRIPTIVE ACTIONS TO ADDRESS THE INCREASED FLUKE POPULATION?

Fascioloides magna is indigenous to North America (Bassi 1875) and probably coevolved with white-tailed deer (Pybus 2001). Wapiti entered the continent approximately 11,000-70,000 years ago (Bryant and Maser 1982). Within these hosts, GLF may have been widespread throughout Canada and the United States (Pybus 2001). Its distribution was severely curtailed due to market hunting and the near-extirpation of wild ungulates in the late 1800s. However, isolated pockets of GLF persisted, one of which was in the Rocky Mountains in BC and Montana, perhaps due to the rugged terrain and limited cost-effectiveness for the market hunters. Wapiti from the Yellowstone region, where GLF does not occur, were used to re-stock extirpated populations throughout the west (Lloyd 1927, Lothian 1981) and thus the distribution of GLF remained restricted even after wapiti populations rebounded. Eventually, natural dispersal through mountain passes has introduced sufficient numbers of GLF to establish a population in BNP. It is apparent that the fluke coexists with wapiti and white-tailed deer with limited effects on host populations. Occasionally, individual wapiti accrue sufficiently high numbers of GLF to result in death; however, this situation is rare.

- continued on page 23 -

Giant Liver Fluke

- *continued from page 22* -

Thus, GLF appears to be a natural component of wetland ecosystems in the Rocky Mountain parks.

The relatively benign relationship between wapiti or white-tails and GLF may contrast the effects in moose populations. Suitable habitat and environmental conditions occur in the Bow Valley; yet moose are scarce (Holroyd and Van Tighem 1983). Indeed, as the fluke population increased throughout the 1970s and 80s, moose numbers in the Bow Valley declined. Immature GLF migrate continually in moose liver and even a few GLF cause extensive tissue damage, possibly leading to increased predation and decreased body condition and productivity (Lankester 1974, Berg 1975). Given that moose are relative new-comers to North America (Bubenik 1997) it is not surprising that the host-parasite relationship is not as well-tuned as in the native (white-tailed deer) or earlier arrivals (wapiti) on the continent. Current levels of GLF in BNP may pose significant risk for moose.

Natural events and specific management actions could alter the prevalence of GLF in the Bow Valley. For example, the re-establishment of wolves in the Bow Valley since 1985 may reduce the fluke population by a subsequent reduction or re-distribution of wapiti. Similarly, the recent management removal of wapiti from the Banff townsite area (T. Hurd, *BNP, pers. comm*) and/or prescribed burning of emergent vegetation in spring also could reduce GLF in that population and thus reduce transmission to wapiti and moose. However, GLF is readily translocated in infected wapiti (Bassi 1875, Pybus 2001), a problem that poses management concerns for BNP and other populations.

In association with the investigations in BNP and KNP, GLF was identified in Elk Island National Park (EINP) in 1987 (Pybus unpublished). The source of infection remains a mystery: there are no records of GLF during annual culls in EINP throughout the 1960s and 70s, yet from 1988 to 1995, GLF was found in approximately 50% of adult wapiti in the northern portion of the park. Liver damage was minimal and intensity was low (<15 GLF). From 1999 to 2001, the prevalence increased to 75-80% in adult wapiti and intensity rose to 35 GLF. Some wapiti with >80 GLF were documented. These increases suggest that in the mid- 1990s, GLF hit a threshold that resulted in rapid population growth. This issue concerns wildlife managers inside and outside the park because wapiti from EINP are translocated to various provinces and states, many of which do not lie within the known natural distribution of GLF.

To address management concerns, a treatment protocol was developed among EINP, Alberta Fish and Wildlife, and Alberta Agriculture (Pybus *et al.* 1991). Although not 100% effective, the protocol significantly reduced the likelihood of translocating GLF along with wapiti from the park. Unfortunately, the protocol recommendations were developed when the prevalence and intensity of infection in EINP animals was low. Further work is required in the context of greater infection parameters to deal with wapiti in EINP and those translocated from the highly-contaminated Bow Valley. Long-term management programs in western parks must consider the implications of GLF and use caution whenever wapiti from infected populations are translocated, particularly to moose habitat. Methods of reducing GLF populations might also be investigated.

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Managing the Ecological Integrity of Elk Island National Park

- continued from page 3 -

issues. My experiences with SAC indicate that a number of issues are arising:

- EINP needs to increase personnel and financial resources to implement an ecological integrity-based management model. This includes an improved understanding of the effects of natural (e.g., ungulate herbivory, beaver activity) and anthropogenic activities (e.g., adjacent land uses, roading networks, deposition of airborne contaminants, park management practices) on the flora and fauna in the park.
- Biological monitoring within the park needs to be optimized to better serve the integrity-based management approach.
- SAC and EINP would benefit from increasing representation from the social sciences.

EINP's commitment to engage local community and other stakeholder groups when developing and implementing its management actions is highly commendable. Increased communication among SAC, EINP and these groups would assist progress towards ecological integrity-based management beyond the park boundaries.

I expect that science advisory committees could assist other Parks to better understand the extent of current scientific challenges and to create a direction through which these issues can be addressed. However, meaningful application of the ecological integrity-based model needs to be accompanied by substantial increases in staffing and funding either at the park or regional level. Without these resources, the challenge to manage successfully for ecological integrity in EINP (and probably most parks) is akin to harvesting the Prairie Provinces with a pair of blunt scissors.

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Table 1. Membership of Elk Island National Park's Science Advisory Committee and Park Ecosystem Secretariat involved with ecosystem management and communications.

SCIENCE ADVISORY COMMITTEE

Dr. Brian Amiro, Research Scientist, Canadian Forest Service, Edmonton
Expertise: Fire Ecology, Meteorology.

Dr. Edward Bork, Assistant Professor, Dep't Agricultural, Food & Nutritional Sciences
University of Alberta, Edmonton
Expertise: Grazing Management, Plant Ecology.

Mr. Jack Brink, Head of Archaeology, Alberta Provincial Museum, Edmonton
Expertise: Archaeology, Anthropology, Aboriginal History.

Dr. Robert Hudson, Professor, Departments of Renewable Resources
Agricultural, Food & Nutritional Sciences, University of Alberta, Edmonton
Expertise: Ungulate Ecology, Bioenergetics.

Dr. Philip Lee,[1] Research Associate, Department of Biological Sciences
University of Alberta, Edmonton
Expertise: Terrestrial Ecology, Forest Management.

Dr. Fiona Schmiegelow, Assistant Professor, Department of Renewable Resources
University of Alberta, Edmonton
Expertise: Terrestrial Biodiversity, Landscape Ecology.

Dr. Garry Scrimgeour (Chair), Research Scientist, Forest Resources Business Group
Alberta Research Council, Vegreville
Expertise: Aquatic Ecology and Biodiversity.

[1] Past member

EINP'S ECOSYSTEM SECRETARIAT

Ms. Kalya Brunner, Ecosystem Communications Specialist EINP
Expertise: Environmental Education & Programming, Communications.

Dr. Ross Chapman, Conservation Biologist
Expertise: Environmental Impact Assessment,*Ecological Restoration.*

Mr. Normand Cool, Conservation Biologist
Expertise: Wildlife biology and ungulate management.

Mr. Steve Otway, Chief Park Warden
Expertise: Park Management Team member, Fire ecology.

Can a chickadee cross the road?

- sontinued from page 18 -

June, 2000. Observers returned after 4 hours and then once a day for 10 days to monitor the return of colour-banded birds. Relocations were conducted for 7 individuals for each treatment for each of the 3 species, which differed in their seasonal movement habits. Relocations were conducted on the yellow-rumped warbler (long-distance, tropical migrant, *Dendroica coronata*), the golden-crowned kinglet (short-distance migrant, *Regulus satrapa*), and the red-breasted nuthatch (facultative resident, *Sitta canadensis*). Time to return represented the dependent variable in subsequent analysis by Cox regression. We predicted that barriers would impede the movement of forest-dwelling birds and, thus, that birds would find their ways home more quickly when they were relocated along, rather than across, the barriers.

RESULTS

In the playback experiment used to assess barrier permeability, 1018 individuals of 36 species responded to 161 different trials. Species were grouped by guild (e.g., wood warblers) and only those with greater than 20 replicates were used in subsequent analyses which were first divided into forest dependents (which included some corvids [Corvidae], warblers [Parulidae], chickadees [Paridae], nuthatches [Sittidae], and kinglets [Regulidae]) and generalists (which included sparrows [Emberizidae] and robins [Turdidae]). Forest dependents were significantly less likely to respond to the destination playbacks when the trial contained a gap and when trial distance increased. Kinglets were less likely to respond than the other forest-dependent birds (Figure 1). Taken together, birds were less likely to cross rivers than either of the other two barriers (meadows and roads). In the analysis of generalists, birds were actually *more* likely to cross gaps and this behaviour was more pronounced for robins. These birds showed no discrimination by barrier type or trial distance.

In the translocation experiment used to measure cumulative barrier effects, average relocation distance was 2.1 km and average forest cover within the presumed return path (measured by a digital map of forest cover) was 37%. Neither distance nor forest cover differed as a function of species or treatment and, in the final analysis, there was no effect of distance or forest cover on return time. Birds showed a slight but significant reluctance to cross the barriers. However, species-specific patterns belie the generality of this result (Figure 2).

- continued on page 26 -

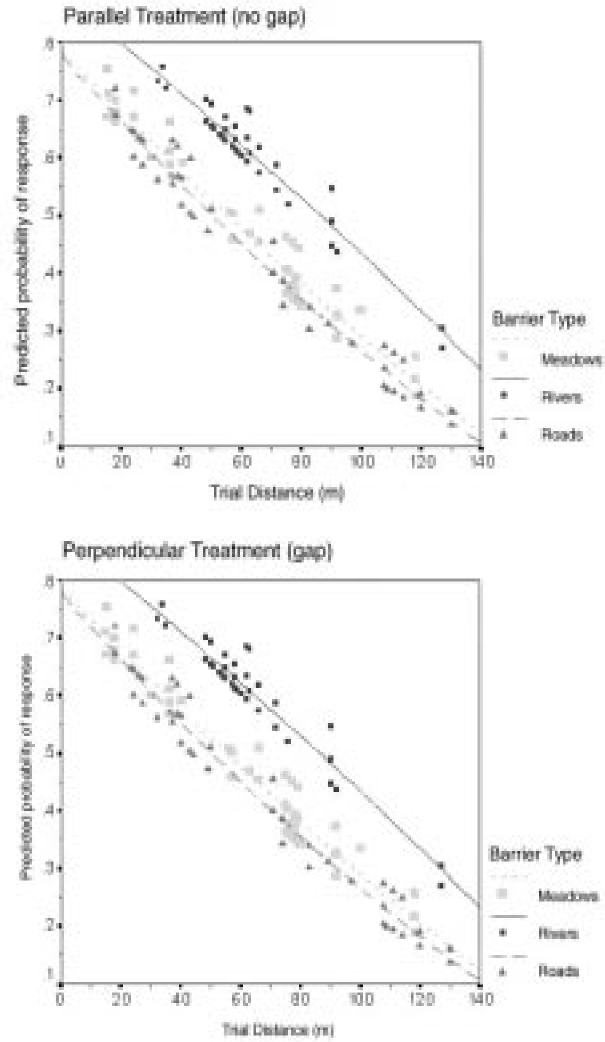

Figure 1. The predicted prob-abilities, generated by logistic regression, of responding to audio playbacks in two gap configurations and three barrier types in Banff National Park. Only forest birds with similar responses are included in these plots (some corvids warblers, chickadees, and nuthatches). Kinglets were less likely to respond across all treatments and are not included here.

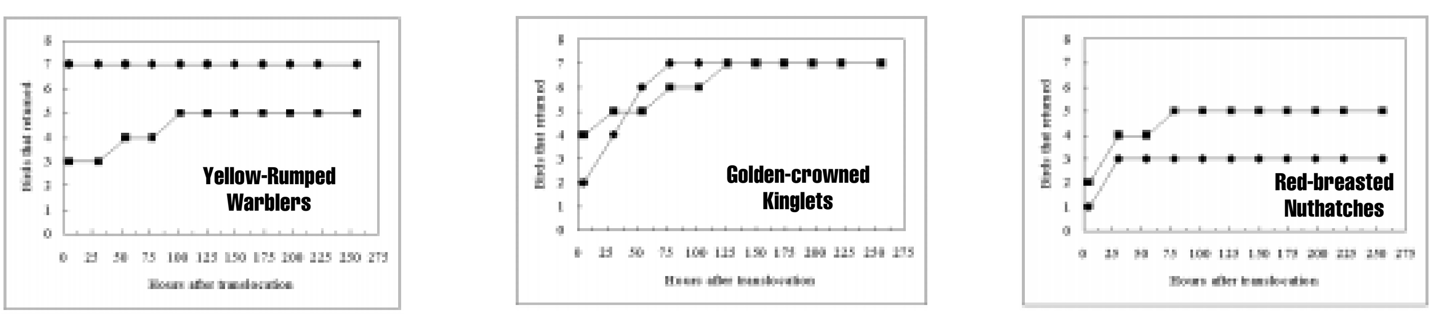

Figure 2. Homing success of translocated territorial, mated male Yellow-rumped Warblers, Golden-crowned Kinglets, and Red-breasted Nuthatches (n = 42; 7 individuals per treatment per species). Circles and squares depict birds translocated respectively along and across potential barriers to movement in the Bow River Valley bottom, Banff National Park.

Can a chickadee cross the road?

- continued from page 25 -

The neo-tropical migrant (yellow-rumped warbler), responded as we predicted: birds were more likely to return and returned sooner when they were relocated parallel to the barriers. But the short-distance migrant (golden-crowned kinglet) was apparently indifferent to barrier configuration and showed no clear difference in its response to the two treatment types. And the resident (red-breasted nuthatch) responded approximately opposite to prediction: birds were more likely to return and returned sooner when they were relocated *perpendicular* to the barriers.

DISCUSSION

The results of the playback experiment, during which birds showed the greatest reluctance to cross rivers, were surprising in the context of road ecology, but they make more sense with an evolutionary interpretation. Forest birds, which may sometimes evade avian predators with erratic flight or dives, would presumably find these maneuvers more risky over water. Unprepared by their evolutionary history for the danger of road-caused mortality, birds may fail to recognise road surfaces as an unsafe place to land under such circumstances. The birds were less willing to respond in gaps than in continuous forest parallel to the roads, and their willingness declined as gap distance increased. These results are consistent with other studies of gap crossing behaviour (Desrocher and Hannon 1997, St. Clair *et al.* 1998). Although statistically significant, these effects were not large, perhaps suggesting that the barriers in the Bow Valley do not represent particularly large impediments to forest birds.

The results of the translocation experiment suggest that some forest-dwelling birds may have difficulty crossing multiple parallel barriers in their habitat, but that others may actually move across these more quickly. Still others may be indifferent to the presence of apparent barriers. It was surprising that the neotropical migrant (Yellow-rumped Warbler), which crosses a continent annually, appeared to have difficulty crossing the barriers. It is similarly difficult to say why the resident (nuthatch) appeared to be impeded by the lack of barriers in the parallel treatment. One possibility is that it is less adept at homing and relocation across the barriers provided a better navigational cue (i.e., perpendicular birds would know that the noisy highway was normally south of them, thus they should fly north to get home; parallel birds would still be north of the highway and perhaps unsure which direction to fly). Another possibility is that nuthatches were repelled by other territorial birds in their return paths since residents generally defend larger territories and for a larger proportion of the year than do migrants.

MANAGEMENT IMPLICATIONS

Results from the playback experiment do not suggest that roads pose a significant barrier for forest birds relative to other barriers in their natural environment. Nonetheless, the fact that barrier permeability declines with increasing gap size suggests that divided highways with forested medians should create less significant barriers (narrower gaps) than those with grassy medians. In the translocation experiment, the unexpected direction of species differences underscores the need to base our management plans on explicit empirical evidence, rather than predictions alone. Taken together, roads and other linear features appear to have a relatively minor effects on the movement of forest birds across the Bow Valley. Future analyses will determine whether the other investigated effects – habitat avoidance and road-caused mortaility – are more severe.

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Old Growth Forests in Canada. Sault Ste. Marie, ON. A Science Perspective. This symposium will tackle questions such as: What is an old-growth forest in the Canadian context; are there national definitions? Are old-growth forests physiologically and ecologically distinct from managed mature or "overmature" forests? and What contributions do old-growth forests make to local, regional and Canadian biodiversity? Sessions are designed for forest scientists, forest managers, and policy-makers with interests in Canadian temperate and boreal forests. Contact: Bruce Pendrel, Natural Resources Canada, Canadian Forestry Service - Atlantic Forestry Centre P.O. Box 4000, Fredericton, NB E3B 5P7. Tel: (506) 452-3505; fax: (506) 452-3140; oldgrowth@nrcan.gc.ca

November 2-8, 2001
"Wilderness and Human Communities: The Spirit of the 21st Century" The 7th World Wilderness Congress. Port Elizabeth, Eastern Cape, South Africa. Organized by the Wilderness Foundation (South Africa) and the WILD Foundation (USA). The Aldo Leopold Wilderness Research Institute invites you to participate in the technical session, "Science and Stewardship to Protect and Sustain Wilderness Values." The symposium will be structured to enhance international and inter-cultural communication, and will integrate poster discussion presentations into each session to increase one on one dialogue. Contact 7th World Wilderness Congress Secretariat, Wilderness Foundation South Africa. Tel: ++27 (0) 31 4622808; fax: ++27 (0) 31 4624656; or The WILD Foundation (USA). fax: (805) 640-0230; info@worldwilderness.org; www.worldwilderness.org

November 13-15, 2001
"Integrating Practical Approaches." ORAFS Watershed Restoration Workshop 2001. The Oregon chapter of the American Fisheries Society will present an updated repeat of its popular watershed restoration workshop series. The program will feature scientists from California to British Columbia with diverse restoration expertise. Topics span from rhetorical concepts to on-the-ground planning, treatment, maintenance and monitoring, and will address river geomorphology, soils, riparian forests, fish and wildlife, water quality, and social issues. Contact: Richard Grost. Tel: (541) 496-4580; e-mail: rgrost@compuserve.com

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