retained large portions of the land and eventually allocated these lands to newly established public agencies such as U.S. Forest Service (USFS), National Park Service (NPS), and Bureau of Land Management (BLM). Western states were also granted "school trust" lands from the federal government, inheriting millions of acres (usually in separate square mile sections) that were intended to be leased or sold to raise money for public education (Shinneman, McClellan et al. 2000).

Recreation

Recreation use has occurred since the incorporation of the area into the National Forest System and continues to increase in diversity and amount. Winter recreation (especially, but not exclusively, motorized recreation) creates disturbance and snow compaction in openings, over wetlands, and along linear routes.

Wildlife Considerations – Snow Compaction

Snow is an integral component of habitat. Snow depth and characteristics affect animals' access to prey or vegetation, the ease of travel, and availability of insulated microsites. Modern human activities, particularly use of snowmobiles and skiing, have the potential to alter snow conditions.

Winter in the mountains of Wyoming poses challenges for warm-blooded animals. In addition to snow, extreme cold and wind make it difficult to maintain a positive energy balance, that is, to provide more calories (whether from stored fat, stored food, or by active foraging) than the animal must consume each day to maintain its body heat. Many native animals meet this challenge by leaving the area (migration) or by storing fat and reducing energy demand (hibernation). Most of the breeding birds migrate south for the winter. Some birds and mammals move to lower elevation where the weather is less extreme and snow is less deep. Black bears and many rodents hibernate.

However, even at high elevation, some animals are present and active all winter. Some animals have anatomical adaptations for locomotion on or through snow (like the large feet of snowshoe hare or the shoulder structure and long legs of the moose which allow it to move through deep snow and to spend the winter at higher elevation than deer and elk (Marchand 1996). Animals that are active on the surface may change color to provide camouflage (like ptarmigan, weasels, snow buntings, and snowshoe hares). Insulation may be increased by the growth of a denser coat (Ivanter, in Merritt et al 1994) or deposition of subcutaneous fat. Many animals have seasonal physiological adaptations, like changes in metabolic rate, fat storage, or ability to mobilize energy in response to cold (e.g. Merritt 1984). Other species live in or beneath the snow.

Animals that live in snowy environments are adapted for survival with snow. They may rely on snow for creation of sheltered microsites or for competitive advantage over species lacking their adaptations. High mortality or reduced reproduction may occur in years with little snow {Formozov 1946, Jannett 1984, Merritt 1985, Merritt 2003}. Alterations in snow compaction have implications both for animals that live above the snow ("supranivian") and for those that live on or below the ground surface, at the base of the snowpack ("subnivian").

Supranivian species at high elevation include the lynx and the snowshoe hare, both of which have large feet and long legs that support them on top of the snow when another animal of the same weight would sink and be unable to travel efficiently.

In an early assessment of the effects of snow compaction on animals, Bury {1978} concluded that the animals most affected were small mammals that live beneath the snow and are active during the winter. A review some of the features of the snowpack that affect subnivian wildlife habitat is given in the *Wildlife section of Appendix D (Biological Diversity.* For a more thorough review, see {Pruitt 1960, Halfpenny 1989, and March and 1996}. For an extensive review of the physical properties of snow and the ecology of snow-covered ecosystems, see(Jones, Pomero et al. 2001).

Alterations in Snow Compaction with Winter Recreation

Skiing, snowshoeing, and snowmobiling alter the formation of the snowpack. On the Medicine Bow NF, snowmobiling affects far more area than downhill skiing, cross-country skiing, and snowshoeing. In the first snows of the season, any of these uses will compress the snow hard against the ground (in the same way that snow freezes to a driveway under tire tracks). Unlike natural snow, this compacted snow is not likely to melt off (after an early snowfall followed by mild weather), terminating access to food earlier in the autumn. Compacted snow will also melt later in spring, again denying access to food supplies for animals that survived the winter. Finally, this compression onto the ground eliminates the basis of the formation of the subnivian space (the air space under the snow around grass and other clumps of low vegetation) replacing it with a dense layer that animals cannot burrow through.

These winter recreation activities also alter the density of the snowpack. The degree of natural compaction of snow is variable. In open windy settings, snow is blown and the “arms” of the flakes are broken, forming pellets that lie in a dense pack. However, even in the open areas in the Snowy Range, snowmobile and ski tracks are clearly visible, indicating that compaction (at least in portions of the area) is increased compared to that created by natural forces. In more sheltered forested areas, the fluffy snow becomes denser over time because of changes in physical structure (metamorphosis as water molecules migrate in the snowpack), compression by overlying snow, and by alteration (even melting) at the surface. However, it generally remains far too soft to support a walking person, for example, unlike a track created by skiers or snowmobiles.

Studies in the Snowy Range at the Glacier Lakes Ecosystem Experimental Site found that the density of snow on snowmobile trails was 1.5 to 2 times as dense as snow off trails {Musselman, pers. comm.}. These results are similar to those of Schmid {1971} in Minnesota. Compaction may occur in off-trail areas because about 75% of the compaction of fresh snow caused by snowmobiles can be attributed to the first pass {compared to compaction after 5 sequential passes, Keddy et al. 1979}.

Environmental consequences for Wildlife Snow Compaction

There are five possible effects of snow compaction on wildlife.

1. **Effects on lynx** (**and other species) of increases in other predators** at high elevation. Lynx, with their large feet, long legs, and light bodies, have a competitive advantage over coyotes, bobcats, and other predators in deep soft snow. Without a compacted travel route, these other species would have to struggle through long distances of deep snow to reach high elevations where snow may be compacted enough for them to move easily. These predators, like coyotes, may compete for prey with lynx (Buskirk, Romme et al. 2000) if they are able to hunt off-trail.. There is no direct evidence of this effect beyond anecdotal sightings and inference from range alterations on Cape Breton Island (Parker, Maxwell et al. 1983).